Forest Landscapes and Global Change

New Frontiers in Management, Conservation and Restoration

Proceedings

Edited by
João Carlos Azevedo
Manuel Feliciano
José Castro
Maria Alice Pinto

IUFRO Landscape Ecology Working Group
International Conference

Bragança · Portugal
September 21 to 27, 2010

Forest Landscapes and Global Change
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Instituto Politécnico de Bragança, Portugal
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Foreword

Twenty years ago, Dr. T. Crow and Prof. B. Anko initiated a proposal to establish a new working party (WP) within the Division 8 of IUFRO, known as landscape ecology. Back then, the field was in its most rapid growth period with many unknowns. Quite a few scholars challenged us about whether this young discipline was science. This challenge was partially important because landscape ecology has strong components and commitments to managers and policymakers. Today, landscape ecology is matured with solid principles and implementations in resource management. Many members of the WP made significant contributions to advance this field for its recognition. At the first international conference in 1990, there were a small handful of participants. After the announcement of this conference, over 400 abstracts were submitted. By August 6, 2010, there were at least 233 registered individuals from 44 countries.

Previous bi-annual conferences had been held in the United States, Japan, Italy, Canada and China. In the last decade, the WP also paid much attention to publishing the papers presented at our bi-annual conferences. Several books and special issues based on these conferences have been published. The WP is now soliciting proposals for future conferences. Please contact any of the committee members during the conference to discuss your interests and plans. One particular effort made by conference organizers and the WP committee is to support students. We believe that student participation is vital for both the science of landscape ecology and the growth of the WP. In 2008, we offered travel fellowships to over 28 graduate students. This year, over 20 individuals received similar support.

We would like to offer special thanks to Dr. Thomas Crow for his leadership since 1990. The WP has grown to have a permanent Webpage (http://research.eeescience.utoledo.edu/lees/IUFRO/), a listserv to promote communication (iufro8-l@mtu.edu), an online registration service and a committee structure that is composed of regional coordinators and liaisons with the International Association of Landscape Ecology (IALE). As of July, 2010, there are 475 members in the WP database. The journal of Landscape Ecology reserves a special page for us to publish important developments from the WP. Since 2008, the WP started sponsoring summer short courses and regional workshops for researchers, students and managers. To keep our communication beyond this conference, I strongly encourage you to subscribe to a membership via our Webpage and share your experiences, new developments, personnel changes, etc. via the WP's listserv.

While growing, we face new challenges. The increasing influence from global change is, no doubt, a major one. The science of landscape ecology can no longer be independent of the changes surrounding us. An equally important issue is from the increasing demands of people and intensified activities. These challenges are the primary reasons for us to have the theme of this conference as "Forest Landscapes and Global Change: New Frontiers in Management, Conservation and Restoration". Through face-to-face interactions during the conference, I am very confident that everyone will be stimulated for new initiatives under this theme. However, we hope the stimulations will go beyond the conference and are translated to your daily actions after returning to your home.

The WP appreciates the kindness of Instituto Politécnico de Bragança to organize this conference. We also owe a lot to the members of the Organization Committee, Scientific Committee and the Scholarship Committee for their quality work over the past 48 months. Without the financial and in-kind support of many organizations, we would not be able to have this great conference.

Jiquan Chen
Chair, IUFRO8.01.02

Toledo, Ohio, USA, September 2010

Preface

This volume contains the contributions of numerous participants at the IUFRO Landscape Ecology Working Group International Conference, which took place in Bragança, Portugal, from 21 to 24 of September 2010. The conference was dedicated to the theme *Forest Landscapes and Global Change - New Frontiers in Management, Conservation and Restoration*. The 128 papers included in this book follow the structure and topics of the conference. Sections 1 to 8 include papers relative to presentations in 18 thematic oral and two poster sessions. Section 9 is devoted to a wide-range of landscape ecology fields covered in the 12 symposia of the conference.

The Proceedings of the IUFRO Landscape Ecology Working Group International Conference register the growth of scientific interest in forest landscape patterns and processes, and the recognition of the role of landscape ecology in the advancement of science and management, particularly within the context of emerging physical, social and political drivers of change, which influence forest systems and the services they provide. We believe that these papers, together with the presentations and debate which took place during the IUFRO Landscape Ecology Working Group International Conference – Bragança 2010, will definitively contribute to the advancement of landscape ecology and science in general.

For their additional effort and commitment, we thank all the participants in the conference for leaving this record of their work, thoughts and science.

The Editors
João Carlos Azevedo
Manuel Feliciano
José Castro
Maria Alice Pinto

Bragança, Portugal, September 2010

Section 1
Scaling in landscape analysis

Environmental drivers of benthic communities: the importance of landscape metrics

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Abstract

The distribution of aquatic communities is dependent on processes that act at multiplescales. This study comprised 270 samples distributed over 2 years and used a nested sampling design to estimate the variance associated with three spatial scales: basin, site and microhabitat. Habitat assessment was made using River Habitat Survey. The derived Habitat Quality Indices and the benthic composition were crossed with landscape metrics and types of soil use, obtained from GIS data, using multiple non-parametric regressions and distance-based redundancy analysis. Invertebrate variation was mainly linked with intermediate scale (site) and landscape metrics were the main drivers determining local characteristics. The aquatic community exhibited a stronger relationship with landscape metrics, especially patch size and shape complexity of the dominant uses, than with habitat quality, suggesting that instream habitat improvement is a short-term solution and that stream rehabilitation must address the influence of components at higher spatial scales.

Keywords: landscape metrics, soil use, macroinvertebrates, habitat, spatial scale

1. Introduction

The hierarchy theory indicates that small scale physical and biological features are hierarchical nested by variables on larger spatial scales, which means that in-stream conditions are constrained and controlled by successive larger-sale factors, interacting as filters along those scales (Frissell et al. 1986; Poff, 1997). Lotic biological assemblages occurring at a given site are a subset of the potential pool of colonizers that have passed through a system of filters related to the environmental variables and their modification by human action (Boyero, 2003; Bonada et al., 2005). This is the case of geology, climate and landscape-level factors such as land use or vegetation patterns that have been shown to influence local habitat condition and therefore the composition of benthic fauna (Roth et al. 1996; Lammert & Allan, 1999; Joy & Death, 2004). More recently, studies tended to focus on analyzing the dependence of hydromorphological characteristics on catchment level features and land-use, in particular whether reach or catchment scale vegetation constitute suitable predictors of in-stream features (Allan, 2004; Buffagni et al., 2009; Sandin, 2009). There is a strong need to develop habitat assessment strategies that integrate different complementary spatial scales from microhabitat level (including hydraulics) to the assessment of river corridor condition and surrounding land use (Cortes et al., 2009). These aspects have been already incorporated into methodologies proposed in different field surveys (e.g. Raven, 1998). There is no doubt that the spatial hierarchy of fluvial ecosystems is a crucial aspect to consider, since identifying the relationships between different levels allows associations to be made between habitat features, processes and communities. This knowledge is essential for improving the implementation of appropriate

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management and monitoring measures (Sandin, 2009), as the effect of multiple human pressures on aquatic habitats is spread over several spatial scales (Hughes et al., 2008).

The main objective of this work was to assess the influence of environmental attributes expressed at different scales on stream communities, particularly macroinvertebrates, and to determine how the habitat descriptors are shaped by higher spatial scales, namely landscape patterns.

2. Methodology

A hierarchical nested design was used for sampling benthic communities. In this study it was considered 4 catchments (Rivers Olo, Corgo, Pinhão and Tua), 15 sites distributed by the river network, 3 transects in each site and 3 micro-habitats (replicates) in each site. All catchments are located in the Douro basin (Northern Portugal) and are subjected to distinct natural conditions (such as high gradient streams ranging from 1100 m to 50 m of altitude). Furthermore, there are preserved areas, like the Olo and Tua catchments, contrasting with other areas influenced by an intensive agriculture (specially vineyards), located in the downstream sectors of rivers Corgo and Pinhão (Figure 1).
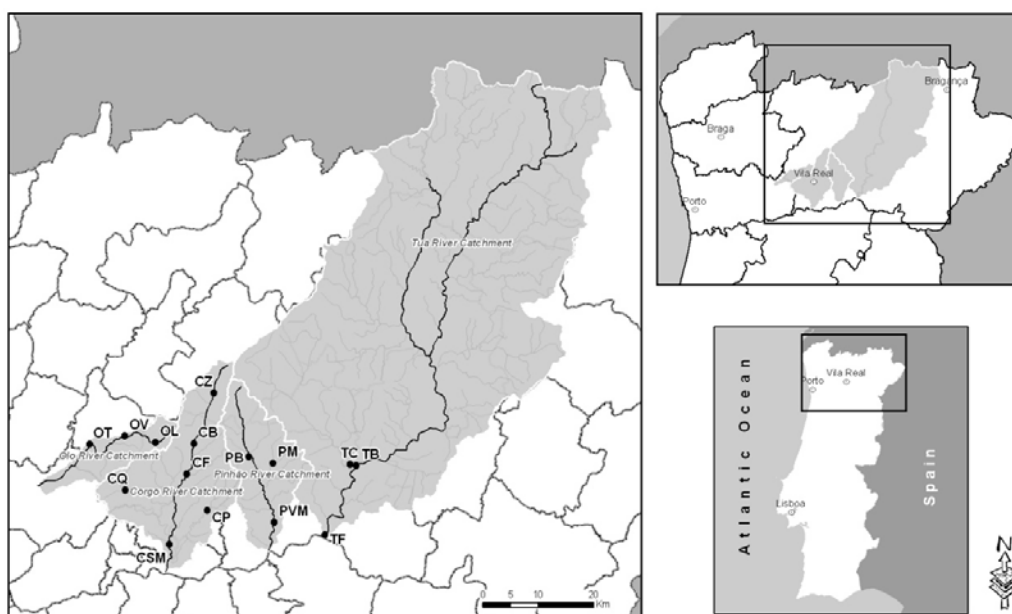
Figure 1: Location of the 15 study sites along the Olo, Corgo, Pinhão and Tua rivers, all from the Douro catchment, Northern Portugal. Study sites are spread along the longitudinal axis of the main rivers, but the Tua catchment, which was only sampled in the lower section.

Invertebrates sampling was made in 2006 and 2007 in these micro-habitats using surber samples. Invertebrates were identified to genus level to most of the families (except Diptera and Oligochaeta).The relationship between large scale variables and the benthic fauna was assessed using both species composition and species traits. The environmental variables considered covered two levels of observation:

  a) At landscape and soil use scale the data was obtained from Corine Landcover and it was considered a circle of 1km radius around each site. In the first case we used a set of metrics that can be grouped in patch metrics of density and size, edge, shape and of diversity and interspersion. These metrics were further applied to each type of soil use originating a total of 48 variables (Table 1).
  b) At the aquatic habitat and river corridor scale it was applied the River Habitat Survey methodology (RHS - Raven et al., 1997, 1998). Ten transects or "spot checks" were made at

50m intervals along the 500m reach and discrete descriptions obtained (e.g. cover channel substrate, flow type, aquatic vegetation types, bank vegetation structure, artificial modifications). Continuous observations or "sweep up" along the 500m reach characterized features and modifications not described at the spot-checks (e.g. natural and man-made features, or riparian vegetation). Two habitat indices, derived from the RHS were determined: 1) Habitat Quality Assessment (HQA), that is an expression of the habitat quality (e.g., physical habitat, vegetation cover, the use of marginal land), and 2) Habitat Modification Score (HMS) that quantifies the extent of artificialization (e.g. weirs, bank protections) along the channel.

Table 1: Environmental descriptors used for describing landscape-land use and habitats at each of the 15 sites included in the Rivers Olo, Corgo, Pinhão and Tua, The landscape metrics were applied to the different soil use types resulting in a total of 48 landscape variables.

Landscape metrics	Soil use variables	Habitat descriptors
PATCH DENSITY AND SIZE METRICS	Agriculture land, except vineyards (area in m^2 and %)	**ARTIFICIAL FEATURES** Habitat Modification Score (HMS)
Number of patches	Vineyards (area: m^2 and %)	
Total edge	Coniferous woodland (are: m^2 ; %)	**HABITAT QUALITY**
Patch size stands dev.	Broadleaf woodland (area: m^2; %)	HQA flow
	Mixed woodland area (area: m^2; %)	HQA channel
SHAPE METRICS	Urban area (area in m^2 and %)	HQA bank features
Mean shape index	Scrub & shrubs (area in m^2 and %)	HQA bank vegetation structure
Mean patch fractal dimension	Water surface including reservoirs	HQA point bars
Weighted mean patch fractal dimension	and wetlands (area in m^2 and %)	HQA in-stream channel vegetation
		HQA land use
		HQA trees
		HQA special features

A nested permutational MANOVA from resemblance matrix based on the Bray-Curtis coeficient was used to test the significance of benthic composition from the different spatial levels (catchment, site and transect). Multiple non-parametric regressions from distance-based linear models (DISTLM) were established between invertebrate taxa and the environmental variables by using the following independent variables (separately): habitat quality indices, soil use variables and landscape metrics (Table 1). Ordination techniques using distance-based redundance analysis (dbRDA) were established between benthic fauna, but expressed as metrics sensitive to contamination and soil use and landscape metrics. The biological metrics were extracted from Varandas & Cortes (2009) since they proved to be the most sensitive to disturbance in catchments of North Portugal (Table 2). Multivariate analyses were carried out using the package PERMANOVA for PRIMER (Anderson et al., 2008).

Table 2: List of invertebrate metrics selected (Oliveira & Cortes, 2009). Acronyms are indicated in bold.

Invertebrate metrics			
Families of Predators	**fP**	% Shredders	**%Shr**
Fam. of Ephem., Plecop., Trichop.	**fEPT**	% Scrapers	**%Scr**
Families of Swimmers	**fSwi**	% Filterers	**%Fil**
Families of Clingers	**fCling**	% Gatherers	**%Gath**
% Rheophilous	**%Rhe**	% Predators	**%Pred**
Genus of shredders	**gShr**	% Limnophilous	**%Lim**
Genus of Filterers	**gFil**	% Omnivorous	**%Omn**
Families of Gatherers	**fGath**	% organisms with branchial respiration	**%br**
% Intolerants	**%Int**	% organisms with cutaneous respiration	**%cr**
Index	I**BMWP**	% organisms with aerial respiration	**%ar**
Index	**FBI**	% organisms parasites	**%Par**

Results

The results of the MANOVA for benthic composition are presented on Table 3, separately for each year, and showed that site produced the significant differences for both years ($p < 0.05$) whereas differences between catchments were less evident.

Table 3: Hierarchical MANOVA performed separately for both years of field study (2006 and 2007)

Source of variation (2006)	df	Mean squares	Pseudo-F	P
Catchment	3	16625	1.482	**0.044***
Site	11	11157	5.415	**0.001***
Transect	30	2062	1.439	**0.001***
Residual	90	1433		
Source of variation (2007)	df	Mean squares	Pseudo-F	P
Catchment	3	11771	1.290	0.115
Site	11	9122	4.859	**0.001***
Transect	30	1178	1.065	0.182
Residual	90	1763		

Multiple non-parametric regressions (DISTLM) between macroinvertebrate taxa and habitat quality illustrated the greater importance of landscape metrics in shaping benthic composition, in particular the fractal dimension of hardwood forest, agriculture patches and number of vineyard patches, followed by soil use (agriculture; $p < 0.05$) (Table 4).

Table 4. Multiple non-parametric regressions, using AIC criterion, between benthic invertebrate communities, habitat indices, land uses and landscape metrics.

MODEL with RHS indices; R2= 0.218			
Variables selected (Best model 2 var.)	**AIC**	**Pseudo-F**	**P**
HQA flow type	109.60	1.22	0.269
HQA vegetation channel	109.26	2.03	0.380
MODEL with Land use variables; R^2= 0.313			
Variables selected (Best model 2 var.)	**AIC**	**Pseudo-F**	**P**
Agriculture area	107.75	3.09	**0.04***
Hardwood forest	107.31	2.12	0.22
MODEL with Landscape metrics; R2= 0.978			
Variables selected (Best model 13 var.)	**AIC**	Pseudo-F	**P**
Area weighted patch fractal dimension of agriculture	106.93	4.00	**0.01***
Total edge hardwood forest	106.19	2.40	0.05
Patch size standard deviation of mixed forest	105.98	1.75	0.11
Number of patches of vineyard	105.22	2.01	**0.02***
Mean fractal dimension area patch of hardwood	104.63	1.70	0.07
Number of patches of agriculture	103.51	1.85	0.07
Area weighted patch fractal dimension of mixed forest	101.24	2.30	**0.03***

The dbRDA ordinations, grouping biological and environmental data are represented on Figure 2, with separate plots for biological and environmental variables. The 1st axis reflected the longitudinal variation, where the landscape variables linked to the natural cover (forest and shrubs) define the sites located upstream and the ones associated with the vineyard influence more the lower reaches. On the first sites we may notice the presence of less disturbed communities reflected by higher values of the biotic index, EPT, shredders and intolerant fauna, whereas this pattern is replaced downstream by a dominance of organisms with branchial and cutaneous respiration, belonging to trophic groups with mainly filterers and gatherers. Concerning the relation between benthic fauna and soil use it was also detected a longitudinal gradient related to soil use from natural areas (e.g. hardwood forest) to agriculture (including vineyards).

Figure 2: Redundance analysis (dbRDA) between invertebrate metrics and landscape metrics. The left diagram represents the biological metrics and on the one on the right represents the landscape patterns. Acronyms for landscape metrics: **N** number of patches; **SD-** patch size standard deviation, **SI-** mean shape index**, SH-** mean patch fractal dimension**, FR-** area weighted mean patch fractal dimension**;** the last letters represent vegetation types: **VIN** vineyard; **AG** agriculture; **FF** broadleaf forest; **FR** coniferous forest; **FM** mixed forest; **URB** urban area (see Table 2 for the biological metric codes)

Discussion

Many studies using environmental variables determined at different spatial levels, attempt to extract the relevant scales that lend structure to aquatic communities such as benthic macroinvertebrate assemblages (Roth et al., 1996; Lammert and Allan, 1999). Lowe et al. (2006), who made a revision on patterns and processes across multiple scales of stream-habitat organization, emphasize the fractal network structure of stream systems at a landscape scale and mention the need to understand how the spatial configuration of habitats within a network affect fluxes of individuals and materials. The same authors conclude that broader use of multiscale approaches to explore population and community dynamics and species-ecosystem linkages in streams will produce research results that are applicable to management and conservation challenges. This study found that landscape metrics provided a powerful tool for assessing both macroinvertebrate dynamics, instream habitats and also the river corridor. It was also

found that soil use descriptors were associated with the typological functioning of the river system displayed by the longitudinal succession of benthic assemblages.

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Habitat suitability models for two species of forest raptors in Catalonia. Methodological consequences related with different scales and data sources

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Abstract

Species distribution along a territory is a function of different environmental variables that changes in space and time. In this communication we use GIS based information from different sources and at different scales (1x1 km^2 and 10x10 km^2) for elaborating habitat suitability models of two forest raptors species (*Buteo buteo* and *Accipiter gentilis*) along a north-south gradient in Cataluña. The area of study has an extent of 7000 km^2. Forest raptors species presence/absence data on 679 1x1 km^2 grid cells of the Catalan Breeding Bird Atlas, and Spanish Forest Map at a scale 1:50,000 are the main information sources. Logistic regression methods have been essayed for comparison across different scales. Unexpectedly, preliminary results show no relation between variables like land use type or diversity of habitats and raptors presence at 1x 1 km^2, and this relationship is only significant for *Buteo buteo* at 10 x 10 km^2 scale.

Keywords: Habitat suitability models, land uses, logistic regression, changing scales.

1. Introduction

Animal species related to forest habitats are dependent on habitat extension but on habitat quality as well. Advances in knowing species distribution and habitat requirements are essential for studies of population genetics, evolutionary and conservation biology, biodiversity maintenance and territorial planning, among others. Recent georeferenced information about not only species distribution in Spain, but also related to climate, lithology, changes in land uses or historical disturbances (wild fires, floods, wind storms) at different scales are valuable data sources that contribute to the elaboration of habitat suitability models that are the basis for connectivity or habitat fragmentation analysis (Pascual-Hortal & Saura, 2008). Specialist species have been affected by reduction of habitat extension and population fragmentation (see Farhig, 2001; Lindenmayer, et al, 2003; Alderman et al, 2005) with the consequence of reduction on effective population levels. Spanish forest raptors are not the exception, and a proper knowledge of habitat requirements and habitat suitability is needed. Underlying reasons for explain mismatch between potential and real distribution of a species are scale dependent, and the explanation of this dependence is one of the goals of habitat suitability models –HSM hereafter- (Ottaviani et al, 2004; Guisan and Thuiller, 2005).

In a previous paper (García del Barrio et al, 2009) we essayed HSM for two forest raptors on two forest districts of central-east Spain with presence/absence data at 10x10 km^2 scale. The aim of this paper is to compare the performance of HSM at changing scales and using different data sources. Forest raptors species chosen are goshawk (*Accipiter gentilis)* and common

buzzard (*Buteo buteo*) distributed in a noth-south gradient of 140 km in Catalonia with presence/absence data at 1x1 km^2 and frequency data at 10x10 km^2 aggregation level.

2. Methodology

Study zone is located in Catalonia (northeast Spain). Seventy 10 x 10 km^2 (5 x 14 quadrates) units were selected along a 140 km north-south gradient. Limits were 42º 32' N - 41º 16'N and 1º 25' E – 2º 3'E. Geographic gradient ranges from Pyrenees Mountain with altitude over 3000 m to Mediterranean coast at sea level.

Species data came from 679 1 x 1 km^2 quadrates surveyed in the Catalan Breeding Bird Atlas 1999-2002 (Estrada et al. 2004), covering less than 10 % of the study zone. Land use data came from the Spanish Forest Map at a 1:50,000 scale. Forest raptors selected were goshawk (*Accipiter gentilis*) and common buzzard (*Buteo buteo*). Goshawk is a species with a wide distribution area across Europe, inhabits several types of forest from mountain coniferous to Mediterranean evergreen at low lands. Common buzzard is a species broadly distributed along Iberian Peninsula, less dependent than goshawk of extensive forested areas.

Land uses have been reclassified following Table 1. Mean elevation was the physiographic variable selected. Mean annual precipitation, mean annual temperature and summer precipitation were the climatic variables (Gonzalo, 2007).

Generalized linear models (GLZs) had been essayed; binomial-log for presence/absence data at 1 x 1 km^2 level, and normal-log for frequency data at 10 x 10 km^2 level (Statistica v.7). Firstly we examined each independent variable in relation with the dependent and secondly, if there was significance of any of the independent ones, they were put together and interactions were considered in the model.

3. Result

The analysis at 1 x 1 km^2 resolution have not had noteworthy relationships between dependent and independent variables, neither land uses variables nor climatic or topographic ones. Table 2 shows, for the two raptors species, matches between land uses in habitat areas and total study area. Figure 1 represents the distribution of forested land use in three areas with the presence of the raptors and total study area. Goshawk presence is reduced to 28 of 679 quadrates (4.1 % of the effective sampled area) and main land uses in this area are very similar to that on the total area, only with the exception of fewer incidences of artificial land uses. Common buzzard reaches 24 % of presence (163 of 679 1 x 1 km^2 quadrates are occupied) but no significant relationships between species presence and land use or climatic variables have been found.

At 10 x 10 km^2 scale, goshawk frequency has not relevant relationships with independent variables selected, and modeling is not possible. The case of common buzzard is different because an equation that explain 36 % of deviance can be formulated

$$F_{Bb}= -3.223+0.516xA+0.021xF+0.001xCxF-0.005xCxA-0.009xAxF \qquad (1)$$

F_{Bb}: frequency of presence at 10 x 10 km^2 (nº presences/nº total)
A: % of articial areas
F: % of forest areas
C: % of cultivated areas

Equation 1 shows that final model includes only land uses variables, not topographic or climatic ones. Two single variables (A, F) and three interactions between A, F y C slightly explain actual distribution of common buzzard in the study area (Table 3). There is no evident explanation to the incidence of interaction variables, whereas the positive effect of forest areas is obvious but the same effect of artificial in not so much explainable.

4. Discussion

The paper explores the use of recently sampled data of nesting birds in Catalonia in relation with main land uses and other topographic and climatic variables. Presence/absence data at 1 x 1 km^2 resolution and frequency data at 10 x 10 km^2 where used for modeling Habitat Suitability for two forest raptors species. Surprisingly, no relationships where found at the more detailed scale, and only a slight relation could be modeled (Figure 2) for the more abundant raptor species (common buzzard) at a coarser resolution level.

These are not good news because high spatial resolution data of species distribution should be the basis for modeling connectivity, habitat fragmentation and other indicators relatives to species conservation. If we could not model in relation with the main territorial requirements of a species, and where they are located across the territory, it would be difficult to predict species colonization movements or habitat loss driving forces.

It should be possible that the two main reasons that affect the absence of correlation found at 1 x 1 km^2 resolution, is that the sampled territory is less than 10 % of total territory and land uses distribution in species presence plots and total plots is quite similar, where no determinant for other species and other sampling areas at the same resolution levels, but there are not very much reasons to be optimist with the problem of true or false absences. Manel et al (2001) showed some problems that are not been solved in data acquisition methods, and modeling HSM with this kind of data is not so accurate.

Next question is relative to habitat saturation by a target species in a territory. This relationship depends not only of potential habitat or potential niche but also of the effective niche. There are some biotic interdependence that land uses variables or climatic and topographic ones do not reflect. Human pressure in Spain over raptor species had historically reduced their distribution areas, driving some of them near extinction. Absence of preys is other meaningful reason that we could not evaluate in these models, and for the migrant species maybe questions relative to synchronization of movements are important too.

Finally, we could conclude that the use of presence/absence data at 1 x 1 km^2 resolution for two raptors species in Cataluña, in relation with land use, climatic and tophographic variables had not improved the slight predictive power of the HSM at 10 x 10 km^2 resolution. Including variables of avian richness, potential prey's richness or some relative could be improving the response of models but, in general, data relative to these variables are not available at broad scales.

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Tables and Figures

Table 1: Main land uses in the study area (14x 5 quadrates of 10 x 10 km^2 in Catalonia)

Land cover class	Total Area (ha)	%
Tree forested (F)	441000	63
Cultivated areas (C)	161000	23
Grassland and pastures (G)	35000	5
Artificial (A)	35000	5
Scrub land (S)	21000	3
Others (O)	7000	1
Total	70000	100

Table 2: Relationships between land uses in total sampled area and areas with presence of raptor species

| | 1x1 | | | | | | 10X10 | | | | | |
| | Total area | | *Accipiter gentilis* | | *Buteo buteo* | | Total area | | *Accipiter gentilis* | | *Buteo buteo* | |
	n	%area	n	%area	n	%area	n	%area	n	%area	n	%area
Tree forested (F)	679	62.4	28	63.2	163	66.0	70	62.6	19	60.4	56	63.2
Cultivated areas (C)	679	25.5	28	29.0	163	28.1	70	22.9	19	24.7	56	23.8
Artificial (A)	679	4.1	28	1.9	163	1.3	70	4.8	19	8.8	56	3.9
Grassland and pastures (G)	679	3.2	28	2.6	163	1.7	70	5.3	19	2.7	56	5.0
Scrub land (S)	679	2.9	28	2.4	163	1.8	70	2.9	19	1.7	56	2.5
Mosaic with trees	679	0.7	28	0.0	163	0.3	70	0.5	19	0.6	56	0.5
Other forested	679	0.6	28	0.1	163	0.2	70	0.7	19	0.7	56	0.7
Body water	679	0.5	28	0.7	163	0.6	70	0.3	19	0.4	56	0.3
Mosaic without trees	679	0.2	28	0.0	163	0.0	70	0.1	19	0.1	56	0.1

Table 3: Generalized Linear Model statistics for common buzzard frequency at 10 x 10 km^2 scale.

	Df	Residual Desviance	Scaled P Chi^2	Change desviance	P desviance	F
Intercept	69	3.15290	70			
A+F-C*A+C*F-A*F	64	2.00510	70	1.15	0.36	7.33
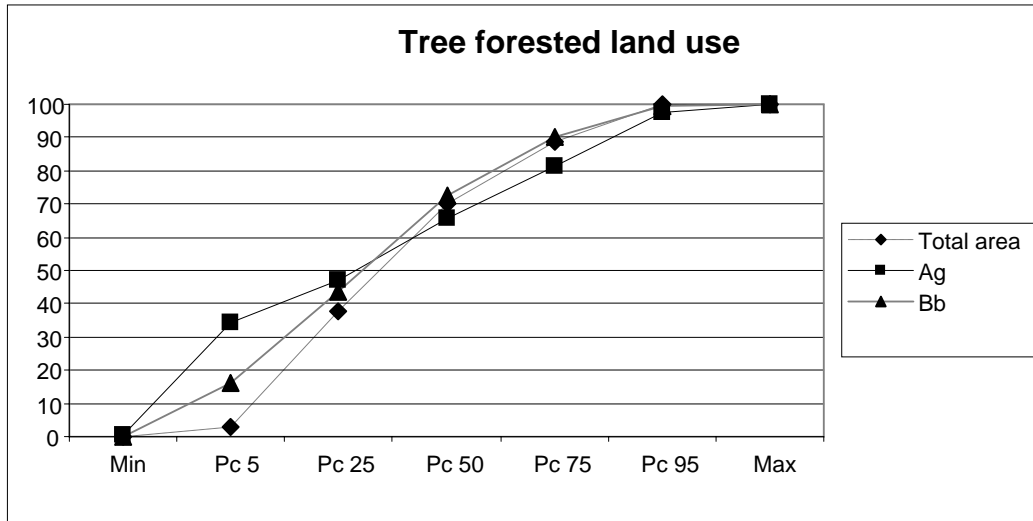
Figure 1: Distribution of land use tree forested land use on total sampled area in quadrates of 1 x 1 km^2, with presence of *A. gentilis* (Ag) or *B. buteo* (Bb). Min= Minimum, Pc= percentile, Max= Maximum.
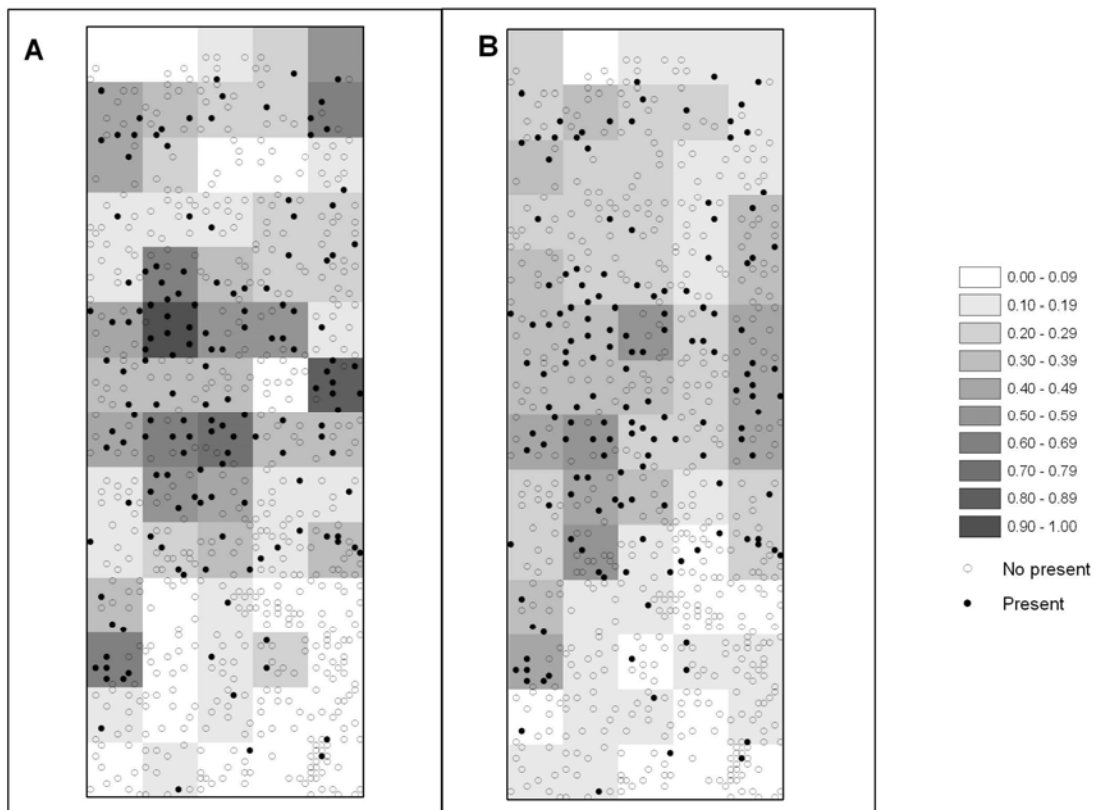
Figure 2: Real (A) and modeled distribution (B) on 10 x 10 km^2 for common buzzard. Circles in both A and B represent presence/absence data at 1 x 1 km^2 level.

Section 2
Patterns and processes in changing landscapes

Recent relations between forestry and agriculture in Poland - the rural landscape on the axis of openness and enclosure

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Abstract

The paper refers to a complex problem of landscape change in Poland. It concentrates on quality as well as quantity transformation within forestry and agriculture and their consequences for the rural landscape. A systematic increase in a forest cover connected with a decrease in agricultural land is observed in Poland. The tendencies are accompanied by landscape disturbance processes, such as settlement sprawl and intensification of agriculture.

The work presented here stresses the influence of above mentioned factors on landscape structure; it employs a broad-scale analysis and focuses on the last two decades. The issue of landscape heterogeneity is widely investigated and regional differences have been underlined. Since the landscape configuration experiences crucial changes, an axis of openness- enclosure and its spatial redistribution received special attention.

Keywords: landscape, structure, rural areas, reforestation, Poland

1. Introduction

A spatial arrangement of elements demonstrating open or enclosed character strongly determines landscape configuration. Patterns of open and enclosed spaces organize and differentiate the land. Besides their compositional values (see Bell 2004), coexistence of open-enclosed units fulfils significant ecological functions, e.g. enhancing or inhibiting material and energy flows in ecosystems. The context of openness and enclosure may also underline variability of landscapes and their dependence on a man-made impact.

The Polish rural landscape has been facing considerable changes for the last two decades, which result mainly from operation of new driving forces appearing after a political reorientation in 1989. Demands of a market economy altogether with a global environmental agenda, restrictions and regulations introduced by EU accession in 2004 set in motion new processes. They modify traditional land-use patterns, influence structure, functions and values of the rural landscape. Interestingly, the processes are well pronounced in interrelations between forestry and agriculture- two main functions held by the rural areas in Poland.

2. The Polish rural landscape and its characteristic features

Regarding a landscape typology at a continental level, at least two types of the rural landscape should be distinguished in Poland: open fields and strip fields (*e.g.* Kostrowicki 1994, Meeus 1995). Agricultural land has had the greatest share in the total area of the country for centuries; nowadays it equals 50.9 % (Stat.Yearb.Rep. 2010) and consists mainly of arable fields and meadows. Noteworthy, non-natural factors have dominated the evolution of the agricultural landscape and very close relations between: 1. meadows, pastures and the river network and 2. arable land and settlement constitute a typical structural feature of the rural

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landscape (Kostrowicki 1959). Villages frequently formed by a dispersed settlement pattern; surrounded by rather small, long and narrow fields; with the presence of diverse eco-margins and forests in a distance can give a short characteristic. Farms in Poland are small; majority possesses their land in separated plots, 18% of them in more than 6 parts (The Country Program of Rural…, 2009).

To a lesser degree, fragmented territorial structure is also found in the Polish forest cover. Altogether with a predominance of poor biotopes, a relatively young age of trees and uneven afforestation, it poses serious difficulties for maintenance of ecological functions. Forestry is the second land- use function in the country, the Poland's forest cover reached 29.0% of the total area in 2009 (Stat.Yearb.Rep. 2010). This insufficient quantity is accompanied by natural and anthropogenic hazards (Liro 1998). It has been estimated that about 70% of a forest cover is formed by tree stands designated for complete felling sites. In addition, forests demonstrate a depleted species composition and a simplistic structure, where biotic components are not adjusted to existing habitats (Smykała 1993, after Rykowski 2003). In general, woodlands have been highly fragmented and are retained now in the areas featured by the worst agricultural qualities. The greatest amounts of forests are found in the west, north, and south-east of the country (The Lubuskie Region [*c.* 50 %], Pomerania and Podkarpackie).

3. Large-scale spatial processes and land-use tendencies in the rural areas

3.1. Land- use tendencies
The Polish rural landscape has encountered high dynamics of land-use changes for the last twenty years. An analysis of statistical data and relevant literature (*e.g.* Ciołkosz, Poławski 2006) allows identifying main directions of the transformation: 1. sharp decrease in meadows and pastures, 2. steady decrease in arable fields, 3. steady increase in forested areas, and 4. dynamic increase in built areas. Many authors (*ibidem*) stress instability of land- use in Poland; however, agriculture and forestry still are dominant.

3.2. Agricultural areas
A steady decline of agricultural land has been noted at least since 1930s (Ciołkosz, Poławski 2006), but after the political turnover in 1989, the process accelerated again. The loss coincides with transformation of agriculture in Poland.

Incoming market requirements caused a systematic decrease in the amount of farms and led to abandonment of land having poor soil conditions, which are being partially afforested. However, the percentage of fallow and uncultivated land has been declining since a period 2000- 2002 (11.9 % in 2000) and in 2008 accounted for 3.8 % (Environment, 2010). Simultaneously, strong demands for housing sites lead to designation of thousands ha for residential areas. Shrinking of agricultural land is accompanied by decrease in diversity of crop and breeding varieties and by strong limitation of pasture. These sharp changes are softened by environmental instruments acquired after UE accession, but polarization between high-productive areas and abandonment of land takes place. Contrary to arable fields, meadows and pastures, the area of orchards increases and is occupied by modern, larger farms (Kulikowski 2007). The Country Program of Rural Development 2007-2013 confirms further steady decline in the total agricultural land. Its statements allow also to anticipate growing importance of land consolidation and size polarization of farms (*e.g.* a further loss of medium-size enterprises).

3.3. Forest areas
In contrast to agricultural land, the amount of forest areas systematically grows. Dynamic post-war reforestation was strongly connected with an ownership structure- new forests emerged mostly on the state's grounds and therefore the northern, north-western and south-eastern parts of Poland show the highest rate of a new forest cover. Distinctively, the availability of uncultivated land during the last two decades does not correspond with the need to improve environmental and ecological functions of the rural areas. A forest cover should be especially strengthened in central and eastern parts of the country, where it suffered advanced

fragmentation. However, supply of convenient land is limited there mainly owing to competition of agro-environmental schemes and a growing demand for arable fields. Therefore the planned total amount of afforestation estimated at 1.5 million ha will have to be reduced. According to the government's plans, a forest cover in 2020 should equal 30% and after 2050 33% (The Country Program for Afforestation 2003).

Importantly, numerous activities aimed at improvements in forests' quality have been undertaken. They are aimed at replacing 'a normal forest' scheme and mono- functional forestry by a multifunctional model (Rykowski 2003). In consequence, importance of ecological functions and renaturalisation is stressed, the share of broadleaved trees systematically grows and the age structure gets better (Raport o stanie lasów 2009). On the other hand, a quantity and quality rise is accompanied by several processes initiated in farming areas, but having evident impact on forests and their ecological functions, such as settlement sprawl and intensification of agriculture. Additionally, the demand for timber rises; requirements of energy market and pressure on increase in renewable energy affect both supplies of wood and a crop structure.

3. 4. Land transformation processes and landscape degradation

Although considerable environmental and ecological benefits result from a growth of a forest cover and from improvements within an ecological network, disturbing changes of landscape structure are observed. Out of several major land transformation processes described by Forman (2006), suburbanization, agricultural intensification, settlement sprawl and reforestation are of the greatest importance in the case of the Polish countryside. First of all, contrasts between intensive and extensive land- use become more emphasized.

Expansion of vast areas featured by agricultural intensification is followed by disappearance of small biotopes and elements subdividing the landscape and it brings with it immense landscape homogeneity. This process is widely experienced in the northern and western parts of the country. Noteworthy, processes involved in landscape degradation often act in a synergy and spread widely. For instance, the spectacular loss of road alleys demonstrates advanced disappearance of valuable landscape elements throughout the country (Worobiec, Liżewska 2009). Furthermore, the negative impact on the landscape is reinforced by uncontrolled development, chaos in spatial planning and a lack of regard for landscape values.

Concerning a dimension of landscape composition and configuration, two axes have shown high sensitivity to new conditions: order- chaos and openness- enclosure.

4. Openness and enclosure of the rural landscape

Interrelations between open and enclosed space (as analysed in material physical categories) influence not only visual qualities of a landscape, acting as one of its aesthetic descriptors (*e.g.* Tveit *et al.* 2006), but also an overall context of landscape structure. The axis openness- enclosure is strongly connected with scale. This work, owing to a range of research is focused on a broad scale and concentrates on national or regional levels of analysis. On the base of relevant literature and the author's own research, and concerning landscape variability in the openness-enclosure aspect, some directions of landscape change can be outlined (table 1).

Noteworthy, the two main types of agricultural landscape differ in their extent. Open fields are featured by a large scale, whereas strip fields units are usually formed by smaller aggregations of many similar landscape cells. As mentioned before, owing to demands of intensive cereal and animal production, expansion of large fields takes place. This process is connected with field consolidation, turning meadows to arable land and with a loss of eco-margins and semi-natural landscape boundaries.

Landscape enclosure is usually encountered in forest and semi-wild landscapes. Both of them are connected with land abandonment and both can be accompanied by planned or

unplanned reforestation. Contrary to forest and semi-wild landscapes, an agricultural landscape formed by large modern orchards is linked with intensive cultivation.

Semi-wild landscapes develop in two main ways. First one appears when large patches are adjoined to neighbouring forests and this usually involves occurrence of unclear boundaries. Such situation is frequently met in N and NW Poland. Second is connected with small patches of abandoned land. A dispersed sequence employs tiny individual parcels or their aggregations; the sets are often separated from each other and have partly legible boundaries. This is mostly the case of an agricultural landscape of central, eastern and southern Poland. Parts of the agricultural landscape transformed into wide semi-wild or forest landscapes, to quote the example of the Bieszczady mountains, where after land abandonment dense associations of broadleaved trees and bushes appeared (Wanic 2009).

Table 1. Tendencies of the rural landscape transformation in Poland in the context of openness-enclosure-regional differences and main factors of change (source: author's own research).

Tendency ⇒ open landscape	Tendency ⇒ enclosed landscape
1. Open fields ▪increase in intensively cultivated arable fields; particularly western, north-western and central Poland ▪decrease in meadows and pastures (transformed into arable fields); Silesia, Wielkopolska ▪decrease in orchards (partly transformed into arable fields); Silesia, north- west.	**1. Forest landscape** ▪ spreading out of formerly established large forests: north, north-east, north-west, western borders and south-east *e.g.* owing to contemporary intensive reforestation. **2. Semi-wild landscape** ▪ extensive land abandonment followed by natural succession and later designated for forests: north, north- west, Bieszczady ▪ land abandonment at a less range – individual parcels overgrowing with trees and bushes: mainly central, southern and eastern Poland **3. Agricultural enclosed landscape** ▪ increase in the amount and character of orchards (mainly Vistula Valley, central and eastern Poland).

Some of previously outlined tendencies of landscape transformation exhibit at least one common feature: expansion of relatively huge homogeneous areas. However, organization of these areas is different. Open fields are usually formed by large patches occupied by cereals (mainly wheat, triticale, barley and lately maize), have clearly defined boundaries and a small quantity of other habitats (and inner shapes). Forest landscapes are almost always constituted by large patches spreading out from 'nucleus' towards agricultural land or constituted by dispersed

areas trying to fill the spaces between 'steps' and in consequence forming a much bigger, elongated patch. Their boundaries have a mixed character, can be very sharp or gradual.

Regional distribution of changes demonstrates interesting landscape differences. A coarse- grain pattern is specific to the northern, north-western and western parts of the country. The rural area there tends to be distinctly divided into a small number of large, concentrated patches of agricultural as well as forest landscapes- both of them featured by predominance of compositional simplicity. The relations between open and enclosed here should be stable in the near future, presumably. Central, eastern and southern parts are affected by appearance of new enclosed structures: 1. forest and 'succession' patches, 2. modern, very effective orchards. They systematically change landscape configuration, to some degree introducing more diversity, but at the same time instigating potentially negative tendency, which can lead to a variable-grain or even a coarse-grain mosaic. Regarding a characteristic fragmented spatial and ownership structure, processes of landscape change in these regions may be much more complex and much more difficult to anticipate.

Hence, two important interconnected tendencies of landscape change should be highlighted: spreading out of coarse- grained mosaics represented by large fields and forests, and shrinking of a traditional fine- grained landscape pattern.

5. Conclusions and discussion: landscape diversity

Redistribution of open and enclosed structures deeply affects landscape heterogeneity in Poland. Firstly, new landscape types develop (for instance an agricultural enclosed landscape connected with compact orchards). Secondly, considerable alterations of a landscape mosaic appear. Open fields spread out and continuously simplify. Forest and semi-wild landscapes spread as well, but owing to an ecological movement in forestry, they can be more diverse than before. However, influence of new patches formed by forests or other vegetation overgrowing abandoned land on the landscape is difficult to assess. New elements can enrich central, eastern and southern provinces, but simultaneously, they can constitute a threat for continuity of a fine-grained agricultural pattern, being able to disturb the landscape structure and character. Operation of many processes at the same time may cause an increase in heterogeneity, but on the other hand, it may result in decline in landscape values. Too much diversity can cause chaos (Bell 2004) and regrettably, this is a common feature of the Polish landscape.

Nevertheless, contrasts between diversity and homogeneity become stronger than they used to- vast areas of agricultural or forest monoculture generate the opposition to the traditional landscape formed by numerous tiny units. Therefore, fragmentation of the traditional landscape accompanied by consolidation of open fields and forest landscapes should be emphasized. Additionally, replacement of natural by geometric shapes in landscapes occurs (Solon 2003). Demonstrated processes vary regionally, historical differences between The Reclaimed Land (the western and northern territories) and the rest of the country are reflected in landscape evolution and in a landscape mosaic.

Some of the changes are observed globally. Palang *et al.* (2006), analysing landscapes of Eastern and Central Europe noticed the passage from small-scale variability to large-scale monotony. Many authors (*e.g.* Richling, Solon 1996) recognized a change of rural areas that consists in two general directions of land transformation: increase in diversity, linked for instance with ecological farming and increase in homogeneity within a landscape in highly developed agro-ecosystems.

The last two decades brought with them significant changes of landscape structure in Poland. The threats of advanced simplification and transition of a landscape mosaic belong to the most considerable consequences. Sadly, the changes can lead to a great loss in the traditional landscape.

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A physiotope-based model for ecoregions for the the nationwide ecosystem management of Japan

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Abstract

In this research we suggest a new ecologically-significant planning unit based on ecoregions adjusted to suit Japan's complicated geological history, and to analyze them from a landscape ecology point of view. First, we divided Japan into four main geological regions and within them, delineated physiotope-based ecoregions using regional climate regime as main controlling factor. From a landform-geological map overlay, we derived 7 physiotope classes and characterized each geological region. We quantified the landscape composition and configuration and found that each region has different patch dynamics and mosaic complexity in which the extent of Neogene sedimentary basins and Quaternary strata deposition play a big role. Understanding the geotectonic-climatic-physiotope ecoregion framework of Japan is an important step in devising multi-scale, hierarchical ecosystem management.

Keywords: Physiotope-based ecoregions, landscape metrics.

1. Introduction

The Third National Biodiversity Strategy of Japan highlighted the biodiversity crisis and the importance of land planning, design and ecosystem management at national spatial scale from the viewpoint of biodiversity conservation. The concept of ecoregion is suitable in devising ecologically-significant land planning units that can be classified hierarchically and which transcends administrative boundaries. Omernik & Bailey (1997) noted that ecoregions are ecosystems of large regional extent that contain a group of geographical areas of similar functioning ecosystems, which can be delineated at different sizes and scales according to management goals. Omernik (2004) pointed out the numerous disagreements over how to delineate ecoregions e.g. disagreements on the definition of ecosystems, its complexity and its boundaries. Bailey (1996) noted the challenges of ecoregion delineation using vegetation and biogeographic distribution of animal communities that constantly change due to disturbance, succession and habitat loss, therefore the importance on basing ecosystem boundaries on permanent features and dominance of one particular environmental factor. Bailey's method sets climate as the composite, long-term, or generally prevailing weather as a primary control for ecosystem distribution at the highest level. Physiography modifies the influence on climate, and has secondary effect on ecosystem differentiation.

The Japanese archipelago is characterized by a narrow arc stretching on the eastern margin of the Asian continent, and is surrounded by the Japan Sea, Okhotsk Sea and Pacific Ocean which affect the different climatic regimes formed. In addition to climatic regimes, tectonic structure is equally important in ecoregion formation in Japan. Japan's main islands are divided generally

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into 2 parts: Southwest (SW) Japan and Northeast (NE) Japan by the Itoigawa-Shizuoka line, separated during the early Neogene by the subduction of the Pacific Sea Plate and the Philippine Sea Plate. A belt of Mesozoic metamorphic rocks, the Median Tectonic Line divides SW Japan into the Inner Zone and Outer Zone of SW Japan (Kimura, Hayami & Yoshida 1991). Hokkaido is separated from the main island of Honshu by an important zoogeographical boundary, the Blakiston Line, also known as the Tsuruga Straits.

The purpose of this research is to suggest a new multi-purpose ecologically significant planning unit in Japan based on the concept of ecoregions, adjusted to suit Japan's complicated geomorphological characteristics, accretion tectonics and geological history, and finally to look at the geologic-climatic-physiographic units from a landscape ecology point of view.

2. Methodology

2.1 Study site

This study focuses on the main islands of Honshu, Hokkaido, Kyushu and Shikoku. The Ogasawara archipelago, Ryukyu archipelago and other islands were excluded.

2.2 Delineation of ecoregions

2.2.1 Delineation of ecoregions at macroscale

The four major geological regions: a) Inner Zone of SW Japan, b) Outer Zone of SW Japan, c) NE Japan and d) Hokkaido were delineated using the Index Map of Fossa Magna (Kato 1992) and the Median Tectonic Line (Yoshikawa et al. 1981) and the Blakiston's line. The Climate Regions Map of Japan by Wadachi (1974) was used to determine the boundaries of the climate regions nested within each geological zone (Fig. 1).

2.2.1 Characterization of ecoregions with physiotope classes

The Landform Classification map (MLIT) and Geological Classification Map (MLIT), both at 1:50,000 scale and in ESRI shape format were overlaid using ArcMap 9.3 (ESRI Japan). The resulting 49 landform-geological classes were later reclassified into 7 physiotope classes that identify accretion tectonics, tectonic relief and unique geomorphologic characteristics (Fig. 1). The resulting physiotope classes' map was converted into ESRI GRID format and overlaid with geological regions for quantification of landscape metrics.

2.2 Quantification of landscape metrics

The raster version of FRAGSTATS (McGarigal & Marks 1994), developed by the Forest Science Department, Oregon State University was used to quantify the areas, patch sizes and variability, diversity, proximity and nearest neighbor indices of the physiotope classes of each geological zone. Results are in both landscape level (Table 1) and class level (Fig. 2a-2f).

3. Results

3.1 Typical characteristics by geological regions

3.1.1 Region A – Inner Zone of Southwest Japan

Volcanoes and Volcanic Landforms and Quaternary Plains are the main physiotope classes of
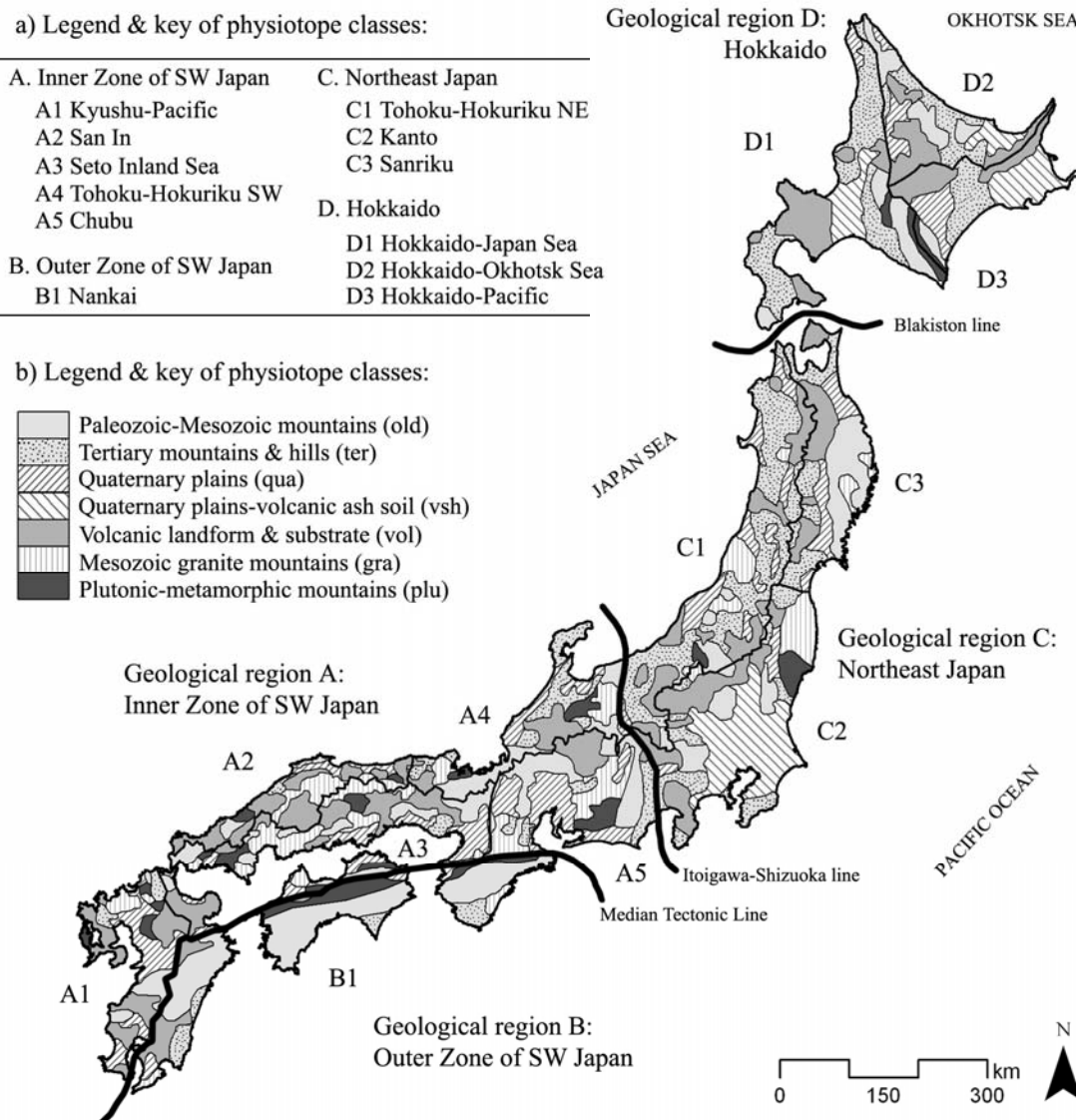
Figure 1: Proposed Physiotpe-based ecoregion map, with four main geological regions followed by regional climatic units nested within, and 7 physiotope classes for characterizing ecoregion units.

this region, consisting of 25% and 22% respectively. It is a fine-grained, fragmented and heterogeneous mosaic interspersed evenly across the region (Fig. 2a-2f).

Analysis on the landscape level reveals a region with the highest patch numbers, but smallest largest patch index among all regions. The highest score in interspersion and juxtaposition suggests that even though physiotope classes are small and fragmented, they remain evenly distributed across the landscape (Table 1).

3.1.2 Region B – Outer Zone of Southwest Japan

Paleozoic-Mesozoic Mountain is the predominant landscape matrix in this region with an area percentage of 57%, largest patch index of 25% (Fig. 2a & Fig. 2c). Analysis on class and landscape level show that physiotope classes has patches with the poorest connectivity and are most fragmented and isolated. Despite the scores, the patches here are strongly connected and

Table 1: Results of landscape level indices by geographical regions

Geological regions	TA (ha)	NP	LPI (%)	MPS (ha)	PSCV (%)	MPI	NNCV (%)	IJI (%)	PR	SHDI	SHEI
A SW Japan	12532743.75	92	7.55	136225.48	126.71	33.32	95.45	95.85	6	1.71	0.95
B Outer zone Japan	3638681.25	16	25.24	227417.58	109.38	2.36	113.05	73.08	6	1.33	0.74
C NE Japan	12279050.00	55	13.71	223255.45	149.08	631.52	99.75	77.24	7	1.75	0.90
D Hokkaido	7794787.50	27	12.51	288695.83	88.69	18.68	120.34	83.59	6	1.59	0.89

TA: Total area (ha); NP: Number of patches; LPI: Largest patch index; MPS: Mean patch size; PSCV: Patch size coefficient of variance; MPI: Mean proximity index; NNCV: Nearest-neighbor coefficient of variance; IJI: Interspersion and Juxtaposition index; PR: Patch richness; SHDI: Shannon's Diversity Index; SHEI: Shannon's evenness index

highly homogenous, but are separated by the Hoyo Straits and the Naruto Straits (Table 1).

3.1.3 Region C – Northeast Japan

Tertiary Mountains and Hills and Volcanoes and Volcanic Landforms are the main physiotope classes, consisting of 30% and 22% respectively, followed by Quaternary Plains with Volcanic Ash Soil, Quaternary Plains, Mesozoic Granite Mountains and lastly Plutonic and Metamorphic Mountains (Fig. 2a). This region is characterized by the presence of an isolated Quaternary Plain with Volcanic Ash Soil patch at a 14% largest patch index (Fig. 2c). Another peculiarity is
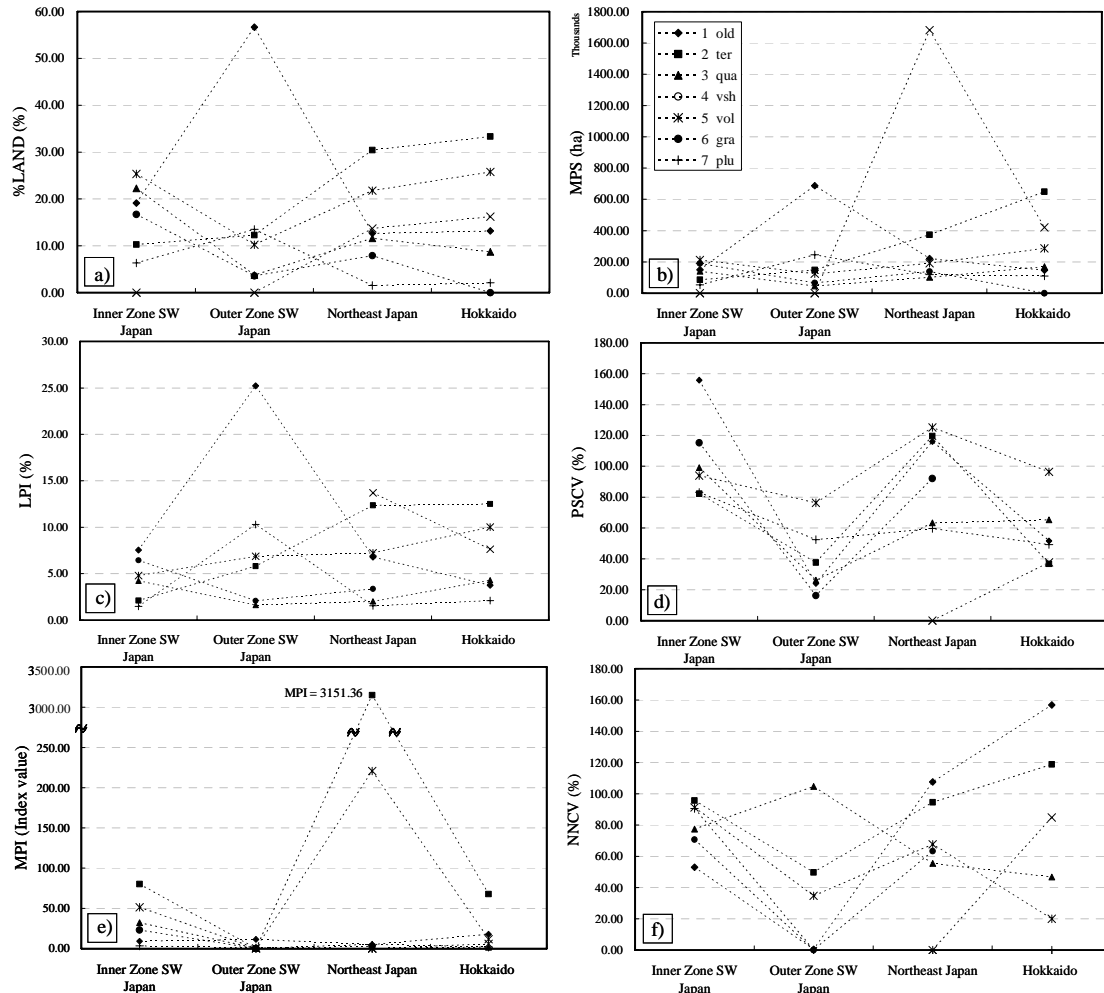
Figure 2: Comparison of landscape indices of physiotope classes by geological regions: (a) Percentage of landscape (%). (b) Mean patch size (ha).(c) Largest patch index (%). (d) Patch size coefficient of variance (%). (e) Mean proximity index. (f) Nearest-neighbor coefficient of variance (%). (Key to physiotope classes in Fig. 1)

the exceedingly high mean proximity index of the Tertiary Mountains and Hills class thus making it the most connected single patch of all regions (Fig. 2e).

Analysis on the landscape level shows strong patch size heterogeneity and strongest connectivity among all regions (Table 1).

3.1.4 Region D – Hokkaido

Interestingly, the land percentage of all physiotope classes in Hokkaido is almost similar to NE Japan, the only difference being the absence of Mesozoic Granite Mountains in Hokkaido. Hokkaido is characterized by fragmented coarse grain size with relatively low connectivity which is distributed unevenly across the region, particularly Paleozoic-Mesozoic Mountains and Tertiary Mountains and Hills (Fig. 2a-2f).

Analysis on a landscape level shows that this region has the biggest mean patch size, lowest patch size heterogeneity, very low connectivity and most fragmented patches (Table 1).

4. Discussion

Landscape compostion of physiotope classes among the geological regions vary. Inner Zone of SW Japan consists of older terranes, volcanic landforms and the highest percentage of Mesozoic granite rocks formed around 150 million years ago. Both NE Japan and Hokkaido consist mainly of newer terranes of Tertiary mountains (formed around 20 million years ago) and Quaternary terranes (Fig. 2a). Jurassic accretionary prisms occupied the largest area of the pre-Neogene basement rock of SW Japan when igneous activity and regional metamorphism was most intensive. But during the Neogene era, Neogene sedimentary basins were formed only in certain parts of SW Japan while the entire of NE Japan and Hokkaido were covered with Neogene strata. During the Pleistocene-Holocene period, uppermost Pleistocene and Holocene strata formed extensive Quaternary plains in NE Japan and Hokkaido, while forming a majority of small and narrow plains in SW Japan (Kimura, Hayami & Yoshida 1991). The late Quaternary was also characterized by major changes in species distribution and composition of biotic communities (Delcourt & Delcourt 1988).The Outer Zone of SW Japan is unique both in landscape composition and configuration, being dominated by Paleozoic-Mesozoic Mountains.

In terms of physiotope class configuration, Inner Zone of SW Japan has the most complicated mosaic with small, non-contiguous, independent patches distributed all across the region. NE Japan is unique, characterized by a large, continuous patch of Tertiary Mountain and Hills class type on the Japan Sea side and a solitary Quaternary Plain with Volcanic Ash Soil in the Kanto plains (Fig. 2b-2f). Complexity of landscape mosaics can be linked to the habitat types formed within. The dominant Tertiary mountains and hills patch of NE Japan coincide with the *Fagus crenatae* (broad-leaved deciduous forest) region's extent (MOE, 1989). Quaternary Plains with volcanic ash soil class type is unique because they are situated next to volcanic regions which supply the debris and being soil originating from tephra, it is among the most productive soil in the world (Shoki & Takahashi, 2002).

The ecologically applicability of the results lies in ecoregion delineation of Japan. The 12 climate-influenced ecoregions nested in each geological region display the significance of the Japan Sea, Okhotsk Sea and the Pacific Ocean's influences on each unit and act as the main controlling factor over the physiotope regions (Fig. 1). Even though defining the ecoregions for Japan is not an easy task and will require more extensive study, this physiotope model of ecoregions has potential as a basemap used in conjunction with environmental databases for further refinement of this study and for other research and management purposes.

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Risk areas to flooding in the Hidrographical Basin of Arroio dos Pereiras in Irati, PR, Brazil

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Abstract

This study aimed to identify and map areas the risk areas to flooding in the hidrographical basin of Arroio dos Pereiras, located in Irati - PR (Brazil), identifying the most susceptible areas to accidents of hydrological origin, emphasizing the floods and co-relating the natural susceptibility derived from the natural morphodynamics of the system, where the hidrographical basin (with its inputs and outputs of energy, allied to the relief features) and the susceptibility created by human actions, mainly by the processes of urbanization, which modify the natural dynamics of the system, increasing susceptibility to the occurrence of the phenomenon and creating risks to society.

Word Keys: Mapping - risk areas - flooding - Irati - PR - Brazil.

1. Introduction

According to Tucci (2003), urbanization is one of the main constraints for the increase of the frequency and magnitude of floods, that due to changes made in the process of human occupation, such as soil sealing and deployment of infrastructure that alter the natural dynamics system. Such changes reflect in a higher runoff that leads to an increase of speed and flow of the river watercourses, potentiating the flood risk and other natural disasters linked to the dynamics of water and land such as erosion and landslides.

Before such a reality, it is necessary to conduct studies to identify such areas at flood risk, as well as the frequency and magnitude of the event.

1.1 Location and characterization of the study area.

The hidrographical basin of Arroio dos Pereiras is located in Irati - PR, between the coordinates 533976/7179941 and 539906/7185815 UTM (Figure 1), comprising a total area of 354 ha. It is an hidrographical basin of 3rd order, with a total of 27 river watercourses. Its main sources are located in rural areas and its riverbed runs to central urban area. Thus, the occupation seated along the hidrographical basin, eventually occupy inappropriate areas as the valleys bottoms, marginal areas and flood plains, thereby increasing the risk to flooding.

The study area is included in the geological compartment of the Paraná Hidrographical Basin, with the main geological formation the Irati formation (pyrobituminous shale), with the occurrence of diabase dikes. It has an amount of unevenness to its outfall of about 110 meters, which adds up to a relief that ranges from rolling to rugged, results in areas where river flow may have a lot of energy. However, near its outfall it was modeled a floodplain quite expressive, where the urban area is settled. (Kazubek, 2006).

1.2 Natural and Anthropic Constraints of the flood events.

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According to Cunha (2005), rivers and canals overflow their riverbeds at least once every two years, in other words, when there is peak flow, triggered by concentrated rains and the river begins to occupy its larger riverbed or floodplain. What makes these risk areas is human occupation, that by ignoring or disregard the natural dynamics of the drainage network provides housing in these areas and often the walls of buildings of the river banks (photo1).

When the occupation of the bottom of a city valley does not consider the natural dynamic of the system, considering riverbed just the river watercourse and not respecting the larger riverbed, which is its area of flight in the events of greater flow, creates what we call risk, which is the sum of the natural susceptibility, more created susceptibility, more the vulnerability that the population is exposed (EMPLASA / SNM, 1985).

Other factors that act as constraints or even aggravating of the flood events are the infrastructure projects that increase according to the urban development such as soil sealing, the reduction of green areas, changes in canals such as rectilinizations and canalizations, which, when poorly scaled, ultimately aggravate the situation, since they reduce the area occupied by the flow, blocking the water flow in the peak events, leading to leakage or even rupture of pipes and galleries.

In the case studied, the hidrographical basin of Arroio dos Pereiras, the floodplain is the area of the basin that has the more consolidated urban occupation, housing commercial activities and services, in other words, it is precisely the central area of the city with a higher potential risk of material losses.

Figure 1 - Location of the Hidrographical Basin of Arroio dos Pereiras
Org: Campos, 2006.

2. Methodology

The thematic maps were generated using the software Spring 4.3 (1996), from image of QuickBird ® 2004 satellite (Irati 2006), topographic maps of the Army (SG 22-XCI-4) at 1:50000 scale, base-letters of the city 1:50.000 and cadastral urban letter cadastral at 1:10,000 scale.

To map the risk areas they were considered the subdivision and land use, the characteristics of the drainage network (watercourse morphology and location of flood plains), structural change and watercourse contention and historic of previous events in the local press, brigade of firemen, residents and researchers of local history. These procedures allowed to identify and map the most susceptible areas to flooding using the GIS tools.

For this work we established the period from 1983 to 2006 to identify the time of recurrence of the phenomenon and they were considered only large and medium magnitude events, which have records both in the local press and in government agencies as City Hall and Fire Department . Because there is not a well established civil defense, the records are few and

there are not photographs that would make it possible to map more precisely the coverage areas of the flooding.

Photo 1 - Margins of Arroio dos Pereiras on May 24 Avenue.
Author: Campos, 2006.

3. Results

They were identified eight most relevant events which occurred in 1983 (2 episodes), 1987, 1992, 1993, 2000, 2002 and 2004, totaling 8 events.

In flood events (medium and large magnitude) all central area is reached, since it is settled on the floodplain of two hidrographical basins: Arroio dos Pereiras (our subject of study) and Antas River, being Arroio dos Pereiras tributary of Antas River.

The frequency of events of greater magnitude seems to occur in a range of approximately 30 years, always in May, but for lack of documentary records from the period before 1983, it was decided to map only from 1983. It was noted during the period from 1983 to 2006 that the recurrence time ranges from 40 to 10 years for the events of greater magnitude and from 1 to 2 years for the events of lesser magnitude.

Floods of greater magnitude (Figure 2) usually occur between the months from May to July. Of these, three major floods occurred in May (1983, 1987 and 1992).

In 1983 there were two of the major floods in history, one in May and another in July, which reached the entire downtown area, where is located the center of trade and services, and also different neighborhoods at different points of the city. In July of this year it was registered the highest average precipitation: 487.9 (INMET / 8th District of Meteorology). The events of 1983 were compared by older residents as equal to that which occurred in early 1950 (photos 2 and 3).

Photo 2:03 - Flooding of the early 1950s (near 7 de Setembro Street, central area)
Source: Irati (2006).

The flood occurred in 1993 that also had large proportions was considered atypical, not by months of occurrence (in September) which is usually rainy, but by being accompanied by a big hailstorm, which caused an average accumulation of 60 cm of ice, reaching especially the city center and within the municipality. The material losses that occurred due to this phenomenon were immense, reaching 100% in some cultures, hundreds of homes lost their roofs, fall of gas stations covering, industrial sheds, among others (Folha de Irati Newspaper, 1993).

Due to the magnitude of the event (heavy rain with hail), there was still clogging of the storm drainage network of rivers and the river bus by debris, trash, sediment and by the hail itself, which, coupled with the subsequent melting of the ice, led to a great flood, increasing the losses and the number of homeless. According to the local press (Folha de Irati Newspaper, 1993), which covered the event, residents said in the same day (September 29, St Michael's Day), 30 years ago, the same event occurred.
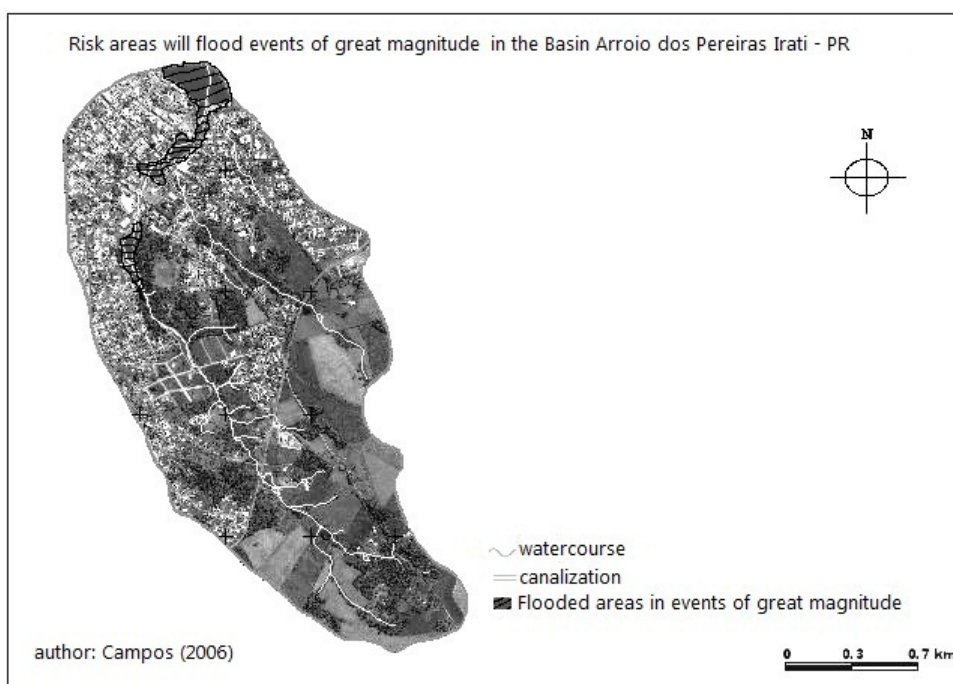
Figure 2 - Risk areas to flooding of great magnitude
Org: Campos, 2006.

Since 1993, there were few events of flooding occurred and documented: 01/2000, 01/2002 and 05/2004 (local press). These were of lesser magnitude in the urban area and no record in the Fire Department. The largest losses recorded from these events were concentrated in the rural area, with losses in agricultural production, but that go beyond this study area.

Structural works undertaken by the City Hall are related to reduction of the flooding frequency, although it is known the occurrence of a period of drier years, where the few episodes of more concentrated rain did not represent major risks, because the level of the river water was extremely low and the soil was very dry, with few points of flooding (Figure 3) concentrated just after the outfall of the canalization points.
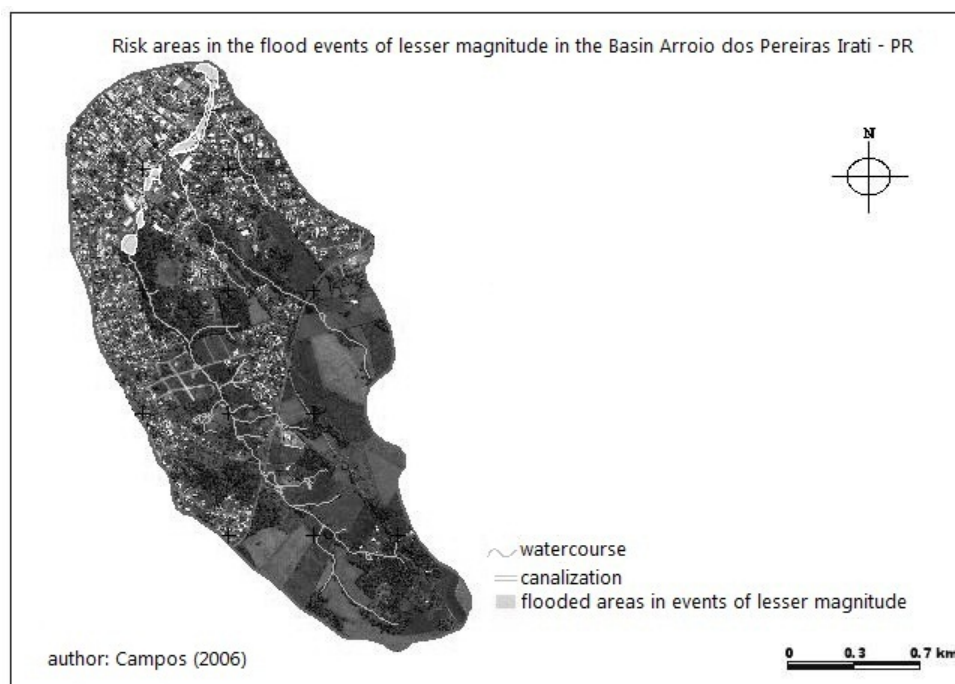
Figure 3 - Risk Areas to Flooding of lesser Magnitude
Org: Campos, 2006.

4. Discussion

All events covered in this survey were recorded by the City Hall, which enacted "emergency situation" for them, except the flood of 1983, where he was declared "State of Public Calamity."

Floods have constituted one of the main problems for urban managers, since the solutions are costly and difficult because permeate relationships of groups with different interests and occupations for the most ancient and well established, as in the case studied. Strategize in order to alleviate the population's vulnerability to these events is the great challenge that society must be willing, starting from the understanding of the operation of the physical system and how the changes made do interfere in their operation, creating risks not only to environment, but mainly to society.

In the areas of the hidrographical basin where the occupation is not yet consolidated, there is the possibility of seeking a rational use, as allocation of green areas for recreation, which could be used for infiltration, decreasing runoff and flood risk to downstream; non occupation of the areas around the watercourses, avoiding landfills and embankments, among others.

These are simple measures, but can effectively reduce the risk to flooding and a more harmonious relationship between man and environment.

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Ecological aspects of soils deflation development in agrolandscapes of the south-east of the western Siberian plain

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Abstract

The research of the modern processes during the cold season of the year (October-April) in the agrolandscapes of the south-western taiga area of the Western-Siberian plain has been done. The intensity of the aeol processes and the ecological and geochemical aspects of their development have been determined.

Keywords: Aeol processes, taiga (thick forest) area, agrolandscape

1. Introduction

Most researchers regard the taiga area of the Western-Siberian plain in the western part of Siberia as the region where modern aeol processes are not practically developing. A.N. Sazhin, Ju. I. Vasilyev (2003) consider the south-east of the taiga area of the plain to be the aeol material accumulation zone. The findings obtained by the authors hold good for the natural taiga landscapes of Western Siberia. Man's economic activities introduce a correction for the natural course of processes and stimulate a number of them as well as aeol processes. Our research done from 1985 to 2008 shows that the modern south-eastern taiga aeol processes may be classified according to their conditions, area, and the mechanism of their development.

Firstly, aeol processes are divided into natural and anthropogenic ones; secondly – they are categorized into global, regional and local ones; thirdly, they fall into destructive and accumulative ones.

Aeol processes do not play a great role in the relief formation of the taiga. They are represented by the near river mouth plain sand spit transfer, sand winding in uncovered places, terrace edges, flow hollows, water-shed plains as well as aeol material accumulation. The natural and anthropogenic aeol processes are well-developed in arable land areas, places of felling, oil and gas extraction zones and some other areas of economic activities.

Aeol dust accumulation carried by air flows over Eurasia should be called a global process. V.P. Chichagov (1999) gives examples of such a transfer. On the 5th of May 1993 in Shizunshan (China) there occurred a transfer of fine aerosol particles from the north-west of Siberia, Central Asia and the northern part of the New Land. On the 13th and the 14th of April 1994, Peking got the material which had been delivered from Poland, Scandinavia, the mouth of the Pechora-river, Western Siberia and Central Asia. The fine material was moving across Asia by means of the north-west transfer which was constant in time. The process developing in the Western Siberia area and those ones which are connected with air mass circulation over its territory refer to the regional aeol processes.

Very often they are represented by dusty storms coming to the investigated territory from Kazakhstan, Uzbekistan and the southern part of Western Siberia. The storm which occurred on 27th-28th of April 1968, may serve as an example. At that time clouds of dust hiding the Sun hung over Tomsk and the Tomsk region as well as the Novosibirsk region. The air was greatly saturated with the light dust which was evenly distributed over the surfaces of land and buildings (Tanzybaev, Slavnina, 1975). Clouds of dust in the south-east of Western Siberia are the remains of the black storm which occurred in plowing and virgin lands of Kazakhstan and the southern part of the Western-Siberian plain (the distance from Tselinograd to Tomsk is more

than 1000 km) The dust composition was made up of particles less than 0,25 mm in 87,4% cases and there were particles of 0,25-0,05 mm in size in 12,6% cases. According to some approximate data, about 20 mln tons of humus, about 1 mln of nitrogen, 240 th. tons of calium and more than 60 th. tons of phosphorus were carried to the territory of the Tomsk region together with dust.

The local aeol processes are those ones which develop in the range of landscape areas on the earth's surface (inter-river areas, terraces) which have no natural vegetation (plowland, felling sites, the areas of oil and gas extraction).

The aim of the present paper is to investigate the modern local aeol processes in the agrolandscapes which developed during the cold season of the year (October-April) from 1989 to 2008. The major factors of the aeol processes development of the investigated region have been considered by N.S. Evseeva, Z.N. Kvasnikova, N.V. Osintseva, T.V. Romashova, 2001; N.S. Evseeva, V.N. Slutsky, 2005 in their works.

2. Initial data and the methods of investigation

In order to reveal the intensity and the dynamics of the local aeol processes development the authors have done a great deal of work. They performed repeated microscale snow survey in the vicinity of the Luchanovo station in the Tom – Yaya interriver area from 1989-2008. They also made route observations, selected snow samples but of the snow thickness and its surface as well using the support profiles; they did a three-time snow water filtering. The authors also dealt with the drying and weighing of the solid sediment, analyzed the granulometric and chemical composition of the aeol deposits. There exist various techniques of determining deflation intensivity and accumulation. They determined the deflation intensity according to the formula stated by M.E. Belgibaev (1972):

$$h=V/S,$$

where h is the depth of soils blowing out, m; V – the volume of the material blown out, m^3; S – area of dust collection, m^2.

The aeol accumulation intensity was estimated according to the aeol deposits in snow as well as aeol particles accumulation per a unit of square. According to the method developed by E.M. Lyubtsova (1994) the accumulation of aeol particles is as follows: weak (less than 50 g/m^2), moderate (50-100 g/m^2), average (100-200 g/m^2), strong (200-500 g/m^2), very strong (500-1000 g/m^2).

3. Results

Aeol processes in agrolandscapes are divided into destructive and accumulative; and they are of an uneven and intermittent character. The destructive processes during the cold season of the year are represented by deflation having its centre development. Wind formed slopes of micro- and nano-relief elevations of a plowland as well as furrows in the process of deep autumn plowing are subjected to deflation. Researchers observe that the Siberian soil cover is vulnerable to strong winds because the soil agregate content which is less that 1 mm reaches 40-88%, i.e. it is characterized by a strong turning to dust process. The antideflation stability of grey wood and soddy-podzolic and ashen-gray plowland soil determined by G.A. Larionov technique (1993) is not mainly high, and it varies in the range of 24-57 and 10-49. Soil particles blown out of deflation centres are carried by winds over various distances and deposited on plowland snow surface, in shelterbelts located not far from the plowing areas.

Besides, fine particles which are carried by windy flows from other regions are accumulated in snow. According to some observations made from 2000-01, 2002-03, 2003-04 and 2004-05, their weak development was seen in 2005-06, 2006-07 (28%), and their average development occurred in 2007-08 (1%).

The average depth of soils blowing out varies from 0,1 mm up to 0,4 mm. The amount of aeol deposits accumulation during the observation period changed in the plowland from 2,5-2,7 g/m^2 (2005-06), up to 824 g/m^2 during the cold season of the year in 2002-2003.

In should be noted that in the cedar forest bordering on the Luchanovo area from the east less than 18,8 g/m^2 of fine grained soil was gathered in snow thickness during the first stage. In the season of snow melting the intensity of aeol processes is high and intermittent which is due to air and soil temperature change, wind velocity, snowfall, etc. Selecting samples from the snow surface using the centre profiles shows that a great amount of aeol material can be accumulated in plowland: from 0,83 g/m^2 to 224,5 g/m^2, and in the cedar forest – from 0,285 g/m^2 to 1,0 g/m^2. When strong snow storms occur, up to 236 g/m^2 of fine grained soil is gathered within twenty four hours. The granulometric composition of aeol deposits is varied enough but dusty particles prevail: dust-up to 90%, fine grained sand-up to 21%, silt – 30%.

Deflation and accumulation have a great effect on the ecological and geochemical processes in taiga agrolandscape territory. They cause the acceleration of natural and technogenic biophyle elements and humus migration, redistribution of the aeol material mass within a plowland and the near – by areas, accumulation of chemical elements and heavy metals as well. The macroelements essential to agricultural plants are removed and redistributed from deflation centres. Humus content in aeol deposits reaches 3,5%, N (nitrogen) up to 0,62%, P (phosphorus) – 0.56%, Cu (copper) – 95 g/t, Pb (plumbum = lead) – 16 g/t, Zn (zink) up to 68 g/t, Ba (barium) – 860 g/t, V (vanadium) – 146 g/t, etc.

The study of the modern aeol processes during the cold season of the year in the agrolandscapes of the south-eastern Western Siberian taiga zone has shown:

1). their development is of a cyclic character which may be well observed in the course of 2-3 or 5-6 summer cycles. From 1988-89, 2000-04 aeol processes were extremely active during the cold season of the year.

2). aeol processes in a plowland affect the fertility of soils changing its mechanical, physical and chemical properties.

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A regionally adaptable approach of landscape assessment using landscape metrics within the 2D cellular automaton "Pimp your landscape"

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Abstract:

We propose an easily applicable and regionally adaptable approach to quantify ecological functioning at landscape level using landscape metrics within the modified 2D cellular automaton Pimp your landscape. In addition to a basic evaluation of land use types, a consideration of landscape patterns is essential to evaluate ecological functions and services. Starting point of the here presented approach is the aggregation of land use types according to the degree of hemeroby. With regard to the concept of habitat connectivity, a cost- distance-procedure allows identifying functionally connected natural areas in a next step. Further indicators to assess ecological functioning were taken into account. Intensity of land use, habitat connectivity and habitat variety can be quantified using here presented set of metrics. We found that the assessment of landscape structure related ecosystem services requests a combination of landscape metrics on the one hand and scientific and normative assumptions on the other.

Keywords: landscape metrics, Pimp Your Landscape, biodiversity, habitat connectivity, landscape fragmentation

1. Introduction

Numerous adaptation strategies concerning effects of Climate Change on agriculture and forestry have been developed during the last decades (e.g. Rosenberg 1992; Molden 2007; Zomer et al. 2008; Allen et al. 2010). Also, various studies on effectiveness of such measures took place (e.g. Goria and Gambarelli 2004; Adger et al. 2007; Van den Berg and Feinstein 2009). Visualization tools that support integrated landscape planning are still rare. Therefore, the interactive planning tool Pimp Your Landscape was developed (Fuerst et al. 2008). It allows both, evaluation and visualization of land use scenarios. This web-based tool supports multi-criteria decision making and participatory processes in land use management at landscape level. It enables even the inexperienced user to design a landscape by mouse click. Basic information of land use classification is provided by the European wide available data set Corine Landcover 2000 (CLC 2000). To evaluate complex interactions between land use types (LUTs), it is necessary to divide the landscape continuum into spatially distinct units, which can interact and communicate. To reflect complex spatial interactions, a modified 2D cellular automaton with Moore-neighborhood was used as development basis for Pimp Your Landscape (Fuerst et al. 2008). So far, landscape structure related aspects of landscape ecology, such as habitat connectivity and landscape fragmentation cannot be appraised with the cellular automaton approach. In consequence, an evaluation procedure has to be developed to take landscape structure into account. Within Pimp Your Landscape, several ecosystem services are assessed

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such as economic wealth, ecological functioning and landscape aesthetics. Landscape evaluation is realized at two assessment levels. The first level (a) provides an indicator based evaluation of LUT- values with regard to each ecosystem service on a relative scale from 0 to 100. The relative scale addresses the problem to provide a basis for comparing changes of various ecosystem services, which each are expressed by different units and address different orders of magnitudes. Regarding cell values, the LUT-values are corrected by integrating cell specific attributes (soil, climate, topography) and the cell specific environment (neighbored LUT).

The here presented paper documents a second evaluation level (b). The assessment of landscape patterns using landscape metrics (LMs) will provide the possibility to correct the result achieved for the ecosystem service "ecological functioning" with regard to superior landscape structure aspects. Aim of our study is to develop a scientifically and normative based system facilitating quantification and assessment of the ecological functioning at landscape level.

2. Conceptual approach

For the usage of LMs as corrective for the ecological functioning of a landscape, relations between landscape mosaic, ecological processes and ecosystem services need to be identified. Landscape structure represents the interface between the land use that is influenced by natural and cultural compounds on the one hand and ecological and functional landscape properties on the other. Hence, quantification of landscape structure considering composition and configuration of patches is of fundamental importance for an assessment of ecosystem services (Zebisch et al. 2004).

LMs can be calculated at three spatial levels: patch level, class level and landscape level (McGarigal and Marks 1995). To ensure an adequate quantification of the considered processes, we mainly referred to class level. An aggregation of LUTs provides not only a spatial but also a functional reference. This classification approach implies three functional groups:

(a) unsealed open space, e.g. Agricultural areas, Forest and semi natural areas, Wetlands;

(b) sealed areas, e.g. artificial areas, streets, rail tracks;

(c) degree of hemeroby.

Especially (c) is of importance because it considers function aspects of the landscape structure. Six degrees of hemeroby are distinguished (Table 1). Each LUT was assigned to one degree of hemeroby. Additionally, a superior aggregation into "natural" and "not natural" LUTs became necessary to assess certain ecological parameters such as habitat connectivity. As no "ahemerobe" LUTs are located in Europe (Steinhardt et al. 1999), this hemeroby class was not considered for calculations.

Table 1: Classification of the human impact on ecosystems and the according degree of hemeroby and naturalness (Blume and Sukopp 1976 -modified)

LMs describing the intensity of land use and the habitat connectivity, which are two of three main evaluation parameters, are based on the hemeroby classification. The degree of hemeroby is used for the Hemeroby Index. Habitat connectivity is based on the sub-classification into "natural" and "not natural" LUTs. The third main indicator, biodiversity, is based on two indices measuring the spatial diversity of a landscape. Figure 1 gives an overview of LMs, indicators and main indicators that are used to evaluate the ecological functioning.

Figure 1: Hierarchical assessment scheme for the ecosystem service "ecological functioning"

3. Assessment of the ecological value

Figure 1 highlightens that intensity of land use, habitat connectivity and biodiversity are used as main factors for evaluating the effect of the landscape structure on ecological functioning. Intensity of land use and biodiversity are integrated into the evaluation by the use of "ecological

linking matrices" that allow for combining various LMs including their mutual impact (Bastian and Schreiber 1999). Figure 2 illustrates the methodological approach. Values of the considered LMs are assigned to five classes. "Hemeroby" that quantifies the degree of naturalness is one factor for the determination of the intensity of land use (left part of Figure 2). For the investigation of the second factor "landscape fragmentation", two LMs get interlinked. The Effective Mesh Size (M_{eff}) is a LM measuring the mean area of unsealed open area. A linkage with the Total Core Area of natural LUTs yields a value of "landscape fragmentation" (right part of Figure 2). The final value of the "Intensity of Land Use" can then be read off the linking matrix (bottom part of Figure 2).

Figure 2: Exemplary application of ecological linking matrices for assessing the intensity of land use

For calculating intensity of land use and biodiversity, the same procedure is applied. For considering different aspects of biodiversity at landscape level we considered two spatial aspects. Shannon's Diversity Index (SHDI) that reflects the compositional component (number of patch types) as well as the structural component (distribution of classes) of landscapes, was taken into account. Additionally, in order to quantify the spatial configuration of patch types, the Interspersion and Juxtaposition Index (IJI) was chosen. Interlinking these two indices within a linking matrix, statements on the variety of habitats can be made. For quantifying the third factor habitat connectivity, the Cost Distance Method is used. This method allows measuring functional connectivity of "natural" habitats (Zebisch et al. 2004). The basic assumption is that "ecological costs" increase with increasing degree of hemeroby of raster cells that need to be crossed for reaching other natural areas. The Moving-Window-method was then applied to identify natural areas that might serve as "stepping stones" between core areas. The value of habitat connectivity ranges from -10 to 10 in 5-point-steps (Table 2).

Table 2: Evaluation of the habitat connectivity

The normative background, which sets thresholds of LMs beyond expert knowledge, is given by German laws and strategies (e.g. BMU 2007; BNatSchG 2010). Thresholds were set following development targets. For example the degree of habitat connectivity mandatory shall be at least 10 % (§20(1) BNatSchG 2010). As ecologists criticize this value being too low (SRU 2000; Krüsemann 2006), a positive evaluation starts at a percentage of >15 % of habitat connectivity. Summarizing the results of all three factors gives the figure to which the preliminarily calculated value for ecological functioning in Pimp Your Landscape should be increased or reduced. It ranges from - 30 to + 30. Due to the relative evaluation scale of 0 to 100, the impact of LMs as superior evaluation tool within Pimp Your Landscape is estimated to be significant.

4. Conclusion and outlook

Concerning landscape panning, LMs within Pimp Your Landscape provide an assessment tool for the evaluation of functions and services that cannot easily be determined. The combination of ecological linking matrices and traits of an additive model provided the possibility to aggregate a large number of landscape characteristics to correct one macro-indicator (ecological functioning). The here presented evaluation approach provides theoretical background for further evaluation criteria such as aesthetics, water quality and economical wealth. For complex methods evaluating the functionality of landscapes not only LMs but also further information is necessary (Lang et al. 2009). Hence, besides a purely quantitative analysis of LMs, scientific findings such as degrees of hemeroby are essential to make basic assumptions. Employing LMs without any assumptions and restrictions would risk misinterpretations (Fortin et al. 2003). An additional measure to avoid misinterpretations is the usage of sets of LMs(Lausch and Herzog 2002; Cushman et al. 2008). Due to local developed landscape characteristics, employing only one LM could lead to an over- and under-estimation of determined characteristics.

Table 3: Classification of the human impact on ecosystems and the according degree of hemeroby and naturalness (Blume and Sukopp 1976 -modified)

Hemeroby/ degree of naturalness	Human impact	CORINE- Landcover 2000	
Ahemerobe/ natural	None	-	"natural"
Oligohemerobe/ close to natural	Very sparsely populated areas	e.g. Moors and heathland, Peat bogs	
Mesohemerobe/ semi-natural	Sparsely populated cultural landscapes	e.g. Complex cultivation patterns, Natural grasslands	
Euhemerobe/ far from natural	Agricultural landscapes, settlements	e.g. Non-irrigated arable land, Vineyards	"not natural"
Polyhemerobe/ strange to nature	Partly built-up areas, dump sites	e.g. Discontinuous urban fabric, Dump sites	
Metahemerobe/ artificial	Biocenosis widely destroyed, inner-cities, industrial facilities	e.g. Industrial or commercial units, Road and rail networks and associated land	
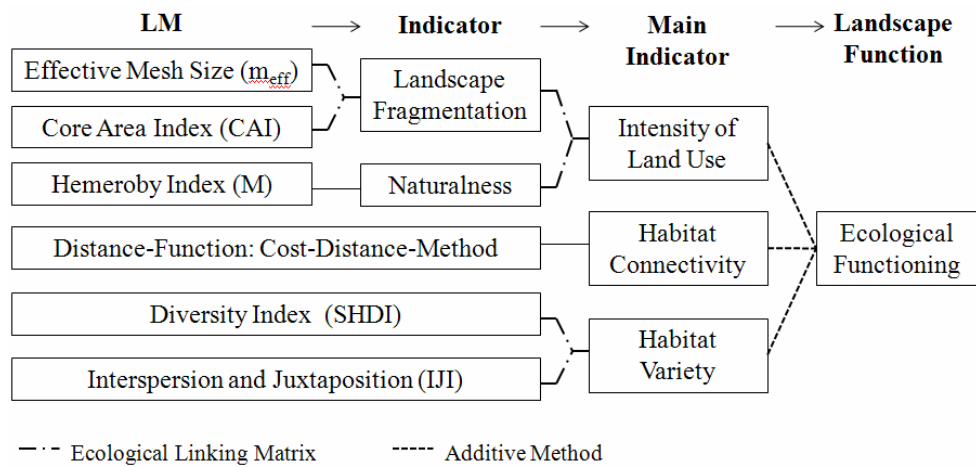
Figure 1: Hierarchical assessment scheme for the ecosystem service "ecological functioning"

Hemeroby Index	Valuation
20 - 36	10
37 - 52	5
53 - 68	0
68 - 84	-5
85 - 100	-10

Landscape Fragmentation		Total Core Area of "natural" Patches (Buffer 100 m) [km²]				
		0 - 2	>2 – 5	>5 - 10	>10 - 15	>15
M_{eff} un-sealed area [km²]	0 – 1	-10	-10	-10	-5	0
	>1 – 2,5	-10	-5	-5	0	5
	>2,5 – 5	-10	-5	0	5	10
	>5 – 10	-5	0	5	5	10
	>10	0	5	10	10	10

Intensity of Land Use		Landscape Fragmentation				
		-10	-5	0	5	10
Hemeroby	-10	-10	-10	-10	-5	0
	-5	-10	-5	-5	0	5
	0	-10	-5	0	5	10
	5	-5	0	5	5	10
	10	0	5	10	10	10

Figure 2: Exemplary application of ecological linking matrices for assessing the intensity of land use

Table 4: Evaluation of the habitat connectivity

Habitat connectivity [%]	Evaluation
0 - 5	-10
5 - 10	-5
10 – 15	0
15 – 20	5
> 20	10

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The effect of land cover changes (1960's-2003) on the habitat morphological spatial pattern and population viability of Baird's tapir in Laguna Lachuá National Park Influence Zone, Guatemala

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Abstract

The current anthropogenic morphological spatial patterns (MSP) of forests usually are not suitable for large mammals such as Baird's tapir, the largest terrestrial mammal in the Neotropics. We intended to evaluate how changes in MSP affected the population viability (PV) of this species. Using land cover images we determined the MSP in different years using software GUIDOS. PV was modeled using software VORTEX. The species habitat reduced from approximately 95% to 46% of the study area. From 1960 to 1983 the majority of the area was core with a few perforations. In 1991 more than the 50% of the core was loss, since then, the reduction of corridors, islets and branches, increased the isolation of the park. The PV changed from 0% to 80% probability of extinction. Results show that habitat modification has accelerated the extinction process. Redirect this tendency is a challenge to land use planning and wildlife conservation.

Keywords: spatial pattern population viability Tapir

1. Introduction

Human activities have modified morphological spatial patterns of natural ecosystems causing great impacts in wildlife (Cuarón, 2000, McCullough, 1996, Escamilla *et al*., 2000). One of the most common disturbances in tropical lowlands at northeastern Guatemala is the transformation of tropical forest for livestock and currently Oil palm plantations, causing habitat reduction and fragmentation, as well as its degradation. Large mammals are especially susceptible to habitat reduction and fragmentation (Kinnaird *et al*., 2003). Baird's tapir is the largest native terrestrial mammal in the Neotropics, including Guatemala, with a body size of 2 meter long, 1.5 meters height and a body weight of 100 to 350 kilograms (Emmons, 1990). We intended to evaluate how changes in land cover from 1960s to 2000s have affected the population viability of this species.

2. Methodology

2.1 Study area
The study area was the Laguna Lachuá National Park's (LLNP) influence zone. The LLNP is a 14.5 square kilometers protected area in the north of Guatemala surrounded by rural communities, mainly Mayan Kekchí, and also big farms. It is traversed by a road known as

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"Franja Transversal del Norte" (Northern Transversal Strip) an area of rural development driven by the Government in the 60s and renovated at present by Oil palm plantations.

2.2 Habitat and Population Viability analyses for Baird's tapir

We obtained digital data of the land cover for the years 1960s, 1983, 1991, 2001 and 2003. The 1960s map was digitalized by García *et al.*, (2009) from a printed map, the 1991 and 2001 layers were obtained at the Forests National Institute (INAB) GIS database and the 2003 from the Ministry of agriculture, livestock and food (MAGA, 2006). All maps were transformed to raster format with a 500 square meters pixel resolution.

2.2.1 Morphological Spatial Pattern Analysis (MSPA)

We analyzed the Baird's tapir habitat in the study area according to García *et al.*, (2009), using the sofware GUIDOS (Vogt *et al.*, 2007; Soille and Vogt, 2009). We delimited the minimum square that includes the LLNP and the nearest protected areas which are currently the forest remnants. We used this quadrangle as study area for MSPA. The MSP for each year was determined.

2.2.2 Population Viability Analysis

The population viability (PV) was modeled using the software VORTEX (Lacy, Borbat, and Pollak, 2005). VORTEX is an individual-based simulation model for PV analysis. The program requires information about the species reproductive system and rates (Miller and Lacy, 2005), we used the data generated during the PV Analysis workshop for Baird's tapir organized by the Tapir specialist group held in Belize 2005, and modified it with the advice of Arnaud Desbiez and Patricia Medici from the Conservation Breeding Specialist Group from the IUCN. For each year, we determined the area of the forest remnant that includes the LLNP, and estimated the population of tapirs using the parameters used by García *et al.,* 2010. Threats as hunting and carrying capacity reduction were not included to evaluate the effect of the habitat MSP. A model for each year was run using a time line of 100 years and 100 interactions.

3. Result

From the MSPA, changes are dramatic, especially from 1983 to 1991 (see Table 1 and Figure 1). In 1960s the 90% of the area was core forest, in 1983 perforations increased to a 4.5% of the area, leading to major change to 1991 with only 16.6% of the area covered by core forest. During this period of time most of the non-core remaining forest was changed to structures such as bridges. In 1991 there are almost no perforations left, and the edge was increased. From 1991 to 2003 the core forest remained almost with the same area, but bridges and branches were constantly declining. Islets at first increased in number but then also decreased which indicates the total destruction of forest remnants outside the protected area.

For the PV Analysis, changes are related to MSP, which changed dramatically since 1983 (see Figure 2). From 1960 to 1983 due all the area was suitable habitat, is expected that existed a continuous population of tapirs including areas of Chiapas in México and southern Petén through Sayaxche and La Pasión river in Guatemala. This population exceeded the 1,000 individuals, and the resulting model showed to be and viable population with 0% probability of

extinction. In 1991 the PV dropped from a initial population of almost 50 individuals with 95% probability of extinction. At 2003, is estimated to have a population of 15 individuals with a high probability of extinction over the next 100 years.

4. Discussion

There exists a direct influence of MSP on PV due it determines the population size; both are useful tools for landscape planning (Beissinger, Nicholson, and Possingham, 2009). The results may show how MSP modifications that occurred in the study area accelerated the natural extinction process of this species. In the 1960s the population viability had a 100% probability of surviving in the next 100 years, and this was changed when the habitat was transformed.

Currently the remaining population is too small to be viable in the next 100 years, this shows that the protected area is too small to retain a Tapirs viable population. The fact that the protected area is too small is a mayor challenge to conservation managers because the influence zone must be also managed and re-ordered in order to increase the PV of large species as Baird's tapir. Current pressures such as forest reduction by livestock and Oil palm plantations increases this challenge.

Management should be directed in reverting the land cover change process, increasing core forest areas and connectivity. Species such as Baird's tapir may be used to design habitat restoration plans that conduce to future MSP that increases the species PV.

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Table 1: MSPA parameters and their proportion in the study area. Source: Authors

MSPA parameter	% of extencion of study area				
	1960s	1983	1991	2001	2003
Core	90.39	86.68	16.58	12.07	13.57
Islet	0	0.01	5.82	6.36	4.09
Perforation	2.57	4.54	0.62	0.34	0.21
Edge	1.61	1.56	3.99	3.36	4.22
Loop	0.4	0.73	1.5	1.35	2.35
Bridge	0.31	0.53	33.96	31.9	18.34
Branch	0.18	0.78	5.05	4.96	3.5
Background	4.54	5.17	32.49	39.67	53.71
Total	100.00	100.00	100.00	100.00	100.00
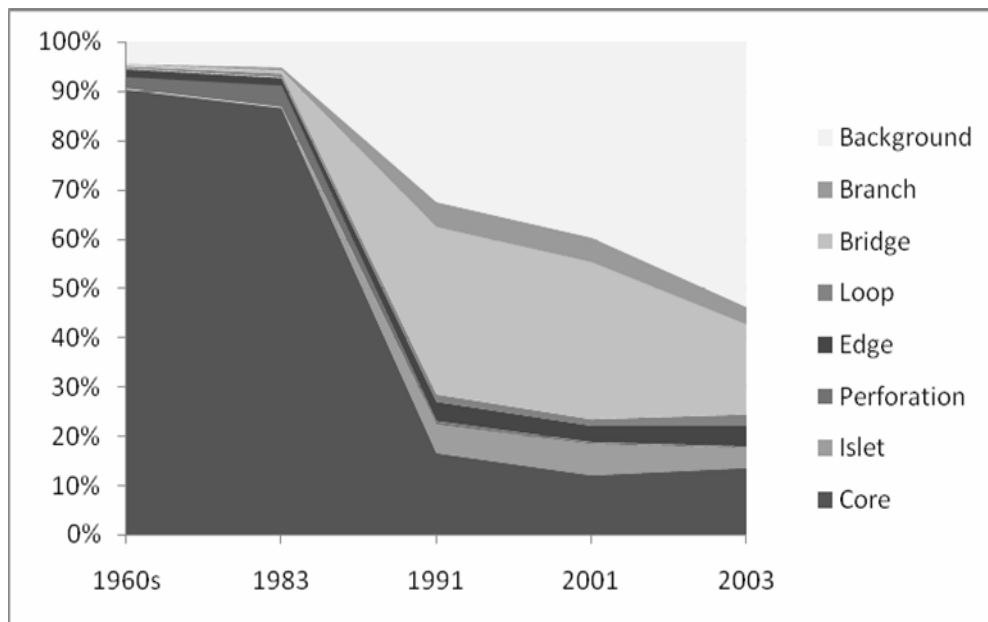
Figure 1: Morphological Spatial Pattern Analysis parameters and their proportion in the study area from 1960s to 2003. Source: Authors
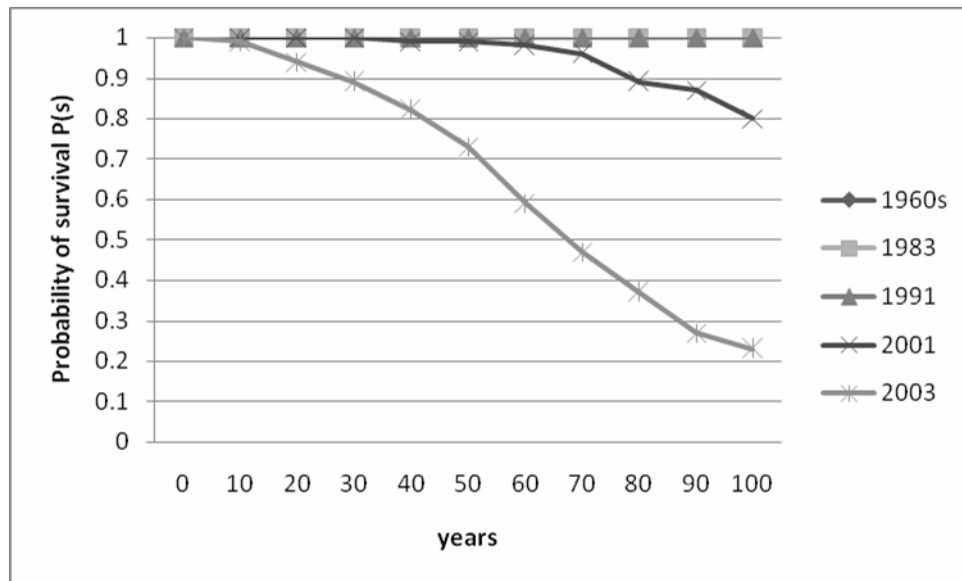
Figure 2: Population viability showing the probability of surviving over the next 100 years for different models corresponding to the years 1960s, 1983, 1991, 2001 and 2003. Source: Authors

Spatial pattern of soil macrofauna biodiversity in wildlife refugee of Karkhe in Southwestern Iran

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Abstract

Information about the spatial patterns of soil biodiversity is limited though required, e.g. for understanding effects of biodiversity on ecosystem processes. This study was conducted to determine whether soil macrofauna biodiversity parameters display spatial patterns in the riparian forest landscape of Karkhe, southwestern Iran. Soil macrofauna were sampled in 2009 using 200 sampling point along parallel transects (perpendicular to the river). Maximum distance between samples was 0.5 km. Soil macrofauna were extracted from 50 cm×50 cm×25 cm soil monolith by hand-sorting procedure. Abundance and Shannon H' index were analyzed using geostatistics (variogram) in order to describe and quantify the spatial continuity. The variograms were spherical and revealed the presence of spatial autocorrelation. The range of influence was 1724 m for abundance and 1326 m for diversity. The variograms featured high ratio of nugget variance to sill. This showed that there was the small-scale variability and proportion of unexplained variance.

Keywords: Biodiversity, Soil macrofauna, Spatial pattern, Variogram

1. Introduction

In the last 15-20 years, riparian forests have become recognized as important components of landscape and serve as a vital link between the aquatic environment and upland ecosystems (Giese et al. 2000). Riparian ecosystems are aquatic-terrestrial ecotones with unique biotic, biophysical and landscape characteristics (Lyon and Gross 2005). Accordingly, sustainability and maintenance of riparian vegetation or restoring of degraded sites is critical to sustain inherent ecosystem function and values (Giese et al. 2000). Many scientists believe promoting sustainability is the overarching goal of landscape (and regional) planning, (Leitao and Ahern 2002).

A current challenge in ecology is underestimating how patterns and processes vary with scale and searching for general principles (assembly rules) which determine the species composition of communities (Guillaume 2002). Also a fundamental and unanswered research question in landscape ecology centers on how the spatial arrangement of the ecosystems influences the distribution and abundance of organisms (Coulson et al. 1999). Description of patterns in species assemblages and diversity is an essential step before generating hypotheses in functional ecology (Guillaume 2002).

If we want to have information about ecosystem function, soil biodiversity is best considered by focusing on the groups of soil organisms that play major roles in ecosystem functioning when exploring links with provision of ecosystem services (Barrios 2007). Information about the

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spatial pattern of soil biodiversity at the regional scale is limited though required, e.g. for understanding regional scale effects of biodiversity on ecosystem processes (Joschko et.al. 2006). The practical consequences of these findings are useful for sustainable management of soils and in monitoring soil quality. Soil macrofauna play significant, but largely ignored, roles in the delivery of ecosystem services by soils at plot and landscape Scales (Lavelle et.al. 2006). One main reason responsible for the absence of information about biodiversity at regional scale, is the lack of adequate methods for sampling and analyzing data at this dimension. An adequate approach for the analysis of spatial patterns is a transect study in which samples are taken in a certain order and with a certain distance between samples (Joschko et.al. 2006). Geostatistics provide descriptive tools such as variogram to characterize the spatial pattern of continuous and categorical soil attributes (Goovaerts 1999; Gringarten and Deutsch 2001; Mohammadi 2006). This method allows assessment of consistency of spatial patterns as well as the scale at which they are expressed (Jimenez et al. 2001).

The aim of this study is to analyze spatial patterns of soil macrofauna (= invertebrates visible at the naked eye) in Wildlife Refugee of Karkhe in the riparian forest of the southwestern Iran. Parameters of soil macrofauna biodiversity comprise: abundance (total abundance of macrofauna), and diversity.

2. Methodology

The study was carried out in Wildlife Refugee of Karkhe in the riparian forest of the southwestern Iran (31° 57/- 32° 05/ N and 48° 13/- 48° 16/ E). The climate of the study area is semi-arid. Average yearly rainfall is about 325.5 mm with a mean temperature of 24^{oc}. Plant cover, mainly comprises *Populus euphratica* and *Tamarix sp.*

The both sides of river are similar, so we sampled on one of the two sides. Soil macrofauna were sampled in 2009 using 200 sampling point along parallel transects (perpendicular to the river). The distance between transects were 0.5 km. The sampling procedure was hierarchically, we considered maximum distance between samples as 0.5 km, but the samples was taken at 250m, 100m, 50m, 20m, 15m, 10m, 5m, 2m and 1m at different location of sampling.

soil macrofauna (= invertebrates visible at the naked eye) was extracted from 50 cm×50 cm×25 cm soil monolith by hand-sorting procedure at the last winter (because at this time moisture and temperature are suitable and soil macrofauna reach their highest abundance). All soil macrofauna were identified to family level.

Number of animals (abundance) and diversity (Shannon H' index) by using PAST version 1.39, were determined in each sample. Classical statistical parameters, i.e. mean, standard deviation, coefficient of variation, minimum and maximum, were calculated using SPSS17 software. Diversity and abundance data were analyzed using geostatistics (variogram) in order to describe and quantify the spatial continuity. Geostatistical analysis was performed using the software Variowin 2.2 (variograms). Spatial distribution maps were made by block kriging using the software Geoease and Surfer 8.0.

3. Result

Soil macrofauna communities were dominated by earthworm, diplopods, coleoptera, gastropoda, araneae, and insect larvae, reaching an abundance of 43.1 individuals / m^2.

Table 1 shows the mean, standard deviation, coefficient of variation, minimum and maximum values for soil macrofauna abundance and diversity.

The variograms revealed the presence of spatial autocorrelation Fig. 1. The parameters of the theoretical models fitted to experimental variograms are given in Table 2. The variograms of two indices were spherical and showed positive nugget, which can be explained by sampling error, short range variability, random and inherent variability. The nugget-to-sill ratio can be

used to classify the spatial dependence of soil properties. In this study we used similar criteria to those reported by Sun et al., (2003). The variable is considered to have a strong spatial dependence if the ratio is less than 25%, and has a moderate spatial dependence if the ratio is between 25% and 75%; otherwise, the variable has a weak spatial dependence.

Soil macrofauna abundance and diversity were moderately spatially dependent (Table 2). The range of influence is considered as the distance beyond which observations are not spatially dependent. This distance ranged from 1326 m for soil macrofauna diversity to 1724 m for abundance (Table 2).

The maps obtained by kriging for soil macrofauna abundance and diversity are shown in Fig. 2.

Table 1. Mean, standard deviation (S.D.), coefficient of variation (CV), minimum and maximum values of for soil macrofauna abundance and diversity

Index	mean	S. D	C.V (%)	minimum	maximum
Abundance (indiv. m^{-2})	43.1	73.9	171	0	480
Shannon (H')	0.55	0.51	92	0	1.9

Table2. Variogram model parameters for soil macrofauna abundance and diversity

Index	Model	Sill	Nugget	Nugget/ Sill (%)	Range(m)
abundance	spherical	1.13	0.59	52	1724
Shannon (H')	spherical	0.27	0.153	55	1326

(A)   (B)
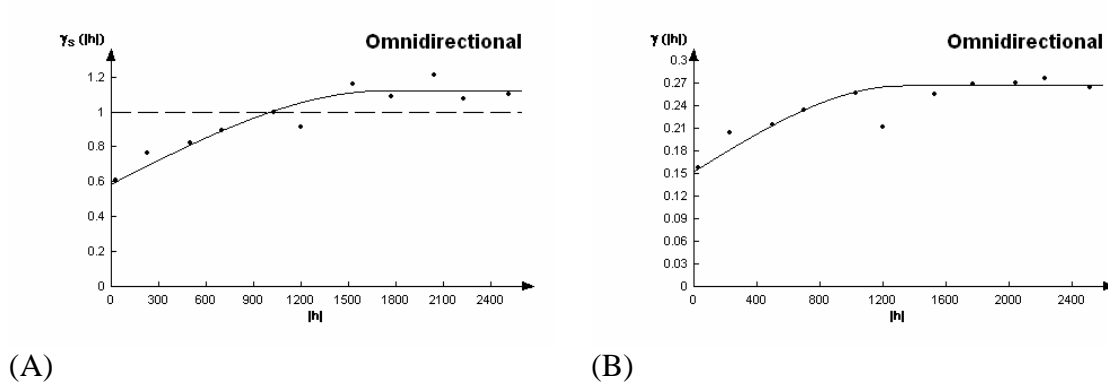
Fig.1. Variograms of (A) Log transformed data for soil macrofauna abundance and (B) soil macrofauna diversity
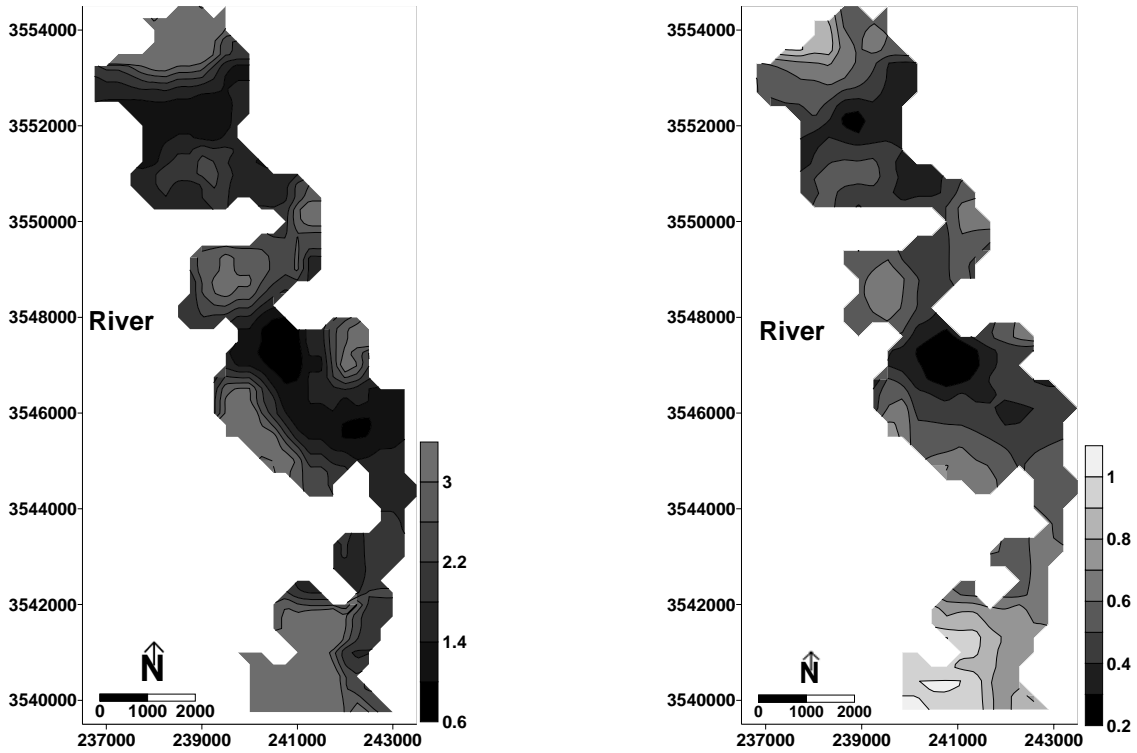
Fig.2. Distribution of soil macrofauna diversity: A – Abundance, B –Shannon H index

4. Discussion

This study showed that soil macrofauna abundance and diversity were spatially autocorrelated within the range of 1519 and 1937 meters. In line with our result Gongalski et.al., (2008) reported the spatial autocorrelation for soil macrofauna abundance and diversity in Mediteranean forest in Russia.

Typically these structures constitute one source of the nugget variance of the variograms (Rossi, 2003). However, the variograms reported here featured a somewhat high ratio of nugget variance to sill (Table 2). This result showed that there was the small-scale variability and important proportion of unexplained variance (Rossi, 2003, Gongalski et.al., 2008,).

Spatial distribution of soil macrofauna at large scales may be influenced by factors like gradients in soil organic matter (quantity and or quality), texture and vegetation cover structure (Ettema & Wardle 2002). These factors together with intrinsic population processes constitute proximate controlling factors of population structure (Rossi, 2003).

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The influence of spatial structure on natural regeneration and biodiversity in Mediterranean pine plantations: a nested landscape approach

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Abstract

Promoting plant diversity in plantations is a worldwide concern. This research aimed to evaluate the effect of the spatial configuration of Mediterranean pine plantations on regeneration and plant diversity in order to facilitate management decisions. Spatial characteristics of pine plantation patches at landscape scale (distances to other vegetation types) and at patch scale (patch geometry and internal structure) were related to abundance of *Quercus ilex* seedlings and the Shannon diversity index of plant species. Results showed that *Q. ilex* regeneration and plant diversity are affected by the spatial configuration. (1) Proximity to oak patches favoured abundance of *Q. ilex* seedlings and plant diversity. (2) Patch geometry affected plant diversity, with larger patches having less diversity. (3) Internal structure influenced both regeneration of *Q. ilex* and diversity. More heterogeneous areas were characterized by higher diversity and less abundant oak regeneration suggesting that some species show different response to microhabitat heterogeneity.

Keywords: fragmentation; texture; context; geometry; spatial configuration

1. Introduction

Pine plantations cover a large extent in the Mediterranean basin, representing ca. 12% of the total forest cover (FAO 2006). A large extent of these plantations is the result of reforestation programs, carried out since the 19th century (Pausas et al. 2004). Current management trends are based on the multifunctionality of these plantations considering not only the original protective and productive functions but also other factors such as biodiversity or recreation (Brockerhoff et al. 2008). To facilitate plantation management towards mixed stands it is necessary to understand which factors affect natural regeneration and plant diversity. One of these influencing factors is the spatial pattern of pine plantations at different scales (Lookingbill and Zavala 2000) For instance, pine plantation patches can be found in an heterogeneous mosaic of different vegetation types that will influence their dynamic and ecological characteristics. This effect at landscape scale could be assessed by two aspects: vegetation context and patch geometry.

Vegetation context is the relation among plantation patches and other vegetation types. Proximity to specific vegetation types will facilitate propagules exchange (White et al. 2004).

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However, proximity relations could be complicated considering the relief. Mountain areas are anisotropic surfaces where the downhill dispersal of propagules will be easier due to the direct effect of gravity (Ohsawa et al. 2007) or because animal dispersal vectors move downhill in order to save energy (Li and Zhang 2003). Patch geometry considers the shape or area of patches and the effect that those characteristics could have on internal patch dynamics. Patch geometry determines the edge effect (Turner, Gardner, and O'Neill 2001). The edge has drier conditions, with more light and it receives the visit of open habitat species. These differences influence species composition and thus biodiversity and probability of propagules arrival. Turner et al., (2001: 3) defines landscape as *an area that is spatially heterogeneous in at least one factor of interest.* This heterogeneity, can be observed at different scales. Thus, given a landscape with a determined scale, it is possible to identify mosaics of patches within patches. This nested model of mosaics is important to understand the ecological processes because it implies that the spatial configuration of mosaics at different scales are interconnected. Therefore, not only the vegetation context and patch geometry will affect the performance of recruitment of species but also the mosaic of microhabitats within plantation patches (i.e. internal vegetation structure). This structural diversity can be obtained from texture analysis of high resolution imagery (Hepinstall and Sader 1997; St-Louis et al. 2006). Texture is the spatial distribution of different gray-levels in the same band of the image (Haralick, Shanmugam, and Dinstein 1973). Considering that each gray-level is the spectral response to a specific vegetation type or microhabitat, the analysis of the spatial combination of gray-levels can give valuable information about the spatial structure. This type of analysis can be done applying the Gray Level Co-occurrence Matrix (GLCM) developed by (Haralick, Shanmugam, and Dinstein 1973). This method gives the probability that two pixels in the same image window have same tone in a given distance and direction.

In a previous research in the same study area we evaluated the effect of several environmental gradients (climate, distance to oak vegetation and stand density) on biodiversity and plant regeneration of pine plantations (Gómez-Aparicio et al., 2009). Here our objective was to evaluate specifically the effect of the spatial configuration of pine plantations on tree regeneration and plant diversity at different scales. Specifically we asked how is natural regeneration and plant diversity of different species within plantation patches related at landscape scale to the vegetation context of pine plantation patches (proximity to seed source) and plantation patch geometry (area and patch shape complexity) and at patch scale to the internal structural diversity of pine plantations patches

2. Methodology

2.1 Study site

Sierra Nevada National Park (Southeast Spain) is a mountain region with an altitudinal range between 860 m and 3482 m. It has an extension of more than 2000 Km^2, and a main length of 90 Km. Annual average temperature decreases in altitude from 12-16 ºC bellow 1500 m to 0 ºC above 3000 m. Precipitation is scarce in summer, while the winter precipitation is mainly in form of snow over 2000 m. The average annual precipitation oscillates from less than 250 mm in the lowest and Eastern part of the mountain, to more than 700 mm in the highest peaks.

2.2 Dataset

Regeneration and plant diversity variables were obtained from the Forest Inventory of Sierra Nevada National Park collected during 2004-2005 (SINFONEVADA). 275 inventory plots within pine plantation were selected for the analysis covering a gradient from 974 to 2439 m a.s.l. Plot size ranged from 300 to 400 m^2. Two additional subplots were established within each

larger plot: a 5-m radius circle to measure the number of saplings (DBH = 2.5-7.5 cm) and seedlings (DBH < 2.5 and height < 1.3 m) of tree species, and a 10-m radius plot to measure the species composition and abundance by the Braun-Blanquet cover-abundance scale. Regeneration within pine plantations was measured as seedling abundance. The species considered in the analysis was *Quercus ilex* subsp. *ballota* (Desf.) Samp. *(Q. ilex).* Other major species were not considered due to their low abundance in the inventory. Saplings were not considered, since oak saplings could have been established before the establishment of the pine plantation, and pine "saplings" could be suppressed old planted individuals. Plant diversity was measured using the Shannon diversity index for the total of species and considering only herbaceous species, only flesh-fruited woody species or only dry-fruited woody species. The distinction among woody species was considered in order to account the differences in dispersal syndrome. Flesh-fruited woody species usually have endozoochorous syndromes whilst rest of species can have other syndromes such as exozoochorous or anemochorous. This distinction was not made for herbaceous species because most of them (> 95 %) have dry fruits and abiotic dispersal.

A simplification of the forest vegetation map of Andalusia 1:10 000 (CMA 2001) was used to identify pine plantation areas and calculate patch geometry and vegetation context variables. The different vegetation classes used were selected according to their possible contribution to regeneration and plant diversity in pine plantations. The vegetation classes considered were: (1) pine plantation (> 50 % tree cover and > 75% conifers), (2) Oak and broadleaved species (> 5 % tree cover and oak presence), (3) shrublands (< 5 % tree cover, > 20 % shrub cover and <1800 m a.s.l.), (4) riparian vegetation and (5) agricultural fields.

2.3 Analysis

2.3.1 Vegetation context and internal structure

The vegetation context of each inventory plot was calculated obtaining the distance to the different vegetation classes considered above using ArcGIS 9.2 (ESRI Inc., Redlands, USA). Three different distance algorithms were used: Euclidean neighbouring distance and weighted neighbouring distance favouring downhill or uphill movements. The weighted neighbouring distance was applied to consider the anisotropic surface of the relief through a cost surface (slope) based on the Digital Elevation Model (DEM) of Andalusia (ICA 2005). It was calculated multiplying the Euclidean distance by a factor between 0 and 1 depending on the sign and degree of the slope. The internal structure was quantified from texture analysis of orthophoto imagery in black and white of resolution 0.5 m and obtained in 2001 (ICA 2004). The calculations were done with GRASS 6.3.0 (OSGF) and the module r.le 5.0 (Baker 2001). The analysis was run for each inventory plot in a radius of 20 m from centre point and considering eight neighbouring cells to calculate the adjacencies of the GLCM. Two texture indices based on the GLCM were selected according to their common use in landscape ecology to estimate heterogeneity: *entropy* and *contrast.* Both were positively correlated (R=0.66, *P*<0.001, n=275). Context and internal structure variables for each inventory plot considered (n=275) were related to regeneration and plant diversity variables using correlation analysis.

2.3.2 Patch geometry

Isolated plantation patches were selected and used to calculate area and shape index (Hill and Curran 2003) (n = 11). The criteria for selection were clear isolation to delimit edges and enough inventory plots with a good distribution within the patch. The selected patches cover the whole range of the study area. Geometry variables were related to regeneration and plant

diversity variables using correlation analyses. Regeneration and plant diversity were calculated as the average of the values of all inventory plots within each patch.

3. Results

3.1 Vegetation context

Plant diversity declined with increasing distances to oak vegetation, riparian vegetation and shrubland (Table 1). However, proximity to riparian vegetation was not influencing herbaceous diversity. Surprisingly, the diversity index for flesh-fruited woody species had significant positive relationship to distance to agriculture fields. Considering distance to oak, shrubland and riparian vegetation, the algorithm favouring downhill dispersion had higher correlation strength than the others (weighted downhill > Euclidean > weighted uphill). In contrast to plant diversity indices, seedling abundance of *Q. ilex* showed only a strong negative relationship to distances to oak (Table 1). Abundance of *Q. ilex* seedlings showed also similar pattern of differences among algorithms than plant diversity indices (Euclidean = weighted downhill < weighted uphill).

3.2 Patch geometry

Patch area showed negative relationship with Shannon diversity index for all species (ρ=-0.59, *P*=0.05), herbaceous species (ρ=-0.60, *P*=0.05), and woody species although the latter relationship was not significant. Shape index did not correlate significantly with any of the Shannon diversity indices. Abundance of *Q. ilex* seedlings did not present significant relation with any of the geometry variables considered, although there was a positive trend with shape index (ρ=0.13, *P*<0.6) and a negative trend with patch area (ρ=-0.19, *P*<0.7).

3.3 Internal structure

Shannon diversity indices for all species, herbaceous species and dry-fruited woody species were directly correlated with heterogeneity measured in both *entropy* and *contrast* (Table 1). Shannon diversity index of flesh-fruited woody species and abundance of *Q. ilex* did not show significant correlation with internal structure (Table 1).

4. Discussion

Our results confirm that regeneration and plant diversity in pine plantations are influenced by the spatial configuration at different scales, specifically with greater influence at landscape scale (vegetation context and patch geometry) than patch scale (internal structure). Nevertheless, this effect is constrained by environmental gradients, mainly altitude, considering the mountainous study area (Gómez-Aparicio et al. 2009). The multiscale approach used has proven that processes at different scales influence the overall outcome expressed at the patch level (Turner, Gardner, and O'Neill 2001). However the response varied depending on the group of species and spatial variables considered.

Once climatic conditions are favourable, propagules must arrive from vegetation patches surrounding pine plantations. Results suggest that distance to these vegetation patches determines the abundance and presence of other species than pines. From all vegetation classes considered, oak vegetation was the most influential. Thus, pine plantations closer to oak vegetation might show in general a more mixed combination of species. This finding agrees with general theory of seed fall being inversely related to distance to seed source (Hewitt and Kellman 2002). Furthermore, the differences among context algorithms (uphill, downhill,

Euclidean) suggest that seed dispersal is favoured from species-rich patches occurring at higher altitude towards lower situated pine plantations. Secondly, patch geometry might affect seed permeability and therefore the overall regeneration dynamic of the patch. According to our results, fragmentation of pine plantations (i.e. patch area reduction) increases overall plant diversity. Thus, increasing edge effects in pine plantations will facilitate higher rates of plant diversity. Patch geometry effects on natural processes are based on the delimitation of isolated discrete units or patches. However some types of landscapes do not present clear patch delimitation (Gustafson 1998). In our study site, landscape is better depicted as a continuum of patches with different perturbation rate and following a belt structure. This limitation was overcome selecting isolated patches across the study site. This approach allowed the study of the effect of geometry on regeneration and plant diversity but also pointed out the complexity of vegetation pattern at landscape scale that eventually might be better depicted as a continuous gradient of point-data (Gustafson 1998). Thirdly, once propagules are trapped in pine plantation patches, seeds will require special conditions to germinate and establish. This study has proven that internal vegetation structure measured in terms of texture indices, might be useful to estimate regeneration and plant diversity. All plant diversity indices but for fleshly-fruited woody species were higher in plots of higher heterogeneity. Areas with higher microhabitat diversity might have a higher abundance of niches for different species that in turns will influence positively plant diversity. This finding agrees with the extensive literature that points the positive relationship between habitat heterogeneity and species abundance and distribution (Noss 1990). Nevertheless, this effect proved to be species-dependent. *Q. ilex* responded in an opposite manner with higher regeneration rates in structurally homogeneous plantation patches. Despite these promising findings and the theoretical usefulness of texture indices as heterogeneity quantification techniques (Turner 1991), further research is needed to test this methodology in other landscapes and at different scales to firmly confirm their reliability.

Table 1. Pearson correlation coefficients between regeneration (Log seedling abundance of *Q. ilex*) and biodiversity (Shannon diversity index for all species, herbaceous, dry-fruited and flesh-fruited woody species) variables and vegetation context (distances) and internal structure variables (entropy and contrast). Riparian distance was square root transformed and rest of context variables were double square root transformed. n=275. (*$P<0.05$, **$P< 0.01$, ***$P< 0.001$).

		Biodiversity				Regeneration
		$SH_{total\ species}$	$SH_{herbaceous}$	$SH_{woody\ dry}$	$SH_{woody\ flesh}$	SE_{Qilex}
Euclidean distance	**Oak**	**-0.21****	**-0.21*****	**-0.28*****	**-0.12***	**-0.33*****
	Shrubland	**-0.17****	-0.09	**-0.18****	**-0.27*****	-0.10
	Riparian	**-0.18****	0.05	**-0.21*****	**-0.20****	-0.00
	Fields	-0.03	-0.1	-0.1	**0.26*****	-0.07
Weighted distance downhill	**Oak**	**-0.22*****	**-0.21*****	**-0.29*****	**-0.14***	**-0.33*****
	Shrubland	**-0.18****	-0.12	**-0.21*****	**-0.27*****	**-0.13***
	Riparian	**-0.18****	0.04	**-0.22*****	**-0.20****	-0.00
	Fields	-0.05	-0.12	-0.11	**0.23****	-0.09
Weighted distance uphill	**Oak**	**-0.20****	**-0.16****	**-0.27*****	-0.10	**-0.32*****
	Shrubland	**-0.15***	-0.05	**-0.13***	**-0.26*****	-0.07
	Riparian	**--0.18****	0.1	**-0.22****	**-0.20****	0.01
	Fields	-0.01	-0.06	-0.07	**0.27*****	-0.06
Entropy		**0.15***	**0.21*****	**0.13****	-0.00	-0.09
Contrast		**0.19****	**0.14***	**0.20****	-0.04	-0.05

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Impact of changing cultivation systems on the landscape structure of La Gamba, southern Costa Rica

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Abstract

Human activities often cause changes and homogenization in landscape structure. To investigate the human impact on a tropical agricultural landscape we mapped land cover and small-scale linear landscape elements in La Gamba (Costa Rica) and compared eight sections by different landscape metrics. Rural sections clearly differed from forests, especially pasture-dominated sections including many linear landscape elements and few big plantations. The largest and most compact patches belonged to primary and secondary forests. Conversely, cultivated landscapes were diverse comprising many small patches. Contrasting the results of other studies, most rural sections obtained higher fractal dimensions than forests, probably due to a higher density of linear landscape elements. Natural landscape elements such as live fences and riparian vegetation which are supporting wildlife movement between forests are declining. Their protection is of major importance, particularly as the globally increasing cultivation of oil palms is significantly altering the countryside of La Gamba and many other tropical land mosaics.

Keywords: Costa Rica, Habitat fragmentation, La Gamba, Landscape metrics, Land use

1. Introduction

Nowadays biodiversity is highly threatened by human activities in all tropical regions of the world (Kappelle et al. 2003). The loss and fragmentation of tropical forests and rapid changes in land use have great influence on the population dynamics of various native plant and animal species (e.g. Morera et al. 2005; Harvey et al. 2008b). By improving the ecological connectivity between forest patches and natural landscape elements in agricultural areas the problem of habitat fragmentation can be alleviated (Morera et al. 2005). Therefore, the presence of natural landscape elements, such as live fences, forest patches and gallery forests is of great importance for wildlife using cultivated areas (Harvey et al. 2005, 2008a; Seaman and Schulze 2009).

The village "La Gamba" is situated at the edge of the Piedras Blancas National Park (southwest Costa Rica) and its agricultural area belongs to a zone that is important for wildlife exchange between forest areas. Since the founding of the village in the 1940s its economy has undergone several changes. Cattle breeding and rice production have always been important and large areas were deforested to gain farmland. From 1954 to 1961 bananas were the most common cash crop in La Gamba. During the great depression in the 1980s many plantations were abandoned, rice fields and pastures remained as the most common forms of land use (Klingler 2007). Nowadays

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rice production sharply decreased while the oil palm industry is on the rise. During the last decade many agricultural areas have been rapidly converted into oil palm plantations which are already the second most area consuming land use type after pastures. The cultivation of oil palms is increasing globally, causing severe problems in many tropical agricultural systems and leading to deforestation, loss of biodiversity, destruction of soils and alteration of traditional countryside (Fitzherbert et al. 2008). Until now in La Gamba new oil palm plantations are mainly replacing former rice fields or pastures and there has not been much deforestation. Nevertheless, this development profoundly affects the economic situation of La Gamba and has strong influence on the landscape structure (Höbinger 2010).

Landscape metrics are a useful too to analyze and monitor changes in landscape pattern and differences between landscapes (Uuemaa et al. 2009). Landscape structure mirrors a wide range of ecological patterns and processes (Turner 2001). Several authors wrote about the use and misuse of landscape metrics (e.g. Li and Wu 2004) and tried to figure out appropriable sets of metrics for different scales and scientific questions (e.g. O'Neill et al. 1988; McGarigal and Marks 1995; Botequilha Leitão et al. 2006; Cushman et al. 2008). A careful choice of metrics is essential to avoid redundancies and misleading results (McGarigal and Marks 1995; Schindler et al. 2008; 2009).

This study analysis the landscape pattern of the La Gamba area, and deviates ecological consequences of ongoing land use change. It shall form a basis for further investigations and action plans for biodiversity conservation in the area and other tropical landscape mosaics.

2. Methodology

2.1 Study area and land cover mapping

The study area, the village La Gamba and surrounding forest areas, is situated in the southwest of Costa Rica (Golfo Dulce Region) and has an extend of 25.66 km² (8°41' to 8°43'N and 83°9' to 83°13'W). To investigate the landscape mosaic we mapped land cover and small-scale linear landscape elements (see Figure 1). The base for the mapping of the region was a "QuickBird 2" satellite image with a pixel size of 2.4 m for the multispectral channels (green, blue, red and infrared) and 0.6 m for the panchromatic channel (La Gamba, Costa Rica, QuickBird scene 052017330010_01_P001, 6/12/2007 © Digital Globe (2008), Distributed by Euroimage).

To produce a vector map showing the land cover, we used the program ArcView® (ESRI, Inc., Redlands, CA) and defined eleven land cover categories: primary forest, secondary forest, shrubland, riparian vegetation, fern-dominated vegetation, pastures, oil palm plantations, live fences and timber plantations, agriculture, settlements and roads and drainage ditches and rivers (including ponds). We used the statistics program R version 2.6.0 (R Development Core Team) to illustrate the results in the form of barplots.

2.2 Landscape pattern analysis

To analyze the landscape pattern, the study area was divided into eight sections. All sections should represent relatively homogenous and characteristic zones of the area and were delineated in order to comprise mainly either forests or rural areas. Each section includes at least five of the eleven land cover categories and is of compact shape (see Figure 1). Three of these sections were summarized as "forest sections" (*Bolsa forest, Station forest* and *Bonito forest*), being mainly covered by primary and secondary forest and five sections were summarized as "rural sections" (*Bolsa, Bonito 1, Bonito 2, La Gamba* and *Station agriculture*), being dominated by anthropogenic ecosystems (see Figure 1).

To investigate the landscape pattern of the area and to uncover differences among the eight landscape sections, we used the software FRAGSTATS 3.3 (McGarigal and Marks 1995) to compute the landscape metrics Patch Density (PD), Patch Area (AREA), Fractal Dimension (PAFRAC), Similarity Index (SIMI), Contagion Index (CONTAG) and Patch Richness Density (PRD). The different patch types were characterized by the class level metrics Patch Area (AREA), Fractal Dimension (PAFRAC), Euclidean Nearest Neighbor Distance (ENN) and Edge Contrast (ECON). We applied the eight neighbor rule to guarantee that linear landscape elements were identified as single patches (McGarigal and Marks 1995; Schindler et al. 2008). As the landscape sections differed in size, we used only metrics standardized for area (e.g. Patch Density instead of the absolute number of patches).

3 Results

Primary vegetation covered 29% of the study area, secondary vegetation 35%, anthropogenic ecosystems 34% and water (rivers and ponds) 2% (see Figure 1). The most area consuming land use types of the agricultural land mosaics were pastures (61 %) and oil palm plantations (31 %). Other land use types (e.g. rice, cacao, bananas) covered only small areas (< 4%). All landscape metrics clearly separated forests from rural sections. Generally, forest areas showed lower values of PD, PAFRAC and PRD and higher values of SIMI and CONTAG compared to rural areas (see Figure 2a). The differences between forests and rural areas were most evident for traditional pasture-dominated landscapes, which typically consisted of many small patches of different type and included many linear landscape elements such as live fences, streets or drainage ditches. Rural sections including few linear landscape elements and big plantations or undivided pastures were characterized by metric values more similar to those of forest sections.

Most rural sections of the study area had much higher fractal dimensions than forests. Patch types including lines showed the smallest patch areas and the highest fractal dimensions (see Figure 2b). Patches of primary forest had the biggest AREA and the lowest fractal dimensions. Secondary forests were smaller and had higher fractal dimensions. All other natural patch types such as riparian vegetation were of very small extent and more complex shaped. The comparison of AREA and PD showed that oil palm plantations consisted of bigger, but less numerous patches compared to pastures (see Figure 3). Primary forests had the biggest AREA, but the lowest PD. Secondary forests were characterized by a much smaller AREA and clearly higher PD. Riparian vegetation covered only smaller areas, but showed a relatively high PD. Categories including linear landscape elements showed the smallest AREA and highest PD.

4 Discussion

For this study eight landscape metrics were chosen with regard to the suggestions of other authors (Botequilha Leitão et al. 2006, Cushman et al. 2008, Schindler et al. 2008). The chosen metrics clearly distinguished forest and rural sections. Forest sections consisted of relatively few, big and compact shaped patches. Conversely, rural areas included more, smaller patches and were more diverse. Fractal dimensions were considerable high for rural areas. This can be caused by very high values of PAFRAC for the categories "settlement and road", "drainage ditch and river" and "live fence and timber plantation" that included linear elements. This clearly demonstrates the importance of considering linear elements when assessing patch shape complexity.

The inclusion of linear landscape elements also has a strong influence on the values of landscape metrics and demands a careful interpretation of the results. For example, the results of this study are not consistent with other studies that show that agriculture causes simple and

compact shaped landscape patches (O'Neill et al. 1988). With exception of section *Bonito 2* all rural sections had higher fractal dimensions than forests. Due to the inclusion of linear landscape elements these high values indicate rather a high density of linear elements than a high complexity of the matrix. The comparison of AREA and PD clearly showed differences in the configuration of the patch types. Primary forests had the biggest extend, but comprised only few patches. Secondary forests were characterized by a much smaller AREA and clearly higher PD because most of these forests were formerly used as pastures. Riparian vegetation covered only smaller areas, but showed a relatively high PD because many small patches and strips of remnant riparian forests were present along the riversides.

The expansion of oil palm plantations causes considerable changes in the landscape matrix. Pasture-dominated parts were richer in ecologically valuable elements such as live fences and riparian vegetation, while within and along oil palm plantations mainly ecologically futile elements such as roads and drainage ditches were found. Compared to pastures plantations had a bigger AREA, but lower PD which reflects that they are labor-intensive permanent cultures of great extend. The land use map (see Figure 1) shows that, conversely to pastures, oil palm plantations were never divided and scarcely bordered by live fences. Hence, the expansion of these plantations involves the risk of a simplification of landscapes and the loss of small natural landscape elements in agricultural areas. This can lead to a significant reduction or shift of the biodiversity in tropical ecosystems affected by oil palm plantations.

Oil palms are a globally rapidly expanding crop which has already replaced large areas of natural forest in many tropical countries such as Malaysia or Indonesia and this progress is still going on. These plantations entail many other problems such as habitat fragmentation, pollution, loss of biodiversity and soil destruction. Because oil palms are unsuitable habitat for most forest species they can act as severe barrier to animal movement (Fitzherbert et al. 2008). To maintain the exchange of plants and animals between the forest areas surrounding the village La Gamba, the conservation of live fences and other natural habitats is of great importance. As the mean patch area of pastures was relatively big (2.52 ha) and the density of live fences was rather low (20.0 m per ha farmland) more live fences could be established by dividing pastures into smaller paddocks (Höbinger 2010). This measure would improve the connectivity of forest patches, increase the tree cover within farmland, and provide a high conservation value of the agricultural landscape mosaic in its unconnected gallery forests (Seaman and Schulze 2009).

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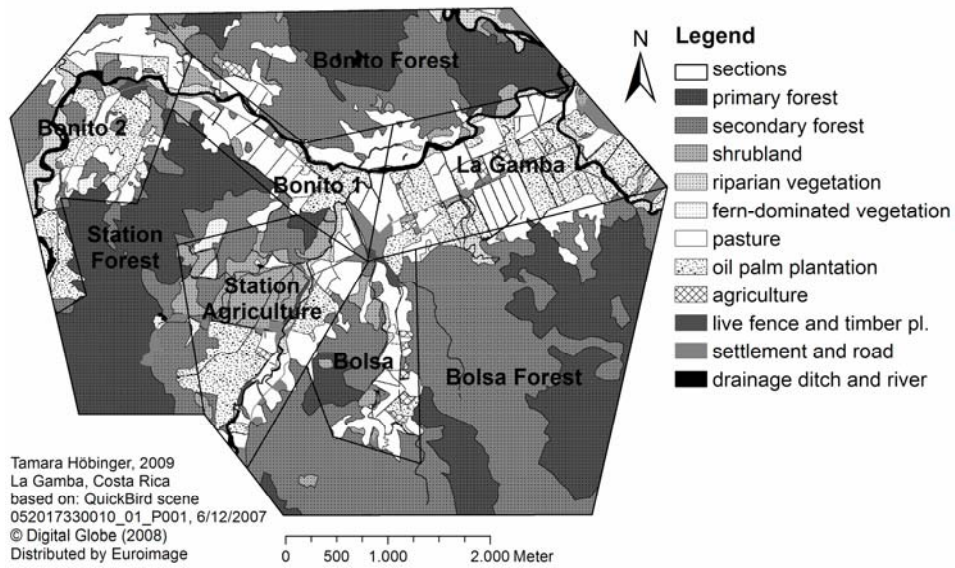
Figure 1: Land cover map and landscape sections used for the landscape pattern analysis.
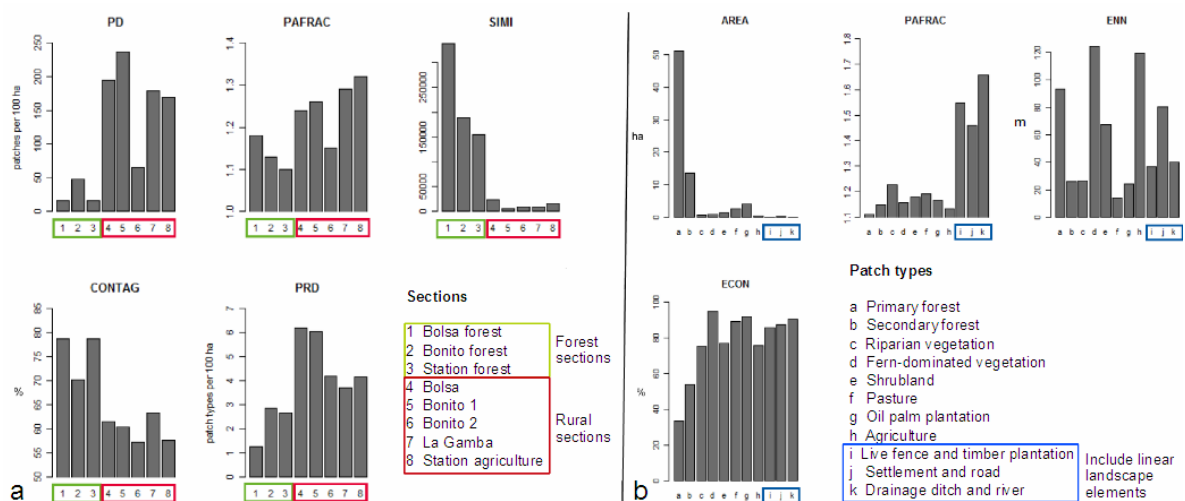
Figure 2: Landscape level metrics (a) and class level metrics (b). The values of SIMI, ENN and ECON represent the area-weighted means of the values of all single patches of the certain section (SIMI)/ of the certain land cover type (ENN and ECON). For the explanation of the metric-acronyms, see section 2.2.
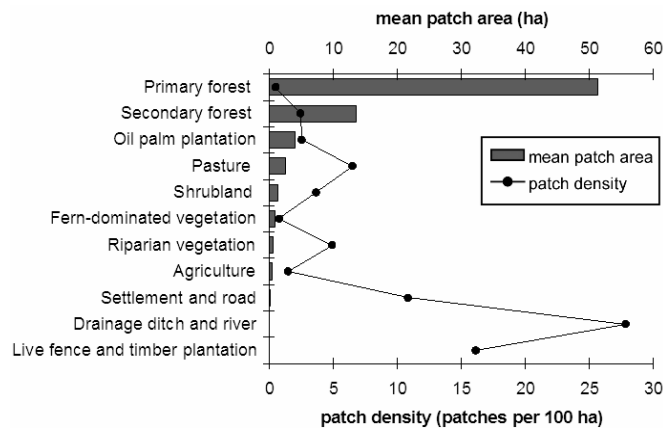
Figure 3: Mean patch area of the land cover types compared to their patch density.

Can lichen functional diversity be a good indicator of macroclimatic conditions?

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Abstract

Climate change is one of the greatest challenges facing conservation and it is predicted that its impact will be most significant in the Mediterranean region. In this work we proposed to study the effect of macroclimate on total lichen richness, abundance and on the proportion of lichen functional groups in order to find the best ecological indicators of macroclimatic conditions. The results showed that lichen functional-groups can be used as an indicator of the macroclimatic conditions at the landscape level and showed to be better than total species richness or lichen abundance. By using three different functional groups we were able to observe shifts in the communities along the climatic gradient. Precipitation, evapotranspiration and relative air humidity were the variables that explained better the shifts from hygrophytic to xerophytic lichen communities. Lichen functional diversity showed to be a good candidate for an ecological indicator of climate change.

Keywords: lichen, functional-groups, species richness, abundance, climate change

1. Introduction

Climate change is predicted to affect many ecosystem services, including water shortages, increased risk of forest fires, northward shifts in the distribution of tree species, and losses of agricultural potential, which in Europe will be most significant in Mediterranean areas (Schroter et al. 2005). In particular in this region it is predicted an increase in drought conditions, due to higher temperature and reduced precipitation (IPCC 2007). There is a need to have tools for monitoring and even anticipating, the subtle changes that are or will occur due to climate change, both in space and time.

Lichens are poikilohydric organisms that lack cuticle or roots, so they rely mainly on atmosphere for their water supply. Epiphytic lichens are considered one of the most sensitive groups to several changes that occur at ecosystem level, namely: air pollution (Branquinho et al. 1999), ammonia (Pinho et al. 2009), land-use (Pinho et al. 2008b) and microclimatic conditions (van Herk et al. 2002; Aptroot and van Herk 2007) due to their integrated sensitivity to changes in temperature and/or precipitation (Giordani and Incerti 2008).

Although unconditionally considered good indicators of microclimatic alterations (van Herk 2002; Aptroot and van Herk 2007), their use as indicators of macroclimatic conditions is not so unanimous. Moning et al. (2009), in the Bavarian Forest National Park, in southeastern Germany, found that total and threatened diversity of lichen species were mainly affected by forest structure, whereas macroclimatic factors were far less important, despite the steep average annual temperature gradient investigated, ranging from 4.2C to 7.8 °C. Other studies that focused on the impact of climate change on lichens suggested that lichens respond to global warming (Insarov et al. 1999). In the Netherlands, arctic-alpine/boreo-montane species appear

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to be declining, while (sub)tropical species are invading, independent of nutrient demands and decreasing SO_2 emissions (van Herk et al. 2002). In Western Europe, the number of epiphytic species appears to be increasing rather than declining, as a result of global warming (Aptroot and van Herk 2007). Model predictions indicate major shifts in the distribution of lichen species (Ellis et al. 2007; Giordani and Incerti 2008).

Despite many authors consider that climate change will affect lichens by shifting their communities, none of them tested this hypothesis explicitly, because these studies were performed considering either total species richness or individual species response. Recent studies (Giordani and Incerti 2008) focused on functional-diversity, but used *posteriori* selected guilds, that were based on the pattern of environmental variables. Because it was based on *posteriori* classification, it is strongly dependent on local communities, and thus cannot have a broader applicability. To overcome this problem and find a more universal indicator, we have made use of *a priory* classification of functional-diversity based on their humidity requirements. The use of lichen functional groups was shown to be better related with several environmental gradients than total biodiversity, at least for NH_3 air pollution (Pinho et al. 2009). Moreover, functional-groups of species have been successfully used to disentangle or analyze in simultaneous the influence of multiple environmental factors (Stofer et al. 2006; Pinho et al. 2008a).

In this work we propose to study the effect of macroclimate on total lichen richness, abundance and on the shifts of lichen functional groups in a regional area ranging from the more humid areas in coastal central Portugal to the SE of the Alentejo in semi-arid areas. This work intends to be a first approach to find the best ecological indicators of macroclimatic changes for Mediterranean areas.

2. Methodology

2.1 Study area

The study was conducted in three different areas of continental Portugal, covering three different macroclimatic regions (Figure 1). The area A is a *Quercus faginea* wood located in the west central part of Portugal, within the Natural Park of Serra d'Aire e Candeeiros. This area belongs to the Mesomediterranean belt, from the Coastal Lusitano-Andalusian province (Rivas-Martinéz and Rivas-Saenz 2009). It has an annual average temperature that ranges from 15 to 17.5 ℃ and an annual average precipitation between 1400 and 1600 mm (averages from 1931 to 1960, (IA 2010)). The area B is located in the southwest coast of Portugal, facing the Atlantic Ocean to the west. It's a cork oak wood (*Quercus suber*) with annual average temperature between 16 and 17.5 ℃, and average annual precipitation between 600 and 1000 mm (averages from years 1931 to 1960 (IA 2010)). This area is in the Termomediterranean belt, within the Coastal Lusitano-Andalusian province (Rivas-Martinéz and Rivas-Saenz 2009). The area C is a holm oak wood (*Quercus ilex*) located southeast from the former area. This area belongs to the Mesomediterranean belt and is placed in the Mediterranean West Iberian province (Rivas-Martinéz and Rivas-Saenz 2009) and its climate is semi-arid warm, with annual average precipitation between 500 and 600 mm and average temperatures ranging between 16 and 17.5 ℃.

2.2 Biodiversity data collection and calculation of lichen-diversity variables

Lichen diversity was sampled in 149 sites, 29 sampling sites in the area A, 77 sampling sites in the area B (Pinho et al. 2008a,b) and 43 sampling sites in the area C. The sampling was carried according to the method described in Asta et al. (2002).

For each site we calculated several lichen-variables: i) total number of species; ii) LDV, lichen diversity value, which is the sum of all species frequency within the grid. Additionally LDV

was also calculated considering functional-groups, by dividing species according to humidity requirements considering species maximum classification in an available index (Nimis and Martellos 2008). Therefore, species classified in the index with 1-2 were considered hygrophytes (LDVhygro), species classified with 3 were considered mesophytes (LDVmeso) and species classified with 4-5 xerophytes (LDVxero). Because we were dealing with different ecosystems the LDV values were used as relative values, i.e. the contribution (%) of each functional group to the total LDV.

2.3 Climatic data and statistical analysis

Lichen data was related with annual average values of macroclimatic series, available from *Atlas do Ambiente* (IA 2010). The variables selected were: precipitation (mm, 1931-1960); temperatre (ºC, 1931-1960); solar radiation (kcal/cm^2, 1938-1970); real evapotranspiration (mm, 1938-1970); insolation (h, 1931-1960); relative air humidity (%, 1931-1960). Values for each sampled site were estimated from the available maps. Correlations between lichen variables and climatic variables were performed using Spearman rank order correlations considering the 149 samples together.

3. Results

No correlation was found between the number of lichen species of each site and the long-term macroclimatic variables studied, except for relative air humidity (Table 2). However the total LDV value showed to be positively related not only with relative air humidity but also with insolation and solar radiation (Table 2).
All the lichen functional diversity variables showed to be related with the long-term macroclimatic parameters studied, except the percentage of mesophytic LDV with temperature and relative air humidity (Table 2). The relative value of hygrophytic LDV was positively related with precipitation and real evapotranspiration, and negatively related with insolation (Figure 2). On the contrary, the relative value of xerophytic LDV showed to decrease with increasing precipitation and evapotranspiration, but was promoted by the increase in insolation (Figure 2).

4. Discussion

The results show that lichen functional-groups can be used as ecological indicators of the macroclimatic conditions in a regional area. We found that indicators based on lichen functional groups responded better to changes in macroclimatic conditions, than the total number of lichen species or its abundance (LDV). The fact that functional diversity responded more clearly to environmental gradients than total diversity was also found in other works but, for other environmental stresses, such as ammonia or atmospheric pollution (Pinho et al. 2008b; Pinho et al. 2009).
The most important climatic factor driving the total richness and abundance (LDV) of lichens was the relative humidity. However, its abundance was also promoted by higher insolation. Although only some works (Heylen et al. 2005) showed this relation between species richness and relative air humidity, the poikylohydric nature of these organisms justifies the importance of this climatic factor. On the other hand, abundance was also related with insolation. Lichens need water to be physiologically active and they need light to photosynthesize. In this way, sites with higher relative air humidity and with a higher number of hours with sun will promote lichens activity and productivity, and ultimately lichens abundance. This hypothesis was also raised in a work in a tropical lowland rain forest. Zotz and Winter (1994) suggested that the low abundance of macrolichens found there was mainly due to low light conditions, combined with high temperature.

By using three different functional groups we were able to observe shifts in the communities along the climatic gradient. Precipitation, evapotranspiration and relative air humidity were the variables that explained better the shifts from hygrophytic to xerophytic lichen communities. In a Liguria case study, Girodani and Incerti (2008) found that 30% of its observed lichen flora was significantly correlated with yearly average temperature and rainfall patterns. This correlation allowed them to identify 3 guilds of species significantly sensitive to these climatic variables: species mainly related to cold-humid climate, species related to humid conditions but occurring in a wider range of temperatures and species occurring in meso to warm areas with humid to dry climate. Although not using the same functional groups, our results show a similar tendency, not evidenced by a group of individual species as in the former study, but with an *a priori* selected functional-group related to humidity requirements. Above 1400 mm in average of precipitation the hygrophytic community clearly dominated (>50%) over the mesophytic or the xerophytic ones, whereas below 600 mm it corresponded to only one third of the community. The xerophytic community increased clearly and consistently only when the precipitation was below approximately 600 mm. The mesophytic group showed an intermediate behavior. With increasing evapotranspiration the hygrophytic lichens showed a constant increase in relative average and also in variance. Again the xerophytic community responded more clearly only below 450 mm of evapotranspiration.

The hygrophytic lichens responded negatively to increasing insolation, solar radiation and temperature, although that was not as clear as observed for precipitation and evapotranspiration. This decrease in LDV of hygrophytic lichens was associated with an increase in xerophytic ones. These sets of variables (insolation, solar radiation and temperature) induce small changes in the median, and seem to change the variance of the response of the lichen communities.

The group of functional indicators used/applied in this work can be very important in the current context of climate change. It was predicted for the Mediterranean region an increase in drought conditions, due to higher temperature and reduced precipitation (IPCC 2007). This work confirms that changes in macroclimatic conditions leads to changes in the functional structure of the lichen communities. Further studies are needed to evaluate the use of these indicators along time. Moreover, changes along smaller spatial scales should also be tested. The results of this work suggested that changes in sensitive lichen communities could be used as an indicator of macroclimatic changes in space.

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Table 2: Spearman rank order correlation coefficient values between total number of species, total LDV, relative LDV of lichen functional groups related to humidity requirements and the climatic variables. Marked (*) correlations are significant for *P*<0.05. N=149.

Climatic variable	Nºof species	LDV	%LDVhygro	%LDVmeso	%LDVxero
Precipitation	0.125	-0.051	0.598*	-0.248*	-0.557*
Temperature	0.105	-0.110	-0.164*	-0.083	0.326*
Solar radiation	0.004	0.206*	-0.366*	0.161*	0.385*
Real evapotranspiration	0.131	0.043	0.598*	-0.222*	-0.573*
Insolation	0.062	0.336*	-0.421*	0.242*	0.321*
Relative air humidity	0.172*	0.439*	0.392*	-0.069	-0.416*
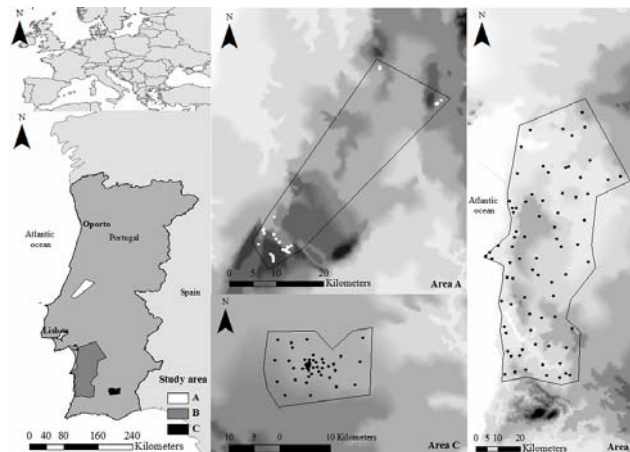
Figure 1: Location of the three areas studied.
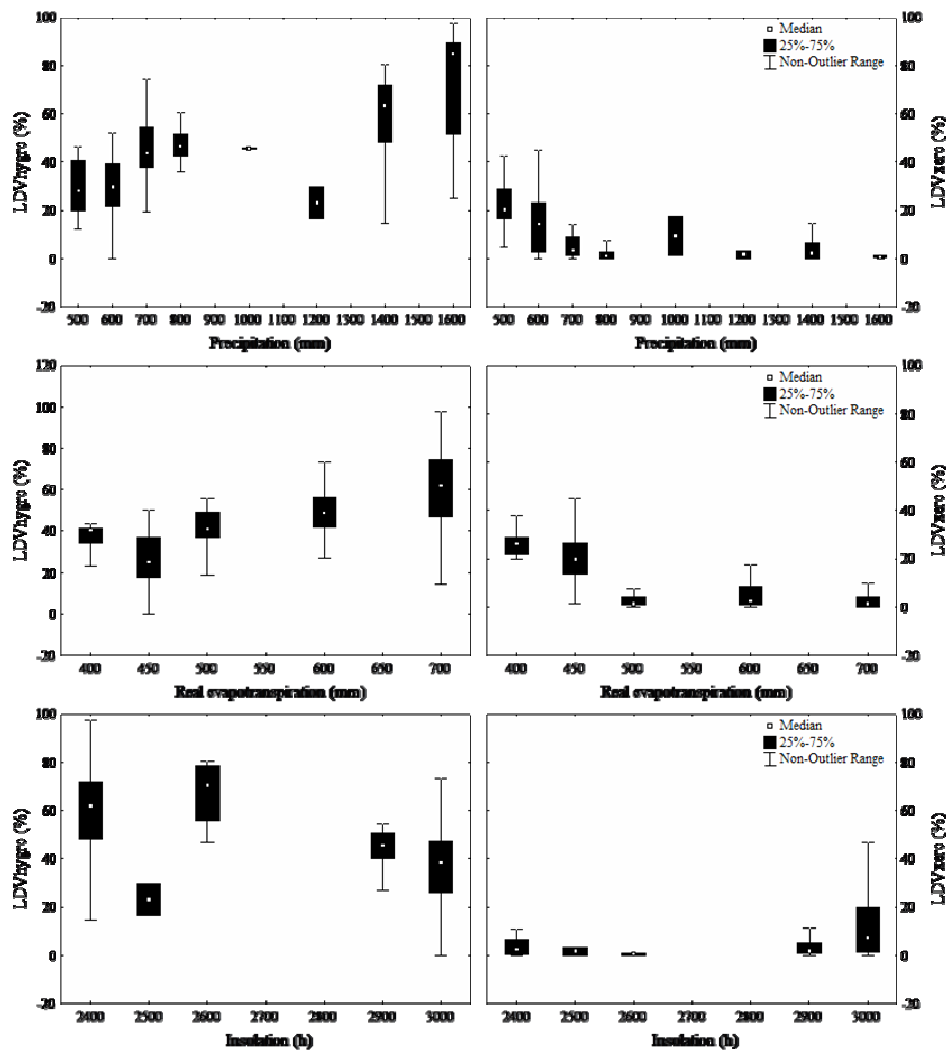
Figure 2: Relative functional diversity LDV related to water stress tolerance in response to the macroclimate variables – precipitation, real evapotranspiration and insolation.

Projections of shifts in species distributions: assessing the influence of macro-climate and local processes

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Abstract

It is currently unclear, whether tree species will be able to keep pace with the ongoing and likely accelerating shift in climate. Here, we estimated the influence of changing macro-climate and local processes on shifts in species distributions. First, we evaluated tree co-occurrence patterns in climate space and estimated the influence of these patterns on current and future species distributions using species distribution models. Second, we combined these models with migration rates from a process-model and a GIS path cost analysis, to estimate key processes influencing tree migration rates and to predict more realistic shifts in large-scale tree re-distributions. Our results showed, that biotic interactions mainly limited species distributions towards favorable growing conditions, while climate was directly limiting primarily where biotic interactions were low. Landscape fragmentation was further strongly limiting migration. In conclusion, this may lead to considerable time lags in range shifts and re-adjustment to new conditions during climate change, especially for late succession species.

Keywords: biotic interactions, macro-climate, Europe, niche-based model, stress-gradient hypothesis.

1. Introduction

Macroclimate is hypothesized to play a key role in large-scale species distributions (Thuiller, Araújo and Lavorel 2004, Woodward 1987, Whittaker, Willis and Field 2001), and thus, the changing climate is expected to shift the distribution of suitable habitats for many species considerably (Root et al. 2003, Parmesan and Yohe 2003). This expectation is consistent with observations during Holocene climate changes, where species adapted their spatial distribution more or less rapidly to the changing climate conditions (Davis and Shaw 2001). For on-going and future climate change, however, it remains unclear whether species will be able to keep pace with accelerating rates of change (Iverson, Schwartz and Prasad 2004). On the one hand, new dispersal limitations emerge, such as anthropogenic landscape-fragmentation that may cause the newly emerging suitable habitats to be insufficiently connected. On the other hand, the expected global warming is predicted to be one or more orders of magnitude faster than past climate change events (Solomon and Kirilenko 1997, Etterson and Shaw 2001) and the influence on range shifts by small-scale processes limiting species establishment, survival and dispersal, such as biotic interactions (e.g. inter-specific competition, facilitation) or disturbances were so far often ignored in analysis on large-scale species responses to climate change (Caplat, Anand and Bauch 2008, Brooker et al. 2007). According to the 'stress-gradient hypothesis',

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abiotic factors such as climate, topography and soil may primarily constrain species ranges under unfavourable growing conditions and here competition is generally low (Bertness and Callaway 1994). Where abiotic conditions are more favourable, biotic interactions increase, and competition may then, additionally to abiotic constraints, further determine species range limits (MacArthur 1972). The constraining effect of interlinked abiotic and biotic processes may not only be important when predicting current species distributions (Meier, 2010), but may be even more important when estimating species range shifts due to changing environmental conditions. Range shifts are mainly determined by the rate of plant establishment, growth and survival at a new location and dispersal abilities (Higgins et al. 2003), and are hence strongly linked to abiotic and biotic conditions. Moreover, because most modern landscapes are highly fragmented, the density of individuals producing propagules is reduced and fewer and more distant sites for those propagules to colonize are available. This may further slow down migration rates (Iverson et al. 2004). Studying the interlinked effects of macroclimate, inter-specific competition and landscape-fragmentation may help to better estimate colonisable suitable habitats of species.

2. Methodology

2.1 Variation partitioning approach
We examined the extent to which the variance in spatial patterns of species explained by species distribution models (SDMs) can be partitioned among abiotic and biotic predictors, and how these partitions depend on species characteristics. We fitted generalized linear models (GLMs) for 11 common tree species in Switzerland using three different sets of predictor variables: biotic, abiotic, and the combination of both sets. We estimated by variance partitioning the proportion of the variance explained by biotic and abiotic predictors, jointly or independently. We then analyzed the linkage of these partitions with species traits using non-parametric tests (Mann–Whitney U-test and the Kruskal–Wallis test, depending on the number of classes differentiated).

2.2 Co-occurrence patterns
Further, we analysed correlations between the relative abundance of European beech *(Fagus sylvatica)* and three major competitor species *(Picea abies, Pinus sylvestris* and *Quercus robur)* in environmental space, analyzing the variation in correlation along two major environmental gradients, namely summer rainfall and annual degree-day sum. In a next step, we projected these co-occurence patterns to geographic space. In a following spatial analysis, we used generalized additive models (GAM) to predict the spatial patterns of species abundances, and we evaluated from these models where and how much the simulated *F. sylvatica* distribution varied under current and future climates if potential competitor species were in- or excluded. For the analysis of co-occurrence we used ICP Forest level I data as well as climatic, topographic and edaphic variables as predictors for modelling the spatial distribution of species using SDMs.

2.3 Implementing migration rates in SDMs
In a final step, we calibrated SDMs using generalized linear models (GLMs) with ICP forest level I data and climatic, topographic, edaphic and land-use variables to predict current and future tree distributions, assuming either no or full migration when projecting to scenarios of future climate. Additionally, we combined our SDMs with an explicit simulation of dynamic tree migration rates (i.e., depending on interlinked effects of climate, inter-specific competition and landscape connectivity). Dynamic migration rates were estimated from a process model (TreeMig; Lischke et al. 2004) using an intense sensitivity analysis of migration rates along gradients of climate, species competition and distance between suitable habitats in fragmented landscapes. We combined the derived migration response with a GIS path cost analysis, to estimate climatically suitable and colonisable habitats and the rate of expected migration of

target species to reach such habitats given constraints of the landscape (fragmentation, climate, competing species). By this, we were able to simulate realistic tree migration patterns across Europe at a comparably fine spatial resolution of 1km for the ongoing century.

3. Results

The variation partitioning approach showed, that over all climatic conditions, the joint contribution of biotic and abiotic predictors to explain deviance in SDMs was relatively small (~9%) compared to the contribution of each predictor set individually (~20% each). The influence of biotic predictors was higher for mid to late succession species than for early succession species.

The results of the correlation analysis were in line with the 'stress-gradient hypothesis' for *F. sylvatica*: towards favourable growing conditions, its abundance was strongly linked with the abundance of its competitors, while this link weakened considerably towards unfavourable growing conditions. This resulted in a North-South and an elevation gradient throughout Europe, with stronger correlations in the South and at low elevations. The sensitivity analysis showed a potential spatial segregation of currently competing species with changing climate and a pronounced shift of zones where co-occurrence patterns may play a major role, but also a general reduction in interaction strength.

Results from the sensitivity analysis of migration rates point to one effect that may help to explain aspects of the 'stress gradient-hypothesis'; the higher the biotic interactions (i.e., increased number of species occurring in a cell) towards species-specific favourable growing conditions, the more migration rates are limited. Climate seems to be directly limiting migration and finally constraining species' distributions only where biotic interactions were low. Landscape fragmentation further lead to considerable time lags in range shifts for some species. In summary, the projected distributions by 2100 predicted from limiting migration rates dynamically with SDMs was rather in agreement with assumptions of "unlimited dispersal" for early succession species, while it matched rather with the assumption of "no migration" for medium and late succession species.

4. Discussion

The influence of biotic variables on SDM performance may indicate that community composition and other local abiotic factors or biotic processes strongly influence species distributions. However, the importance of species co-occurrence patterns for calibrating reliable species distribution models for use in climate effects projections does not seem to be equally crucial under all possible climatic conditions; in our correlation approach we were able to localise European areas (mostly low elevations, more southern part of the range) where inclusion of biotic predictors is recommended. Further we demonstrated, that implementing more realistic migration rates might substantially alter projections, and reduce the uncertainty in projections of species distributions under climate change scenarios.

During recent climate change, many slow reproducing mid to late successional species may not be able to keep pace according to our analysis. Biotic interactions may mainly limit migration rates towards species-specific favourable growing conditions, while climate seems to be directly limiting primarily where biotic interactions are low. Landscape fragmentation may further lead to considerable time lags in range shifts, which may bring migration to a halt where migration is already relatively slow. Assessing the effects of interlinked processes such as climate, inter-specific interactions and landscape-fragmentation on migration rates and species distributions in a dynamic and compound model reduces the uncertainty in projections of species distributions under climate change scenarios. If standard SDMs should be used in the future because of simplicity or where insufficient information on dynamic migration rates is

available, one may consider for each species adequate migration assumptions (i.e. "no migration" for mid to late successional species and "unlimited migration" for early successional species), and may have to investigate more intensively the influence on range shifts by small-scale processes limiting species establishment, survival and dispersal, such as biotic interactions (e.g. inter-specific competition, facilitation) or disturbances, which were so far are often ignored in analysis on large-scale species distributions.

Improved predictions of potential species distributions under future climates and in novel communities may assist strategies for sustainable forest management. Especially in this domain it is important to dynamically adapt management decisions to on-going climate changes, due to the long life span of trees. Tree life cycles take multiple decades to complete, and the rate at which trees can disperse and migrate, invade and form closed forests in areas that become climatically suitable is even slower. Incorporating such local processes by combining a dynamic model approach with large-scale SDMs will be crucial for a better understanding of how tree species interact in a changing climate. This is key to produce more accurate and detailed predictions of tree responses to climate change as are required by forest-management.

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Application of remote sensing to assess the wildfire impact on the natural vegetation recovery and landscape structure in the Mediterranean forest of South eastern Spain

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Abstract

Forest fires in the Mediterranean zone cause major disturbances in landscape structure especially in the wooded stratum, since the recovery of the initial state of the natural vegetation is a complex and very slow process. This process, depending on many factors, passes through several stages leading to changes in the landscape structure through time. In this research, several Landsat TM and ETM+ images were used to assess the impact of wild fire in the Mediterranean forests of south eastern Spain over the past 25 years. The use of the Normalized Difference Vegetation Index (NDVI) for mapping the burnt zones and indicators of landscape heterogeneity allowed us to analyze the degree of landscape change in these forests caused by the fires. In the majority of the observed zones the natural vegetation did not completely recover over this time period. The alteration in landscape structure and its floristic composition depends on the type of vegetation and its maturity before the fire, topography, microclimates, the climate general, and finally, land use and management.

Keywords: Forest fire, Vegetation recovery, Landscape structure, Remote sensing, NDVI

1. Introduction

Situated on the Mediterranean coast in the South East of Spain, The Valencian Community is one of the most affected areas by the wildfires. In 1994 a total of 138404 ha of wooded and non wooded area were burnt which represents a third of the burnt area in Spain. Due to their magnitude wildfires are considered one of the most important driving forces determining the current forest landscape in the Mediterranean basin (Naveh 1994) and several authors speak about a homogenization of the landscape after fires. These fires affect landscape patterns which can affect the ecological processes (Turner, 1989).

The satellite images thanks to their spatial and temporal resolution allow the assessment of wildfires impact on the landscape. In this way we carry out this research using a several Landsat TM and ETM+ images of a burnt area in the South East of the Valencian Community.

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2. Methodology

2.1 Study area

The chosen area is located about 70 km south east of the city of Valencia (figure 1). The dominant vegetation type covering the landscape are the evergreen shrublands (with abundance of *Quercus coccifera*) and pine woodlands (*Pinus halepensis*) with different degrees of development and species compositions (Abdel Malak, 2009). This area suffered several fires in the last 25 years.

2.2 Methodology

In this research we follow the same methodology used by Chuvieco (1996, 2007) in his study to measure the landscape structure using remote sensing images. Chuvieco based his research on only two images in order to compare the landscape structure before and after the fire. However, for this research twelve Landsat TM and ETM+ images were used in order to obtain a more accurate assessment of the evolution of landscape structure (table 1).

The twelve satellite images used have been downloaded for free from the USGS Global Visualization Viewer (http://glovis.usgs.gov/.). We did not perform any geometric correction to these images because the level of their correction was already satisfactory. Nevertheless, in order to compare them a radiometric normalization was carried out using the Pseudo-Invariant Feature Normalization method (Scott et al., 1988).

To detect the burnt area we used a combination of the NDVI bands calculated from the 12 images and stretched between 0 and 200. Displaying the NDVI band of the first year (1984) in both the red and the blue channels and displaying the rest of the years in the green channel, we can detect the burnt zone as a magenta colored area due to the low values of NDVI in the green channel.

In order to quantify the landscape structure two kinds of measures were applied:

-measures applied to the NDVI images as continuous values: (the standard deviation through a profile) which measures the spatial contrast of the image.

-measures applied to intervals of NDVI which measure the spatial structure of a territory.

3. Results

Analyzing only two images, one image before and one after the fire, we obtained the same results as Chuvieco did in 1996. In both profiles (10.5km and 4.5km of length) chosen within two different burnt areas at different times (the first area was burnt in 1986 and the second one was burnt in 1991), we observed that the standard deviation decrease after the fire: 9% in the first profile and 3% in the second profile (table 2&3; figure 2&3). This result indicates that the fire tends to homogenize the landscape. However, analyzing the rest of images we observed that the NDVI and the standard deviation increase with time while the vegetation recover (table 2&3).

The second type of landscape structure measures was applied to a window of 1473.7 ha of an area burnt in 1986. These measures were applied to classified images of 10 intervals of NDVI obtained from an automatic segmentation. The mean area of patches and the index of patch dominance increased while the number of patches, the density of patches and the mean diversity

decreased after the fire (table 4). Nevertheless, it does not have the same tendency over all the observed time period.

4. Discussion

All results obtained in the year after the fire lead to one conclusion: the wildfires tend to homogenize the landscape. The same conclusion was obtained for chuvieco in his study in 1996 but we cannot conclude that the homogenization is forever because all indexes measured in this study change with time and there are differences in space.

The difference in the NDVI values over the time period observed between the two profiles studied is due to the fact that the first profile was chosen inside an area burnt firstly in 1979 and secondly in 1986. The second one was chosen inside another area burnt only one time in 1991.

In the first case the initial vegetation was composed for mattorrals and shrublands because of the first fire and in the second case the initial vegetation was a wooded stratum that is what explains the differences in the vegetation recovery after the two fires. In the first case the pine forest can disappear (Baeza and al, 2007). The initial vegetation and the variation on the precipitations (table 1) can together explain the variability of the NDVI through time.

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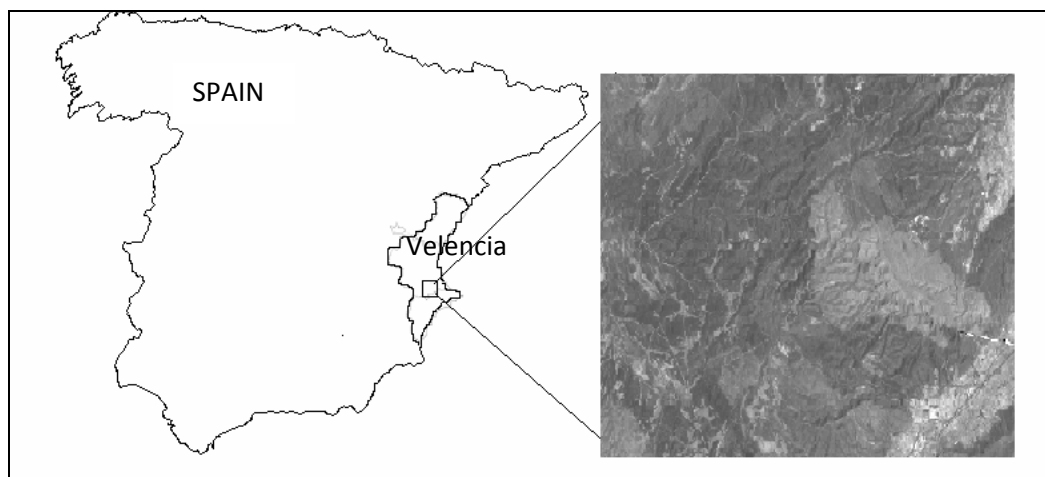
Figure1: Geographic situation of the studied area

Table1: Images dates and cumulative precipitation

Image Date	Cumulative Precipitation (mm/10 Months (Sept-June)) Bañares station
28/07/1984	302.9
23/06/1986	394.9
26/06/1987	880.7
06/09/1990	820.2
20/04/1992	364
29/06/1994	373
21/07/1999	257.4
19/06/2002	497.4
08/07/2003	379.6
18/05/2005	418
03/07/2007	453.5
24/07/2009	730.8

Table 2: NDVI mean values and standard deviation through a profile for the fire of 1986

	1984	1986*	1987	1990	1992**	1994	1999	2002	2003	2005	2007	2009
Mean	136.9	126.9	132.5	133.7	134.3	132.3	141.7	139.8	134.2	137.2	134.8	134.6
Standard deviation	3.3	3.0	3.1	4.1	3.3	2.8	4.6	4.9	3.5	3.7	3.8	3.9

*year of the fire, **Image captured in April
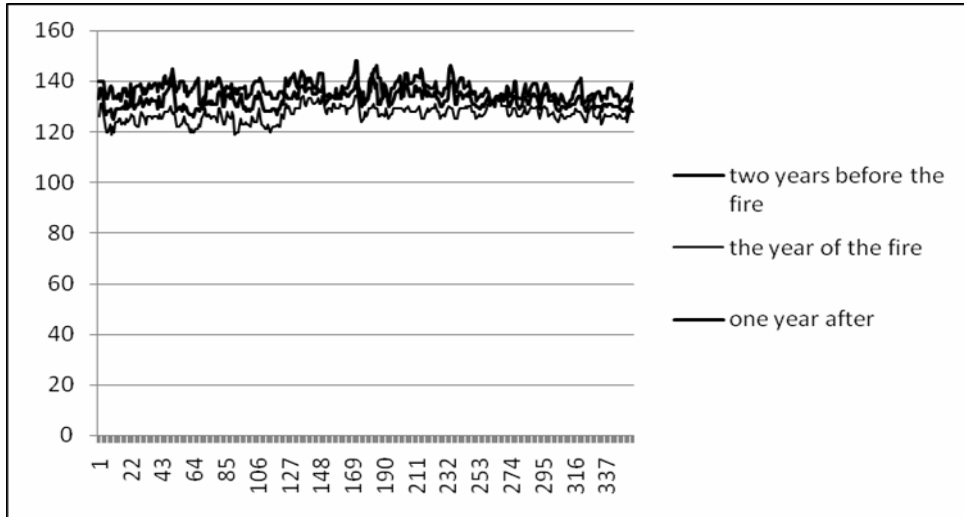
Figure 2: NDVI value through a profile on Matorral cover before and after the fire of 1986

Table 3: NDVI mean values and standard deviation through a profile for the fire of 1991

	1984	1986	1987	1990	1992*	1994	1999	2002	2003	2005	2007	2009
Mean	143.4	140.5	142.1	141.0	117.9	132.1	144.4	142.9	135.0	138.5	136.9	137.4
Standard deviation	4.3	4.0	4.2	3.8	3.7	3.2	5.7	4.5	3.4	3.9	4.3	4.4

*year of the fire is 1991
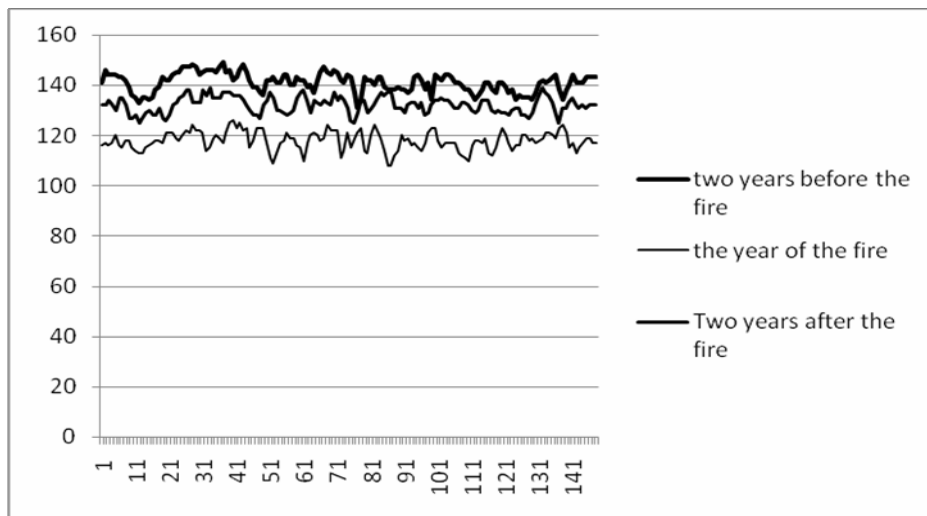
Figure 3: NDVI value through a profile on wooded stratum before and after the fire of 1991

Table 4: measures applied to 10 intervals of NDVI

	1984	1986	1987	1990	1992	1994	1999	2002	2003	2005	2007	2009
Number of patch	7082	5707	6146	7228	7152	6747	7299	7328	6906	6962	6844	7306
Mean area (pixels of 30m)	2.6	3.2	3.0	2.5	2.5	2.7	2.5	2.5	2.6	2.6	2.7	2.5
Density of patch /ha	130.1	104.8	112.9	132.8	131.4	124.0	134.1	134.6	126.9	127.9	125.7	134.2
Mean diversity	2.2	2.2	1.9	1.8	1.6	1.5	1.4	1.4	1.2	1.2	1.1	1.0
Dominance	0.1	0.2	0.4	0.5	0.7	0.9	1.0	0.9	1.1	1.1	1.2	1.3

The use of Voronoi tessellation to characterize sapling populations

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Abstract

The area potentially available to an individual plant represents a concept extensively used in population ecology but it has fewer implementations in forest research. In this paper I use a Voronoi tessellation in order to determine area potentially available to a sapling. The Voronoi polygons were used to characterize spatial pattern of sapling distribution as well as the competition relations between the individuals. Mathematically, the Voronoi tessellation represents one of the best solutions to determine neighbouring competitors of a tree. The area of Voronoi cells is frequently connected to biometrical attributes and the growth of the saplings. Furthermore, analyzing the Voronoi tessellation of a sapling population can indicate the spatial pattern of the saplings. It is considered that weighted Voronoi polygons may be more fitted for assessing sapling relationships but it is more difficult to implement such specific algorithms.

Keywords: Voronoi tessellation, area potentially available, spatial pattern, sapling populations

1. Introduction

Researches used many times mathematical and especially geometrical techniques in their effort to explain individual competition.

The area potentially available (APA) concept represents an uncommon, but rather promising approach, introduced in plant ecology by Brown (1965). The same concept was independently developed by Mead (1966), but early investigations in the field of plants growing space were conducted also by Konig, mentioned in his book „Die Forst-Mathematik" (1835).

From the biological point of view, APA generally defines the area used by an individual to access vital resources, the available area for a plant to satisfy its needs in water, nutrients and light. So APA is very appealing to researchers interested in growth modelling, in their effort to solve an everlasting problem: "Do trees grow faster because they are larger? Or they are larger because they have been growing faster?" (Wichmann, 2002; Garcia, 2008).

Considering the difficulty of the analysis there are few researches using this approach (Mark, Esler, 1970; Moore et al., 1973; Mercier, Baujard, 1997). Smith (1987) considers that this approach is ignored or even avoided due to misapprehend of APA geometrical foundation and computing difficulties. The late period is well-known for its computer development and also numerous and various algorithms were produced. So, the APA re-enters in researcher's attention as a promising investigation tool.

The APA was used to solve not only competition issues but also mortality and dynamics of seedlings (Owens, Norton, 1989) or spatial pattern (Mercier, Baujard, 1997). Regarding spatial pattern, Garcia (2008) considers the interaction between neighbouring growing areas as a result of autocorrelation. Two neighbours which are closer than average, will both have APA undersized values and vice versa. Winsauer and Mattson (1992) have mentioned some advantages to make use of APA in forest researches – potentially available areas are not intersecting each other, there are sensitive to population dynamics and they are correlated with

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growth rates. This final remark represents the key aspect of APA utilisation as a competition evaluation tool because if an individual has a large APA, the competition pressure will affect it less. There is, of course, a drawback – the APA is based exclusively on the position of the individual and not on its biometrical attributes. That's why it is called "potentially".

The objective of this study is to elucidate what kind of information APA can offer regarding sapling populations. Can APA characterize the relationships between saplings? A subsidiary objective is producing software tools for Voronoi analysis.

2. Methodology

The area potentially available of a tree has experienced different forms of interpretation and use, analogous to Brown concept. For example, Staebler (1951), Bella (1971) and Moore (et al., 1973) used in their researches a similar concept named "influence zone". Polygon areas were used as descriptive tool of spatial plant arrangement or as predictive tool of plant performance.

The most correct interpretation remains although the one based on the mathematical concept of space partitioning using Voronoi tessellation. So it is generally admitted that APA of an individual is equivalent to area of the Voronoi polygon which is associated to that individual.

In the bi-dimensional space, a Voronoi polygon of an element includes all the points closer to that specific element than to any other element. The edges of a polygon contain the points located at equal distance from two elements. The vertices of such a polygon are equally located from minimum three generating elements. Considering these properties, two elements are considered to be neighbours if their associated Voronoi polygons share an edge.

It is quite difficult to obtain a Voronoi partitioning for a large set of points, that's why this process is frequently done using specific algorithms and a computer. Algorithms were poorly optimized and the computers were very slow few decades ago, so the process was not pleasant and quick. The last years arrived with great improvements regarding the algorithms and the computer instruments, giving a new chance to Voronoi based applications.

2.1 Developing the software tools

In order to study the area potentially available to saplings I have developed specific software tools, using Microsoft Visual Basic. For the first tool, called VORONOI, I have used an algorithm presented by Ohyama (2008) with O(n2) complexity. VORONOI is stand-alone software which is drawing the Voronoi diagrams using as input data the saplings coordinate placed in a spreadsheet. The user can obtain information regarding sapling neighbours by diagrams analyses. The Voronoi tessellation represents a natural method to select neighbouring trees, a difficult issue in assessing competition indices. The diagrams also offer information about spatial pattern of saplings – it's easier to determine if a pattern is aggregate or uniform.

The second software tool, named ARIA VORONOI, computes the area of each Voronoi polygon. These areas, equivalent to APA values, might be used as competition or aggregation index. Small values of APA might indicate competition pressure and great values of APA coefficient of variation might indicate aggregation of saplings for the analyzed plot.

This software was also developed in Microsoft Visual Basic. The input data represents the saplings Cartesian coordinates, extracted from a spreadsheet. The programme computes area of Voronoi polygons and several statistic indicators - the average, standard deviation and coefficient of variation of APA values. It is generated a grid and each cell of the grid is analyzed to asses which the generator point (sapling) is. The user can choose a grid size step in order to increase accuracy of determining APA values.

It was taken into account the edge effect, so the saplings with incomplete APA were eliminated from the analyses. User can specify a value for the buffer zone – in this way the APA is calculated only for the saplings located in the core area, even if the APA extends outside the core area. If the buffer zone is too small, in some exceptional cases, there might be saplings

located in the core area with incomplete APA (Figure 1). The algorithm computes also the convex hull and all the points (saplings) located on the convex hull are eliminated. The recommended size of the buffer zone is the average distance between neighbours corrected with the coefficient of variation (20 cm in this study).
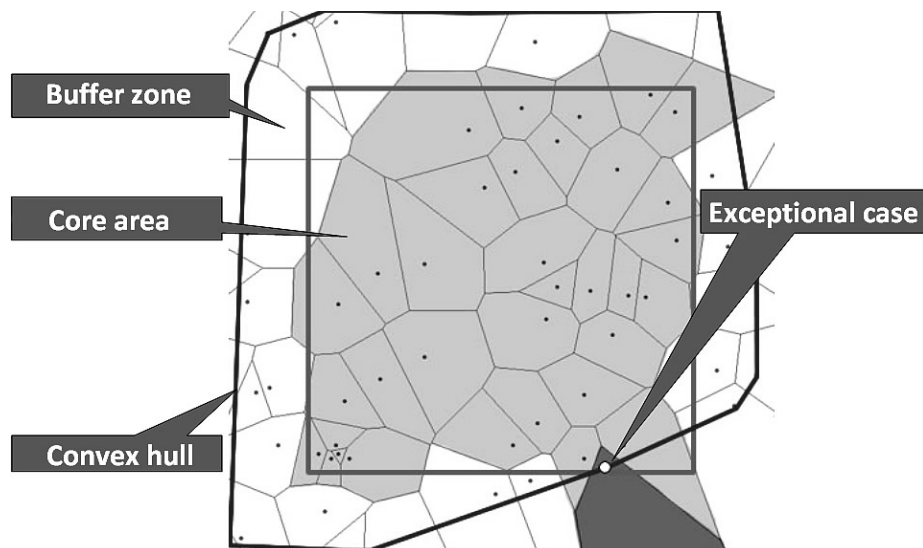
Figure 1: Voronoi tessellation - the buffer zone and the convex hull of a plot

2.2 Material and analyses

The study area is located in Flămânzi Forest District, parcel 50A, near Cotu, a small settlement situated in Botoşani County, Romania. The topography is almost flat, with a slope average of 2-3% and the altitude is around 140 meters. The area of the stand studied is 21.5 hectares and the species composition consists of 30% sessile oak, 20% oak, 30% common hornbeam, 10% small-leaved linden and 10% common ash. The area is regenerated naturally and the regeneration gaps were created in 2001-2002 and were enlarged in 2007. Within this stand a 2.5 hectare homogenous area covered in saplings was selected for further investigation.

I installed a network of ten permanent rectangular sampling plots (7 x 7 m) where I measured the characteristics of all saplings and seedlings. I used a GPS receiver in order to record the coordinates of the centre of each plot and I labelled every sapling and seedling inside the plot. The features of 7253 individuals were determined. The attributes assessed are: species, location of the individuals (x, y Cartesian coordinates), diameter, total height, crown insertion height, two crown diameters along the directions of axes and the latest annual height growth.

The analyses were based on areas of generated Voronoi polygons. There were studied the correlations between APA values and the main structural attributes (dimensional attributes, density), height growth and competition indices – Hegyi (1974) and Schutz (1989).

APA it was also used as a potentially spatial pattern indicator. There are several studies (Mercier, Baujard, 1997; Garcia, 2008) that point out there is a relation between APA values or APA coefficient of variation and the spatial pattern of a population of mature trees. This fact might be relevant to sapling populations, too.

In this case it was analyzed the APA coefficient of variation for each plot in relation with Morisita (1962) and Clark-Evans (1954) spatial pattern indicators. APA coefficient of variation might be an indicator of spatial distribution. In order to find a relationship between aggregation and APA coefficient of variation values I have used a statistical test to establish if there is a significant deviation from Poisson spatial distribution (from the complete spatial randomness - CSR hypothesis). I have generated 19 Monte-Carlo simulations for each plot, using SpPack software (Perry, 2004) to simulate a CSR distribution for the same area and the same number of

saplings. The extreme values of APA coefficient of variation produced the 95% confidence envelope of CSR hypothesis. Higher values of APA coefficient of variations would indicate significant deviations from CSR towards aggregation.

3. Result

At first I have studied the relation between APA and the main biometrical attributes. There were identified very significant correlations with low intensity of APA with sapling diameter (r = 0.23***) and crown diameter (r = 0.21***). This is an expected result because several researchers (Moore et al., 1973; Smith, 1987; Winsauer and Mattson, 1992) mentioned correlations of mature trees APA with the diameter or basal area.

Obviously there is a strong negative correlation between APA and sapling density (r = - 0.99 ***) and even between APA coefficient of variation and density (r = - 0.72 *). The uniformity tendency is more evident at a higher density.

Several studies (Moore et al., 1973; Winsauer and Mattson, 1992) indicate that APA might be correlated with growth and competition. Competition is one of the processes that shape the saplings spatial distribution. Consequently there were analyzed the correlations between APA and competition indices – Schutz index and Hegyi index computed in respect to diameter, height, crown volume and crown external surface. The strongest correlation is between APA and the Hegyi index calculated in respect to diameter (r = - 0.32 ***) and height (r = - 0.27 ***). In order to evaluate the performance of growth it was analyzed the correlation between APA and sapling height growth. Surprisingly, there is no correlation between these parameters (r = 0.08 *). Other studies indicated significant correlations between mature trees growth (diameter growth) and APA but sapling populations seem to be more dynamic than mature trees. This initial developing stage is very unstable regarding spatial distribution of the individuals so APA is a factor with a smaller impact on height growth.

Some authors (Mercier, Baujard, 1997) point out there is a relation between APA values or APA coefficient of variation and the spatial pattern of a population of mature trees. This fact seems to be relevant to sapling populations, because of the APA correlations with spatial pattern indicators – Morisita (r = 0.70 *) and Clark-Evans (r = -0.84 **). The APA coefficient of variation is also correlated with spatial pattern indicators Morisita (r = 0.88 **) and Clark-Evans (r = -0.58). Aggregated patterns lead to higher values of APA coefficient of variation (Figure 2).
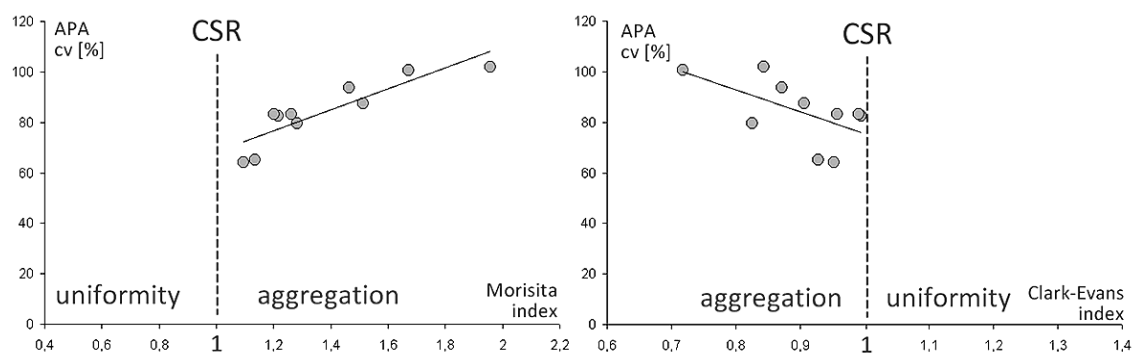
Figure 2: APA coefficient of variation values show aggregated patterns for both
Morisita and Clark-Evans indices

This detail shows that APA coefficient of variation might be used as an indicator of spatial distribution. The Monte-Carlo simulations indicate significant deviations from CSR towards aggregation - the values of APA coefficient of variation overcome the 95% confidence envelope for all the plots (Figure 3).
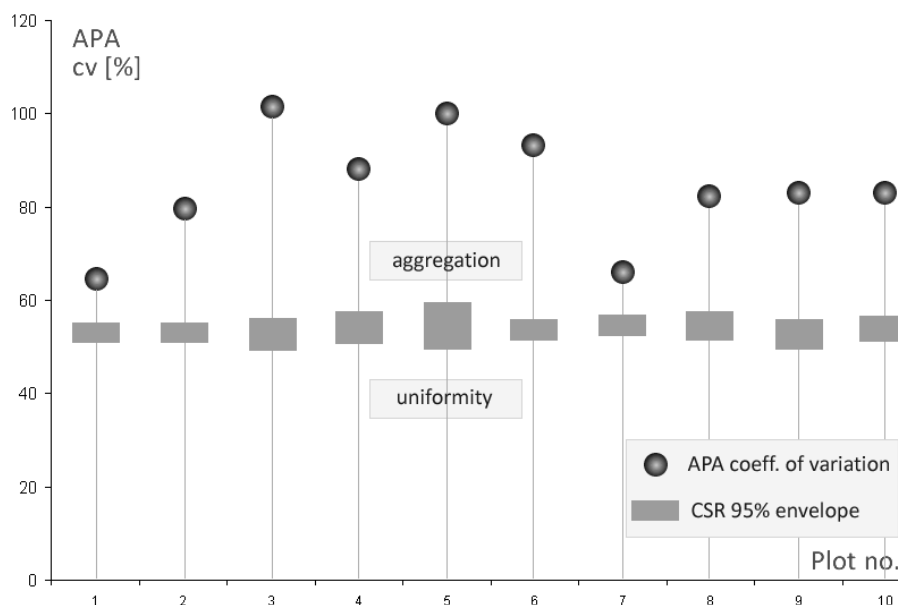
Figure 3: APA coefficient of variation values exceed the higher limits of 95% confidence envelope

4. Discussion

The results indicated that saplings APA have poor relationships with biometrical attributes. The reason might be the fact that APA takes into account only sapling position and no other biometrical feature. There is a solution - the generation of Voronoi weighted diagram in respect to some biometric parameter. VORONOI software has the capability to generate such diagrams. Still, there is one problem because it's very difficult to compute the area of the resulted cells.

In saplings population APA can be described as a low performance indicator of competition because there is no relation to height growth and there are low intensity correlations with competition indices. There might be a possibility to use APA in competition analyses in combination with other attributes, but not as a stand-alone indicator. However, one important aspect in assessing competition is that the non-weighted diagrams are the best mathematical solution to establish the neighbours of a sapling or tree. So APA might be used as a criterion for selecting neighbours. APA coefficient of variation is a straight-forward indicator with positive results as an indicator of spatial pattern. The significance of this indicator might be evaluated by comparing the results with the values of a confidence envelope.

APA in sapling populations is a complex and useful tool for characterizing population structure regarding spatial distribution, but seems more suited to mature trees.

I hope the development of software tools VORONOI and ARIA VORONOI will simplify and support further studies.

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Spatial and temporal dynamics and future trends of change in the coastal landscape of La Araucania, Chile

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Summary

In the coastal rim of La Araucania land use has significantly changed during the last 100 years mainly due to anthropic effects, though to significant natural events too. The aim of this study is to identify the direction and magnitude of change patterns that landscape units have had from 1980 to 2007. The analysis was made in base of information obtained by remote sensing and cadastral mapping of vegetation, evaluating the change of spatial patterns to propose a prospective model to 2017. The prospective method was based on Markov chain and Cellular automata. The results show significant changes in usage patterns, denoting especially forest expansion and fragmentation of natural habitats. For the year 2017, the survey indicates a trend of maintaining the forest, although, however, is expected for a stabilization in the fragmentation process.

Keywords: Coastal rim, landscape units, time series, Markov chains.

1. Introduction

The change in land use is one of the most relevant events in the relation between man and environment. While in many cases the spatial configuration of the territory is due to natural events, are human activities, in particular, economic activity, one of the main agents of change modelers (Van der Veen & Otter 2001; Fan *et al.* 2008; Koomen *et al.* 2008).

According to Peña-Cortés *et al.* (2009), original land use in coastal watersheds of La Araucania has significantly changed in the last 100 years. Landscape has been strongly altered by man and by important natural events like the earthquake and tsunami of 1960, and the recent one from February 2010, creating a cultural landscape dominated by an agricultural matrix and a matrix exponential occupation of forest from 30 years ago. In this sense, temporal analysis of landscape dynamics provides us with, on the one hand, some relevant information about ecological processes associated to magnitude and direction of the changes (Torrejón & Cisternas 2002; Bender *et al.*2005; Peña *et al.* 2006), also a historical synthesis of socio-economic events which resulted in the territory, and the evolution of state policies concerning the use of natural resources.

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Numerous investigations have attempted to develop scientists and planners on the dynamics of change and development of future projections of land occupation (Baker 1989; Cousins2001; Weng 2002; Luijten 2003; Jackson *et al*. 2004; Gómez-Mendoza *et al*. 2006; Fan *et al*. 2008; Wang *et al*. 2010), being widely used scenario and trend analysis (Koomen *et al*. 2008).

This paper presents an application of a series of indices and metrics related to the structure and temporary dynamics of landscape in coastal watersheds of La Araucania. The objective is to identify the direction and magnitude of usage patterns that landscape units have had from 1980 to 2007. It also proposes a scenario to 2017 based on Markov Chain and Cellular Automata in a GIS environment.

2. Methodology

The study area (figure 1) corresponds to the coastal rim of La Araucania, located between 38° 30' y 39° 30' of South Latitude and 72° 50' y 73° 30' of West Latitude. Its surface is 221.993 hectares distributed in four coastal watersheds: Moncul (44.747 ha), Budi (48.494 ha), Chelle (9.267 ha) y Queule river (69.144 ha), which are on a territory formed by mountain ranges, marine erosion platforms and extensive fluvial and marine plains (Peña-Cortes *et al*. 2006). According to Di Castri and Hajek (1976) the weather is oceanic with a Mediterranean influence and an average annual rainfall from 1200 mm to 1600 mm.

2.1 Mapping process

For the identification and analysis of land use coverages were used 1:60,000 scale aerial photographs for 1980, 1:20,000 For 1994 and also the regional classification of the cadastre vegetation resources of Chile (CONAF - CONAMA- BIRF 1999) updated in 2007 in 1:50.000 scale. In all cases we used satellite imagery in support of Landsat and Aster sensor.
On these images we proceeded to classify the various ground covers in a previously established categorization of 14 classes. For the analysis of spatial patterns and dynamic changes of use layers were reclassified into eight classes according to the type of coverage. The processing and data analysis was performed with the software Taiga Idrisi and ArcGis 9.3.

2.2 Analysis of landscape

The analysis of dynamics and patterns of landscape considered calculating magnitude and direction of changes during the assessed process. Among the first one, rates of change annual average for each class was obtained (TCC). For the detailed study of its temporal variation metrics were used at landscape related to the fragments, edges and complex forms described by Patton (1985) and Henao (1988). The heterogeinity of the landscape mosaic was evaluated by the diversity index and Shannon evenness. Regarding the direction of change, it was obtained by an evaluation pixel by pixel to its original state at time 0 to the next state at time 1. The result is given by the pixel number of class x (1-8) are transformed to the class and (1-8) over a period of time t (0-1).

2.3 Prospective model

For the development of a future projection for the current dynamics of the landscape, the method of Markov Chain was used. This produces a transition probability matrix for each landscape unit simulating a future scenario from the two previous statements. After the application of Markov chain, a stochastic projection algorithm was applied to evaluate the probability of each pixel to belong to either category of landscape. Finally, to address the lack of spatial dependence and topological criteria in evaluating the future scenario, we employed a

Cellular Automata algorithm, increasing the likelihood of belonging to a category based on its local proximity.

3. Results

During the period under review has seen a significant increase in the surface of the forest matrix dominated over other ground coverage, especially during the first 14 years of analysis. Moreover, the transition matrix classes and beaches and dunes, have experienced a steady decline over time. Regarding the projection to 2017 shows that the trend will continue with an increase forestry positive as the increase in the native forest, although the latter to a lesser extent. Table 1 shows the annual change rates for each type of landscape.

According to metrics that have characterized the evolution of landscape, it is observed a trend to increase the number of fragments to the end of the period of analysis, which however, slightly decreases in 2017 scenario. While 1994 showed a lower number of fragments, their average size was the largest of the series, which was associated with a low density of edges. The average shape index indicates that the fragments are generally amorphous except 2017 which corresponds to oblong oval, also presented an average fractal dimension gives them a moderate complexity. In relation to the indices of diversity were high for all years with patterns of evenness than 60% in all cases. The metrics of each year can be seen in Table 2.

Finally, in table 3 is presented the direction of changes occurred in landscape units beginning in 1980 represented by rows, through its new state in 2007 represented by columns. Units with more significant changes were wetlands and other wet lands, which became part of the agricultural matrix with almost 15.000 hectares.

4. Discussion

Landscape from the coastal rim of La Araucania is characterized by a marked anthropic difference (Peña *et al*. 2006, 2009). A signal of this is that prevailed coverages are related to productive activities like agriculture, silviculture and developing of human settlements, being these the one which presented major increases in surface from 1980 to 2007.

Regarding landscape patterns, showed a notable increase in the number of patches during the first 27 years of study, accompanied by a higher density and lower edges of medium size, what constitutes clear indicators of processes of fragmentation and habitat loss and it is also accentuated by the irregular shapes. In relation to the future scenario, it shows a tendency towards stabilization in the above processes, expressed mainly in a decrease in the number of fragments, the density of edges and shapes more regular and less complex than previous ones. Finally, in the period 1980-2007 the direction of changes greatly affected the natural areas with native forests, wetlands and thicket, becoming part of the forestry and agricultural matrix, however, the latter also decreases in surface transition to forest matrix, which was identified as the main agent of change in the current configuration of the landscape of the coast rim.

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Table 1: Variation between years for types of landscapes present in the coastal rim of La Araucanía.

Landscape units	1980-1994 (%)	1994-2007 (%)	2007-2017 (%)
Human settlement	4,00	1,30	-0,50
Native forest	-1,90	0,30	0,30
Waterbody	0,80	0,00	-0,90
Wetland and other wet terrains	-10,20	2,10	-2,30
Agricultural matrix	3,00	-1,50	-0,70
Transition matrix	-8,40	-2,50	-1,00
Forestry matrix	15,70	5,60	2,20
Beaches and dunes	-0,40	-5,00	-3,30

Table 2: Temporal variation of the metrics of landscape in coastal rim of La Araucania
TA =total area; NP= total patches; MPS= medium patches size; ED= edges density; TE= total edges; medium shape index; MFRACT= medium fractal dimension.

Metrics	1980	1994	2007	2017
TA (Ha)	166.034	165.835	165.835	165.831
NP	911	873	2.221	1.763
MPS	166.38	288.24	167.58	105.08
ED (m/Ha)	60.03	46.07	74.94	50.87
TE (Km)	9.967	7.64	12.427	8.435
MSI	2,46	2,02	2,1	1,65
MFRACT	1,32	1,3	1,37	1,29
Shannon's Diversity	1,26	1,36	1,46	1,45
Shannon's Evenness	0,75	0,65	0,7	0,69
Dominance	0,51	0,71	0,61	0,62

Table 3: Direction of change in landscape units in the coastal rim of La Araucania.
1= human settlements; 2= native forest; 3=waterbody; 4= Wetland and other wet terrains; 5= agricultural matrix; 6= transition matrix; 7= Forestry matrix; 8= beaches and dunes

2007

Landscape Units	1	2	3	4	5	6	7	8
1	146	0	5	0	8	0	1	2
2	3	14.343	38	952	8.567	1.470	8.475	25
3	9	45	7.018	233	557	46	33	71
4	105	2.509	1.343	6.035	13.908	591	2.265	115
5	65	3.935	481	974	48.876	1.031	7.921	12
6	0	4.684	6	166	6.207	2.798	14.780	18
7	0	367	0	16	311	23	1.108	1
8	14	4	115	98	600	433	552	1.318

(Left margin label for rows: 1 9 8 0)
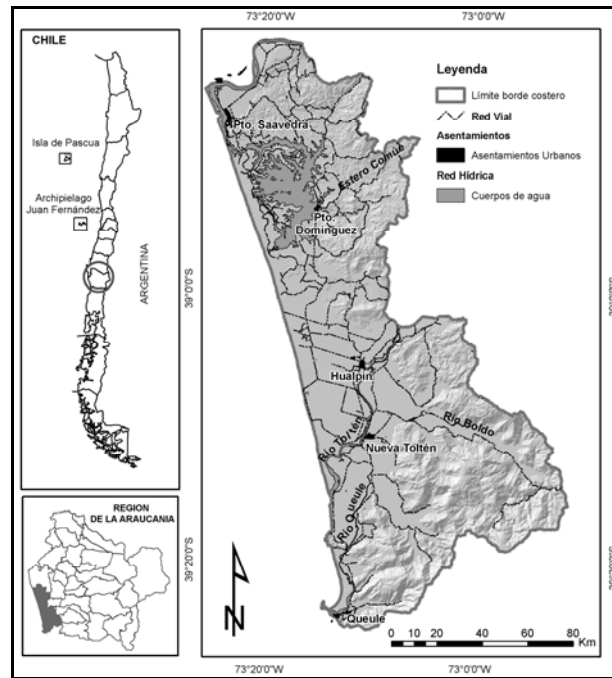
Figure 1: Study area. Elaborated by author.

Multi-temporal analysis of forest landscape fragmentation in the North East of Madagascar

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Abstract

Habitat fragmentation caused by insufficient arable land and rural poverty has become a main concern to tropical forest managers in Madagascar. In order to inform management decisions, the present study aims to provide quantitative information on the fragmentation process and its driving forces in Manompana. Therefore, time series analysis of fragmentation in relation to the spatial distribution of settlements, roads and topographic parameters was done. Results showed that (1) deforestation has been increasing due to expanding upland rice production, thus progressively increasing landscape fragmentation (2) fragmentation dynamic significantly differed with distance to paths, villages and depending on topographic characteristics. In the following these parameters will be used for spatio-temporal modeling of the landscape dynamics to support decision making on sustainable management of natural resources.

Keywords: landscape, fragmentation, tropical humid forest, spatial analysis, Madagascar.

1. Introduction

Fragmentation refers to breaking a whole into smaller pieces while controlling for changes in the amount of habitat (Forman 1995, Fahrig 2003, Ewers 2006). Deforestation is one driver of habitat fragmentation. Fragmentation often results in the loss of habitat and the isolation of the remaining forest fragments. It creates matrices of human-managed areas, secondary vegetation regrowth, and fragments of primary forest (Benitez-Malvido 2003).
The region of Manompana, is a disturbed tropical lowland rainforest,forming a forest corridor between two protected areas with very high levels of endemism: the special reserve Ambatovaky in the South West and Biosphere Reserve of Mananara Nord in the North. In the region of Manompana forest clearing due to slash and burn agriculture and commercial logging are the main drivers of deforestation and thus habitat fragmentation, affecting the landscape structure, the livelihoods and the biodiversity (Forman & Godron 1986, Andren 1992, Reed 1996, Franklin 2001, McGarigal 2002, Kuppfer 2006, Jaeger 2000, Collinge 2009).
This paper aims to study spatio-temporal patterns of landscape fragmentation at a regional scale, i.e. the fragmentation of the forest ecosystem in Manompana in order to inform management decisions.
Therefore, land cover predictions for future were made using SPOT 5 multispectral, multiband images (V 0,50 -0,59 µm R 0,61 -0,68 µm Near InfraRed or NIR 0,78 -0,89 µm and Mean InfraRed or MIR 1,58 -1,75 µm) with a 10 meters resolution from 2004 and 2009. Furthermore,

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we focused on identifying the main factors that play a direct role in shaping the spatial variations in forest cover.

We will start with a description of the data sources and the process of analysis adopted in the study and finally discuss directions and needs regarding the sustainable management of natural resources.

2. Methodology

2.1 Study area

Manompana is situated on the eastern coast of Madagascar (752144 in the East and 1041646 in the north, Laborde Coordinates). This region experiences a warm and humid climate. Rainfall is reliable, and arises throughout the year with a mean annual rainfall of 3677 mm (Weather station at Soanieràna Ivongo, 2009). The wettest months are March and April at the beginning of winter. The temperature lies always above 21°C with a mean annual of 23,7°C (Weather station at Soanieràna Ivongo, 2009). The forest vegetation is typical of tropical lowland rainforest dominated by *Anthostema madagascariensis* and family of Myristicaceae (Guillaumet and Humbert 1975).

2.1.2 Data processing and classification

There are many methods for detecting land cover changes available in the literature such as image differencing and post-classification. In the current study, image differencing was adopted (Singh 2009). This method is used mainly to detect areas with significant land cover changes and does not require atmospheric correction, but requires careful classification of "change / persistence" thresholds.

In detail we followed the succeeding steps. First, the study area was extracted from the respective scene. In a second step, the forest components were identified using the classic method of radiometric intervals. The unsupervised classification was done using the application ISODATA (Iterative Self-Organizing Data Analysis Technics), the supervised classification was done using the application Maximum Likelihood in Arc Map 9.2, Arc view 3.2a and ENVI or *Environment for Visualizing Images* software (Gonzales 1988, Barrett and Curtis 1976). First, ISODATA calculated class means pixels evenly distributed in the data space. Consequently, it iteratively clustered the remaining pixels according to their reflectance (including the diffuse radiation by the atmosphere, the radiation reflected by the pixel and the radiation reflected from neighbouring pixels) using minimum distance techniques. Each iteration recalculated the means and reclassified pixels with respect to the new (class) means. This process continued until the number of pixels in each class changed by less than the selected pixel change threshold or until the maximum number of iterations is reached. Next, Maximum Likelihood methods were applied. This supervised classification assumed that the values for each class in each band are normally distributed and calculated the probability that a given pixel belongs to a specific class. Unless a probability threshold was selected, all pixels were classified. Each pixel was assigned to the class (forest, non forest) that had the highest probability.

Finally, the fragmentation index was analyzed by pattern analysis. Fragmentation is a measure of the ecological quality of a habitat. In order to compute it, the following kernel-based formula (1) was used:

$$\text{Fragmentation} = (n - l)/(c - 1) \quad (1)$$

where n is the number of different land-cover classes present in a kernel, and c the number of cells considered (Monmonier, 1974). The kernel represents the similarity between two cells defined as dot-product in the new vector space.

For this computation, a 3 by 3 kernel (majority filter) was used so that c equalled 9.This interval choice was linked to the importance of reflectance. A reflectance of 100% means that the surface reflects all solar energy in the atmosphere. This corresponds to a fragmentation index of 0. When the reflectance is 0%, the fragmentation index equals 1.

2.1.3 Change analysis

Land cover maps from two different dates, 2004 and 2009, were used to make land cover predictions for 2010. Using Land Change Modeler (Eastman 2006), this was done in two major stages: the transition potential sub-model, which is developed in this paper, stage and the change prediction model stage. A transition sub-model consists of a single land cover transition or a group of transitions that are thought to have the same underlying driver variables. In the first stage, particular transitions of interest for the sub-model and the variables which are assumed to drive the transitions taking place were specified. Variables considered as drivers of deforestation were distance to rivers and streams, paths, villages and to topographic parameters. Using Cramer's V or Phi statistic the strength, association or dependency between two variables (Agresti 2002) was analyzed. The closer V is to 0 when the smaller ie the association between the categorical variables X and Y. On the other hand, V being close to 1 is an indication of a strong association between two variables.

Afterward, gain and loss of fragmentation (forests cover) area were calculated between two periods with the aim to determine the rate of fragmentation in the study area.

3. Results

3.1 Fragmentation Index

The fragmentation was classified in two groups depending on the fragmentation index: a) a forest fragment was considered to have a low level of fragmentation when the index was between [0; 0.1[, b) a forest fragment was considered to have a high level of fragmentation when the index was within the interval [0.1; 1].

Table 1 shows the fragmentation index. In 2004, the index ranged from 0 to 0.875 while in 2009 the values were between 0 and 0.25. The reasons for this difference could be either a) the luminosity at the time when the images were taken was not the same or b) the forest fragments of 2004 have been converted into less fragments in 2009, which is not evident in the short period. In terms of patch numbers, there is a large difference between 2004 and 2009. 17 % of forests cover with low fragmentation in 2004 shows a high level of fragmentation or has been converted into other land uses in 2009.

Table 1: Fragmentation index characteristics

Period	Total area	Count	Minimum	Maximum	Mean	Standard deviation	Patches number	
							Low fragmented class	Fragmented class
2004	30487	18918482	0	0.875	0.054	0.01	65535	5633
2009	22472	18918482	0	0.25	0.017	0.01	11231	6442

3.2 Fragmentation forest area

In terms of forest area, a decrease (occurred during the period under review) was observed between the two periods. A deforestation rate of 5.25 % per year was calculated. Figure 1 explains that 46% of low fragmented forest was changed into the other land use classes in 2009. Approximately, most of the forested area lost has been converted into cropland and only 36% in highly fragmented forest. In fact, there has been a tendency of highlighting small-scale migratory farmers and "poverty" as the major cause of landscape change.

In spite of increased fragmentation, the "gains and losses' analysis showed that some fragments persisted. In reality, more or less 35% of the total forest area resists change. These values illustrate landscape changes at a very high rate. And if there is no action taken soon, large amounts of habitat and biodiversity values will be lost.
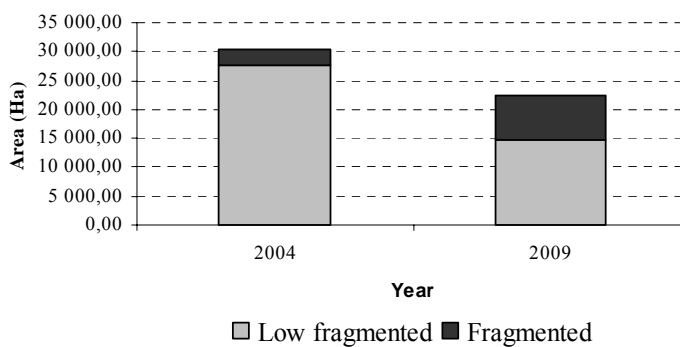
Figure 1: Forest area change from 2004 to 2009

3.2 Change analysis

The impact of distance variables (distance to streams, rivers, paths, villages and topographic parameters) on landscape changes was calculated. Cramer's V test revealed that a) the selected distance variables did not influence low fragmented forest patches because V equal 0; b) distance to path and topographic parameters did, however, impact high fragmented forest patches (see figure 2).
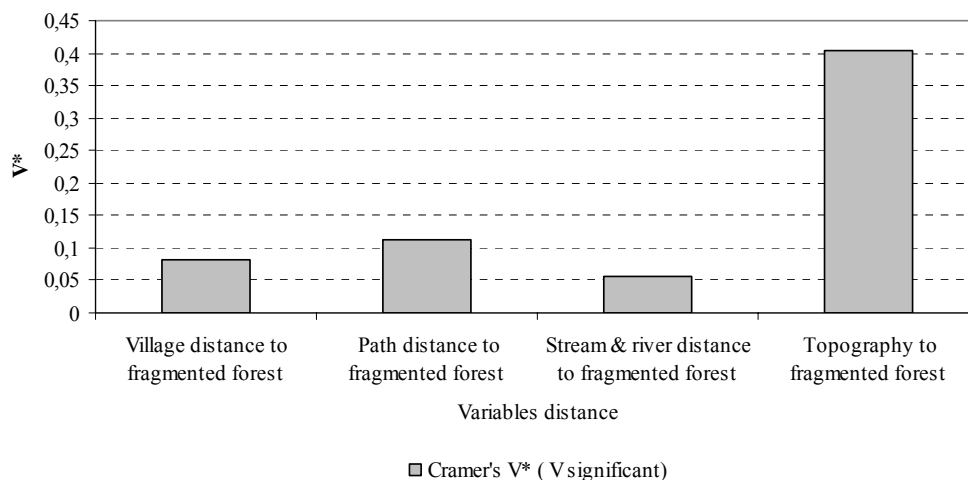
Figure 2: Test of driver variables

4. Discussion

The annual deforestation rate was estimated to be 5.25%. This is very high in comparison to the national rate of 0.3 % (FAO, 2009). This means that the pressure on the forest in the area of Manompana is extremely high. In this part of the country, the local population does not produce enough rice to feed their family, there is a chronic shortage. The rice needs are merely satisfied on an average of nine months per year. The rest of the year people resort to other products, mainly cassava, yams and bananas, as it is often not possible to buy rice during this starvation period. The development of irrigated rice production is hampered by various factors, such as topographical, technical, socio economic and policy. Thus, to maximize production, slash and burn agriculture has remained the main method of food production so far. Therefore, the deforestation is continuously increasing for upland rice production and the landscape is becoming progressively more fragmented. The land use change map and examination of the driving variables of deforestation indicate that distance to topographic parameters and to paths has the highest impact on forest fragmentation, followed by distance to villages, rivers and streams. Topography is an important factor impacting fragmentation. Most likely, because local people's choice of land clearing is strongly related to it. For example, local people prefer areas where slopes are not too steep and land less windy because of climate. Paths are the only way of communication in inaccessible areas. Thus, to access a forestland, the local population opened paths along the forest edge or in the forest itself.

The result from this study will be able to contribute to the objectives of conservation. Indeed, if the variables remain more or less the same in the coming years, meaning that there is no opening of new paths or migration (village), and pertinence area doesn't change, so biodiversity richness biodiversity is maintained.

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Patterns of afforestation process in abandoned agriculture land in Latvia

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Abstract

Afforestation of the former agriculture land is one of the most typical trends of the contemporary Latvian rural landscape. The study examines development of landscape ecological succession, its spatial character and influencing environmental factors within abandoned agriculture land in Vidzeme, central part of Latvia. The study area comprises a great variety in the spatial dynamics of the ecological succession. Character of the ecological succession is influenced by various factors like soil fertility, moisture and light conditions, species composition of surrounding forest, former land use etc. The study aims to assess impacts of these factors on dynamics of afforestation process in order to predict its future development.

Keywords: abandonment, afforestation, landscape ecological succession, environmental factors

1. Introduction

Land abandonment and related natural afforestation process is typical feature of contemporary landscape in marginal areas all over the Europe and most probably this trend will last for the coming years - modelling of land use development in Europe until 2030 shows decline of agricultural land as one of the major factors influencing European landscape in future (Stoate et al 2009). In Latvia afforestation process has been noted from the beginning of the last century, resulting from frequentative change of political and economic situation – if in 1935 forest occupied ca. 27 % of the land area, than by 2008 its area has almost doubled, reaching ca. 50 % (Ministry of Agriculture 2009; Nikodemus et al. 2005). During the last ten years forest area has increased mostly due to natural afforestation, twice exceeding artificial afforestation. This is related to extensive land abandonment after regaining of independence from Soviet Union in 1991 and the following collapse of the collective farming system, urbanisation process and land reform (big share of the agriculture land was retrieved by the former land owners, presently living in city and having not much interest in farming).

In the recent years land abandonment has become an important issue in scientific research, questioning what are the factors influencing this process, how it impacts the landscape structure and biodiversity as well as the potential of abandoned land for use of natural resources or restoration of habitats. Socio-economic and political factors driving the marginalisation process and land abandonment are well studied. However little is known about impacts of environmental factors on ecological succession process and related changes in the landscape spatial structure. Some authors argue that role of these factors is less significant compared to socio-economic factors (Łowicki 2008; Mander et al. 2004).

Though one should bear in mind that once the land has been abandoned, the ecological succession process takes over and environmental factors becomes determinant. The course of

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afforestation, its spatial character and species composition will depend on factors like soil (its chemical properties and humidity), terrain, initial herb layer, nearby forest, as well as former land use (Prach et al. 2001a; Prach et al. 2001b; Barth et al 2003; Alard et al. 2005; Daugaviete 2009; Kopecký and Vojta 2009; Rosenthal (in press)). Depending on interaction of these factors ecological succession might be either arrested or stimulated as well as leading to different succession patterns.

Afforestation of abandoned landscape has significant effect on landscape structure and its ecological functions (Reger et al. 2007; Stoate et al. 2009). Impacts on biodiversity might varying – at the initial stage of afforestation habitat diversity is increasing, while in long term perspective landscape becomes more homogenous thus reducing also biological diversity (Fjellstad et al. 1999; Nikodemus et al. 2005; Sitzia 2010). Abandonment of agricultural land is reducing areas important for resting, feeding or breeding of migratory birds. However secondary succession process might be used also for restoration of natural habitats and increasing of abundance of related animal species (Prach et al. 2001a; Stoate et al. 2009).

Land abandonment also influence the scenic quality of landscape and its identity which might psychologically deject inhabitants causing feelings like isolation, poverty, shame etc. (Bürgi 2004; Palang et al. 2006; Benjamin 2007). Better understanding the role on environmental factors in the process of landscape ecological succession would help to predict the course of its development and to make optimal choice for the future use of the abandoned land.

2. Methodology

The study analyses the spatial character of landscape ecological succession and its influencing environmental factors at the local level within selected pilot areas. The study area comprise an abandoned agriculture land in Vidzeme, central part of Latvia, which represents typical rural landscape including scarcely populated areas in the Gauja River valley bordering the strict reserve zone of the Gauja National Park, as well as more densely populated areas in vicinities of towns Sigulda, Līgatne and Taurene. The pilot areas of the study have been chosen by visual analysis of the latest available ortophoto images from 2007. The most distinct patterns of landscape ecological succession within the study area were selected, covering different spatial character of shrub and tree patches and their species composition. As result 5 pilot areas have been chosen representing 4 patterns of landscape ecological succession (see Table 1).

During the field visits actual borders of woody patches have been mapped as well as density and composition of woody species have been assessed at the sampling sites of 10x10m, by recording each tree and measuring their height. Sampling sites were selected within each patch, thus their number was dependent on size of pilot area and complexity of the secondary succession pattern (20 sampling sites in 1st pilot area; 24 - in 2nd pilot area; 26 - in 3rd pilot area; 14 - in 4th pilot area and 15 - in 5th pilot area).

Environmental conditions and factors were described in the investigation areas. Altogether 13 soil profiles were described during field works according to the international FAO WRB classificator (IUSS Working Group WRB, 2007), 57 soil samples were collected from soil profile diagnostic horizons and physical and chemical analyses were done in the laboratory according to the methodology of *ICP* Forest monitoring (Manual on methods…, 2006). Impacts of nearby forest stand and its species composition on the character of ecological succession have been defined by analysing the forest taxation maps obtained from the State Forest Service. Impacts of drainage systems have been analysed using the melioration maps of the former collective farms. Information on former land use and period since agriculture practice has been given up were obtained from local inhabitants and landowners by direct interviews at the pilot

areas. Dynamics of ecological succession process has been analysed comparing the latest ortophoto images from 2007 with earlier ones from 1997-1998 and 2003-2004.

3. Results

3.1 Development stage and character of landscape ecological succession process

Within the study area 4 patterns of landscape ecological succession could be distinguished: linear development of succession; mosaic development of succession; continuous development of succession and development of succession from edge of a forest (see Figure 1).
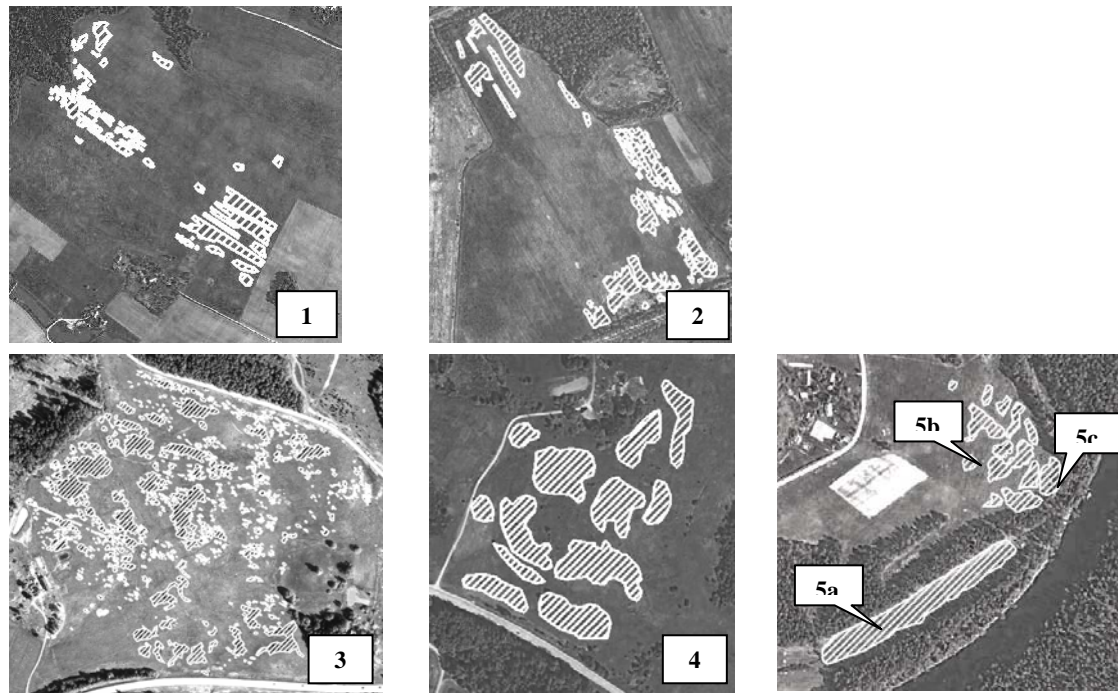
Figure 1: Patterns of landscape ecological succession: 1; 2 - linear development of succession; 3; 4; 5b - mosaic development of succession; 5a - continuous development of succession; 5c - development of succession from edge of a forest.

The most typical pattern in study area is linear succession, where natural afforestation process starts as linear patches following the ploughing direction. Two representative examples of this pattern are found in 1st and 2nd pilot area. Both areas are placed within larger agriculture fields (425 ha and 376 ha) previously used for crop production. Development of tree cover in these areas has started ca. 10 years ago (4-5 years after abandonment) and it is formed by deciduous trees - *Betula pendula* and *Salix spp.* Dominant species within the 1st pilot area is *Betula pendula,* forming mostly sparse stands (up to 50 trees per $100m^2$) with few more dens patches (up to 126 trees per 100 m^2). Height of the trees in these stands reaches 8 m at maximum. The topography of the area is rather plain with prevailing soil groups: Stagnosols, Arenosols, Luvisols and Phaeozems (according to FAO WRB classification). In 2nd pilot area dominant are *Salix spp.* forming visually dense stands, although the number of trees per $100m^2$ also mostly are bellow 50. Height of trees reaches 11 m both for *Betula pendula* and *Salix spp.* Also the topography of this area is plain with widely distributed soil groups: Stagnosols and Gleysols.

Mosaic landscape succession is represented at 3rd, 4th and 5th pilot area. This pattern can be characterised by higher diversity of woody species and irregular shapes of patches. The size of the surrounding agriculture fields is smaller than in two previous cases (134 ha, 102 ha and 38 ha). In 3rd pilot the most common tree species is *Betula pendula,* however few patches are

dominated by *Picea abies.* Tree cover is mostly forming sparse stands. Height of *Betula pendula* reaches 10. In 4th pilot area the most widespread species is *Picea abies,* but also *Salix spp.* and *Betula pendula* are frequent. Maximum height of trees is 9 m. In 5th pilot area mosaic succession pattern is dominated by *Betula pendula* with rather high share of *Picea abies* and *Pinus sylvestris.* The highest trees reach 8 m. In this area tree stands are mostly dense (more than 50 trees per 100 m^2). In all these pilot areas tree species cover has started to develop ca. 10 years ago. The topography of the 3rd and 4th pilot area is slightly waved, and the distribution of soil cover is rather complex, including Luvisols, Phaeozems, Stagnosols, Gleyosols, Planosols, as well as Arenosols and Podzols. In 5th pilot area the topography is plain and mostly covered by Luvisols, Stagnosols, Gleysols and Arenoslos.

Continuous succession pattern has been observed at one part of the 5th pilot area – a narrow field in earlier years used as arable land, but later regularly mowed. The tree cover has developed just recently - during the last 2-3 years, forming rather dense stand (up to 150 trees per 100 m^2) dominated by *Betula pendula* up to 3 m height. Development of succession from the edge of a forest is the most explicit at the 5th pilot area where it is combined with mosaic succession pattern. However also in 1st and 2nd pilot area influence of the forest edge or nearby forest stand on development of linear succession pattern can be observed.

Table 1: Character of landscape ecological succession in pilot areas

Pilot area	Pattern of succession	Year since is abandoned	Dominant tree species	Total area of the agriculture field (ha)
1. pilot area village Nurmiži	linear from forest edge	1996	*Betula pendula* 65% *Salix spp.* 35%	425
2. pilot area near farmstead "Gobas"	linear from forest edge	1996	*Salix spp.* 71% *Betula pendula* 29%	377
3. pilot area near village Ieriķi	mosaic	1995	*Betula pendula* 74% *Picea abies* 18% *Pinus sylvestris* 5,4%	135
4. pilot area village Taurene	mosaic	1995	*Picea abies* 55% *Salix spp.* 19% *Betula pendula* 14%	102
5. pilot area near village Inciems	continuous; mosaic; from forest edge	2000	*Betula pendula* 62% *Picea abies* 23% *Pinus sylvestris* 12%	38

3.2 Impact of species composition of surrounding forest on ecological succession process
Unfortunately forest taxation information was not complete (it did not include all forest stands bordering the pilot areas) therefore comprehensive analysis of relation between species composition in the forest stands and secondary succession patches was not possible. However from the available information it is obvious that tree species composition not always correspond between the succession patches and the surrounding forest. For example in 3rd pilot area composition of the dominant species is similar (*Betula pendula* 50 % - in forest, 74 % - in succession patches; *Picea abies* 23 % - in forest, 18 % - in succession patches), while less dominant species present in forest (e.g. *Populus tremula* – 13 %; *Alnus incana* – 11%) can hardly be found within the succession patches. In the 2nd pilot area where secondary succession patches are formed by *Salix spp.* - 71 %, *Betula pendula* - 29 %, *Picea abies* - 0,1 %, *Alnus incana* - 0,1 %, the species composition of surrounding forest stands is different (*Betula pendula* -53 % and *Populus tremula* – 26 %, including also *Picea abies* - 8%, *Alnus incana* - 5 % and *Pinus sylvestris* – 3 %).

3.3 Impact of soil conditions on ecological succession process

Information from soil maps obtained from State Land Service as well as from soil sampling carried out in the pilot areas mainly do not show direct impact of soil groups and its chemical properties on spatial distribution and character of the ecological succession patches (see Figure 2). Nevertheless, relationship between soil groups and its chemical properties have been recognized within the 3rd pilot area. There it was established that development of shrubs and trees are faster on the soils characterized with poor nutrient status, but on fertile soils this process could be considerably delayed.

Legend
Pilot territory
Development of ecological succesion
Planosols
Podzols
Phaeozems
Stagnosols
Arenosols
Gleysols
Luvisols

Figure 2: Soil conditions in pilot area 1 and 3.

4. Discussion

The study shows that relation between character of landscape ecological succession and such environmental factors as soil properties and species composition of surrounding forest are rather ambiguous, if viewed separately. Development of ecological succession depends on interactions of various factors like topography, geology, level of ground waters, soil and its chemical properties. The previous land use and initial stage of succession prescribed by herbaceous species colonising the abandoned fields also has significant role in this process (Prach et al 2001b; Kopecký and Vojta 2009; Rosenthal (in press)). For example in some cases higher soil fertility can enhance the growth of shrubs, while in another it might increase density of herb layer, thus solving down the course of succession by competitive exclusion of trees (Alard et al 2005).

Furthermore distribution of seeds of woody species depends on dominant winds as well as size and configuration of the field. Although some studies highlight importance of distance from the seed stand and species composition of the seed stand as decisive factor in development of secondary succession (Daugaviete 2009), we consider that degree of influence of this factor depends on size of the field as well as heterogeneity of environmental conditions. In very large and fields with strait edges and plane topography having uniform environmental conditions the afforestation process starts form the edge of forest and might develop into linear patches, while in smaller fields with more complex shapes and hilly topography, where environmental conditions are more diverse, the pattern of secondary succession is rather complex, usually developing as mosaic patches, not always having direct connection to the forest edge. In very small fields surrounded by forest continuous succession might develop covering simultaneously all the area in rather short time.

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Nitrogen retranclocation in pure and mixed plantations of *Populus deltoides* and *Alnus subcordata*

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Abstract

Nutrients allocated to green leaves are recycled through 4 parallel pathways: herbivory, throughfall, foliar resorption and litter decomposition. Nutrients recycled trough each pathway may be of similar magnitude. *Populus deltoides* and *Alnus subcordata* were planted in five proportions (100P, 67P:33A, 50P:50A, 33P:67A, 100A) in Noor, Iran. After 7 years, the effects of species interactions on nutrient retranslocation were assessed. Leaves were collected from the bottom one-third of the tree. Six representative trees (two near the center of sub-plot and one in each corner of it) of each species were sampled for fully expanded leaves. Senescent leaves were also collected from each species in each sub-plot. The Nitrogen retranslocations of both species were not significantly differed between the different proportions also it was not different between the two species. Finally, it should be implied that nutrient retranslocation was not differed as a result of mixing these species at this age.

Keywords: Mixed plantations, Nutrient Retranslocation, Nitrogen fixing tree

1. Introduction

Tree plantations with different purposes are widespread activity all over the world. Almost all the industrial plantations are monocultures, and questions are being raised about the sustainability of their growth and their effects on the site (Khanna 1997). Poplars (*Populus* L. spp.) are preferred plantation species, because their fast growth is expected to meet the extensive demands of wood for poles, pulp and fuel (Kiadaliri 2003; Ghasemi 2000; Ziabari 1993). Repeated harvesting of fast-growing trees such as poplar plantations on short rotations may deplete site nutrients.

Nitrogen losses are likely to be very important for future growth. Therefore, it is appropriate to explore new systems of plantation management in which N may be added via fixation (Khanna 1997). Mixed plantation systems seem to be the most appropriate for providing a broader range of options, such as production, protection, biodiversity conservation, and restoration (Montagnini et al. 1995; Keenan et al. 1995; Guariguata et al. 1995; Parrotta and Knowles 1999).

Nutrients allocated to green leaves are recycled through 4 parallel pathways: herbivory (feces and dead bodies), throughfall, foliar resorption and litter decomposition. Research often focuses exclusively on decomposition, but the fraction of nutrients recycled trough each pathway may be of similar magnitude. This fraction varies with the nutrient considered, the species and the climatic conditions. For example, leaf nitrogen recycling is estimated to be 10% through herbivory, 5% through throughfall, 40% through resorption and 45% through litterfall and subsequent decomposition. Locally, the chemical and physiological characteristics of leaves

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may relate to the ecological status of the species (pioneer vs. late successional species, sun vs. shade tolerant species). Litter chemistry is determined both by the chemistry of green leaves and by the nutrient resorption. The latter has not been given enough attention despite its major role in nutrient conservation both at the individual and ecosystem level (Binkley and Menyailo 2005).

Thus in this paper, we focus on N resorption in pure and mixed plantations in order to increase our understanding of the ecology of these tree species in this region. Therefore our question is: Are there differences in the degree of internal cycling of N (resorption) of each species in different proportions? And dose it differ between the two species?

2. Methodology

2.1 Study site

The study area is located at the Chamestan experiment station, in Mazandaran province, on the northern parts of Iran (36º29'N, 51º59'E). Experimental plantations were established in 1996 using a randomized complete block design that included four replicate 40 m × 40 m plots of each of the following treatments: (i) *Populus deltoides* (100P), (ii) *Alnus subcordata* (100A), (iii) 50% *P. deltoides* + 50% *A. subcordata* (50P:50A), (iv) 67% *P. deltoides* + 33% *A. subcordata* (67P:33A), (v) 33% *P. deltoides* + 67% *A. subcordata* (33P:67A). Tree spacing within plantations was 4 m × 4 m and tow species were systematicly mixed within rows.

2.3 Leaf

Leaf samples were collected from the stands in September 2003. Leaves were collected from the bottom one-third of the tree by clipping two small twigs located on opposite sides of the crown. Six representative trees (two near the center of sub-plot and one in each corner of it) of each species were sampled for fully expanded leaves. In addition, senescent leaves were collected from each species in each sub-plot. The samples were dried at 65ºC and ground prior to analysis. Nitrogen was analyzed using the Kjeldhal.

2.5 Statistical Analyses

The percent of retranslocation efficiency was calculated from the fallowing formula (1):

$$R = \frac{A-B}{A} \times 100 \qquad (1)$$

In this formula A is the weight of each nutrient in fully expanded leaf and B is the weight of that nutrient in leaf litter. The percent of retranslocation between the species and for each species in different treatments were compared using general linear model analysis of variance (ANOVA) tests. Normality of the data was checked for analyses. Statistical analyses were done using SAS 9 software.

3. Result

The Nitrogen retranslocations of both species were not significantly differed between the different proportions. *Alnus* Nitrogen retranslocation was higher in pure plantations than the mixtures, but for *Populus* it was higher under 67%P: 33%A than the other treatments. Nitrogen retranslocation also was not different between the two species, whereas the retranslocation in *Alnus* as Nitrogen fixing tree was lower than *Populus* (Figure 1).
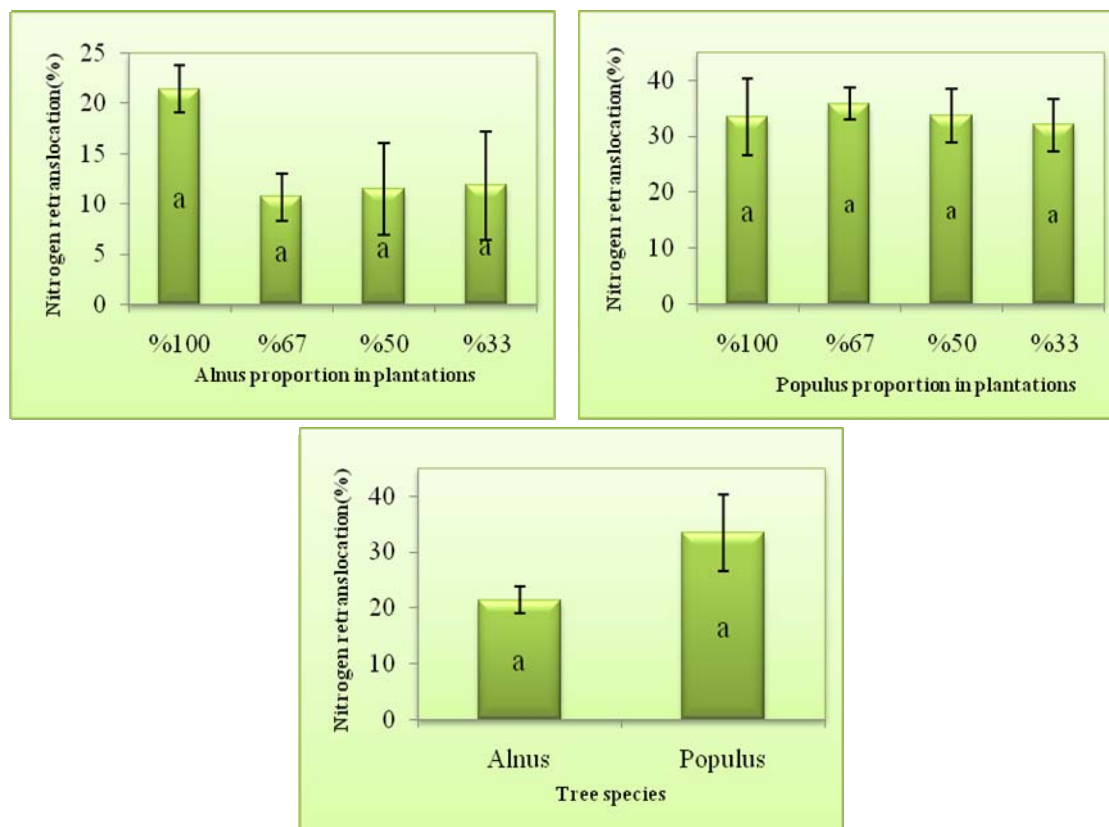
Figure 1: N retranslocation of each species in mixed plantations and between the two species in pure plantations

4. Discussion

In line with our results, Parrotta (1999) showed that N retranslocation were not significantly different among treatments for *Eucalyptus*. He implied that this result suggest that the association with either Nitrogen fixing species is not (yet?) having any positive influence on nutrient availability of *Eucalyptus*. The same conclusion could be stated for the current results. It means that the species have not any effect on nitrogen cycling of other one. In contrary to our results about the two species Cuevas and Lugo (1998) found different nitrogen retrenslocation between the species. In this case it could be concluded that the nitrogen requirements of these two species at this age are similar, although *Alnus* had the lower retranclocation. Finally, it should be implied that nutrient retranslocation was not differed as a result of mixing these species at this age.

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Evaluation of the ecosystem service in the forest formations of Biosphere Reserve "Srebarna", Northeastern Bulgaria

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Abstract

The investigation observes the basic parameters in ecosystem services of the forest formation on the territory of Biosphere Reserve „Lake Sreburna". Wetland system is a part of Danube catchments. Importance of the lake depends of rich biological and landscape diversity. The most important are bird colonies of Dalmatian pelican and waterfowl birds.

Forest formations in the lake and around the wetland systems are natural place for nesting and spreading of the bird populations. They are dominated of willows and popular species. The forest formations in Danubian islands have high level of importance as quality and diversity of the ecosystem services. They are flooded for the different period of time during the high Danube waters. This process reflects and determines the complex of ecosystem services in the reserve.

The results of the research can use for optimization of nature protection and conservation activities in the Biosphere Reserve „Srebarna" and the territories around the wetland system.

Keywords: ecosystem services, forest formation, evaluation

Introduction

Ecosystems provide different ecosystem services. The concept of ecosystem services deals with the benefits that humans gain from natural processes and ecological functions (Costanza et al. 1997). Ecosystem services are supporting (nutrient cycling, soil formation, primary production etc.), provisioning – referring to the resource supply (food, fuel, fiber, water, other goods), regulatory (associated with climate, atmosphere, extreme events, water quality etc.) and cultural (aestetic, spiritual, educational, recreational etc.). Publication of Millenium Ecosystem Assessment in 2005 focused on ecosystem services of different ecosystems, stressing their overall decline.

Forest formations are among the most endangered systems in spite of the fact that they have a great influence on human wellbeing and are providing to us the majority of important ecosystem services. Forest formations of Danubian island and around the lake are marked by changes in water level during the year. Water level fluctuations create a variety of habitats with diverse communities. Habitats are delineated by a range of changes in water regime, soil properties and some other factors. Many primary producers are well adapted to these changes (avoiding unfavourable conditions, being cosmopolites, having persistent stadia or amphibious character) and find optimal conditions for their survival while supporting a variety of other organisms. Water level during the vegetation period as well as the intensity, timing and the extent of floods influence primary production and other processes i.e. mineralization, decomposition, colonization with plants, as revealed from different studies. The researches revealed that ecosystem services depend on biotic community complexity, especially on vegetation type of the area.

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The problems of evaluation of the ecosystem services in the wetland nature system are presented in the investigations of Brander et al. (2006), Hoehn J et al. (2003), Heong K.L. (2008) etc.

Object

The lake Srebarna is one of the biggest wetlands along the Bulgarian sector of river Danuve (Table 1). It is situated in northeastern <u>Bulgaria</u>, near the village of the same name, 18 km west of <u>Silistra</u> and 2 km south of the <u>Danube</u>. The reserve embraces 6 km² of protected area and a buffer zone of 5.4 km². Diversity of the reserve and surrounding territories is determined in Corine Biotope Project in 13 habitate types. The importance of the wetland system is determine from diversity of the rare and protected bird species as Dalmatian Pelican (*Pelicanus crispus*), Mute Swan (*Cygnus olor*), six heron species (*Ardea alba, Ardea cinerea, Ardea purpurea, Ardeola raloides, Egretta garzetta* etc*),* cormorants (*Phalacrocorax carbo* and *Halietor pygmaeus)* etc.

Table 1: Limnological characteristics (Management plan, 2001)

Indicator	Value
Elevation (m)	10,0 - 13,2
Water catchments (km^2)	402
Length of shore line (km)	18,5
Reserve area (ha)	902,1
Open water body (ha)	120
Capacity (km^3) – low water levels	2,81
Capacity (km^3) – high water levels	14,35
Maximal depth (m)	3,3
Years flow (m^3)	12,48
Time of stay (months)	2,67

Diversity of biogeographical provinces is determined from three provinces based on Udvardy (1975):
- Middle European forest formations;
- Pontiac steps formations;
- Mountain territories.

Ecosystem diversity in the reserve "Srebarna" is determined from different wetland types based on the Ramsar convention (1971):

M   Permanente rivers – river Danube between right bank and island Devnia;
O   Permanente fresh water lake – open water body;
R   Seasonal marshes and water bodies – area between left bank of river Danube and river dike from Silistra to village Vetren;
X_f Fresh water bodies with domination of forest formations; seasonal flooded forests – whole territory of island Devnia and part of the river bank between Silistra and village Vetren and right bank of river Danube.
X_k Underground karst and cave hydrological systems – natural spring "Kanarichkata" in the south part of the reserve.
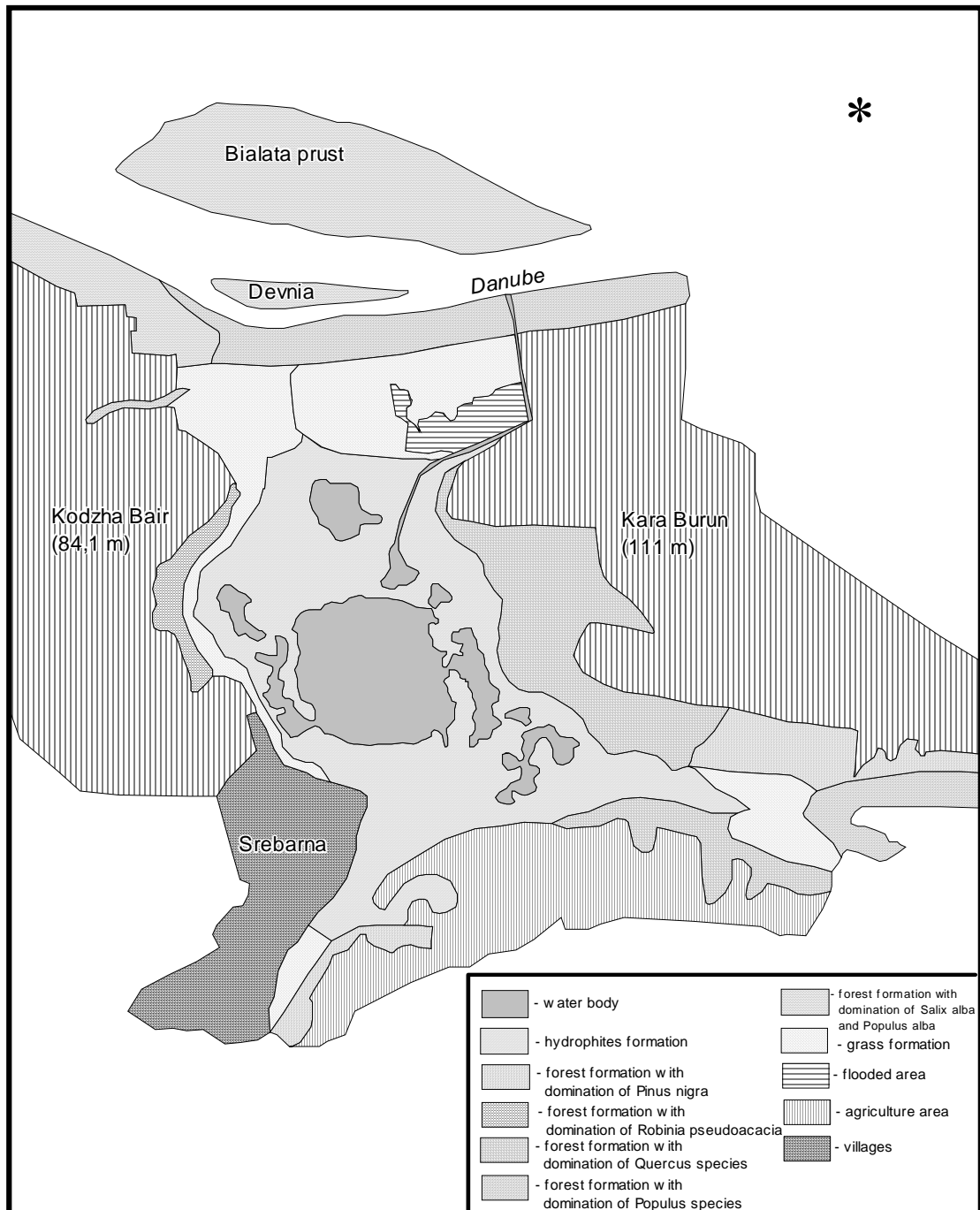
Figure 1: Forest formations in the Biosphere Reserve "Srebarna"

Research problem

The topic of the research is to investigate the importance of forest formations on the territory of Biosphere reserve Srebarna (Northeastern Bulgaria) from the point of view of ecosystem services. Basic vegetation types (Fig. 1), which are presented on the territory of the reserve are:

1. Hydrophite and hygrophite formations dominated from *Phragmites australis, Typha angustifolia* and *Typha latipholia, Schoenoplectus lacustris, Sch. triquetra, Sch. Tabernemontana, Salix cinerea* etc.
2. Mixed forest formations dominated from *Populus alba* and *Salix alba.*
3. Mezokserotermal grass formation dominated from *Poa bulbosa, Lolium perenne, Cynodon dactilon, Dichantium ischaemum, Chrysopogon gryllus.*
4. Mixed forest formations dominated from *Quercus cerris, Quercus pubescens*, *Quercus virgiliana.*
5. Mixed forest formations dominated from *Quercus frainetto* and *Carpinus orientalis* with Mediterannian elements.
6. Forest formation of *Tilia argentea* mixed with *Salix alba.*
7. Artificial formations of *Robinia pseudoacacia* and *Gleditsia triacantha.*
8. Artificial formations of *Pinus nigra.*
9. Agricultural areas on the place forest formations from *Quercus cerris* and *Quercus virgiliana*, in some places mixed with *Quercus pedunculiflora.*

Results

Ecosystem services of the forest formations are connected with specific of the landscape diversity and determinate sustainability of the ecosystems. They secured food provision and nesting condition for the bird species. They have role in the ecological balance of the hydrological resources and whole process of interaction between species. There is real opportunity for using of the biomass in energy producing. Forest formations determine attractiveness of the territory and circumstances for development of tourism.

Present research includes investigation of the key forest formations in Biosphere Reserve "Srebarna".

The first research territory included investigation of artificial forest formations of *Robinia pseudoacacia* and *Gleditsia triacantha* on the place of the vineyard terraces along the slope of hill Kodzha bair (84,1 m) in west part of the reserve. The region characterizes with high level of the erosion processes. The age of forest is 32 years. Whole quantity of the tree phytomass is 75,7 t/ha. The low level of phytomass of forest formation is determined from the fact that these plant species are not typical for the region. The analysis in the management plan of the reserve recommends replacing of the artificial forest formation with natural Danubian forest formations of *Tilia argentea* mixed with *Salix alba.*

The second research area is situated on the foot of hill Kodzha Bair (13-14 m) and showed hydrophytes formations dominated *Phragmites australis, Typha angustifolia*, *Typha latipholia, Schoenoplectus lacustris* and mixed with *Salix cinerea.* The productivity of reed formations is 2,9 t/ha. The hydrophytes species have very important transpiration role in hydrological regime of the wetland system The intensity of transpiration is 1,79 gr/dm^2/h for *Populus alba,* 0,575 g/dm^2/h for *Salix cinerea* and 0,478 gr/dm^2/h for *Phragmites australis. Populus* formations in the buffer zone (18, 1 ha) transpirated 70 200 t water for one season. *Populus* formations in the protected area (56 ha) transpirated 218 400 t water for one season. Hydrophytes formations in the reserve (402 ha) transpirated 1 413 000 t water for one season (Management plan, 2001).

The third research area is situated in the west part of island Devnia (10-11 m), which is part of the reserve territory. Forest formation is dominated of *Populus alba* in the central part of the island and *Salix alba* in the periphery, mixed with *Gleditsia triacantha.* The phytomass of *Salix alba* is 215 t/ha, *Gleditsia triacantha* - 0,97 t/ha and *Populus alba* - 6,3

t/ha in the periphery, where density of this species is not high. The island territory saved and protected the classical Danubian formation with low anthropogenic impact and can be use as etalon territory.

The fourth research area is situated in east part of the reserve along the slope of hill Kara Burun (111 m). The forest formations are presented with mixed forest formations diminated from *Quercus cerris, Quercus pubescens*, *Quercus virgiliana* and mixed forest formations diminated from *Quercus frainetto* and *Carpinus orientalis*. The low quantity of tree phytomass (67,8 t/ha) is depended from low density of the formations and high anthropogenic impact.

The ecosystem service of forest formations in the Biosphere Reserve „Srebarna" can observe in several aspects:

- ⁃ supporting - primary production, nesting conditions;
- ⁃ provisioning – food, wood, and other good;
- ⁃ regulatory – water quality and water regime, regulation of erosion processes;
- ⁃ cultural – aestetic, recreational and touristical.

Conclusions

The basic problem in the ecological situation of Srebarna wetland system is intensive degradation of the systems as a result of long-time anthropogenic impact in the region – building of river dikes and irrigation system.

The eutrophication processes are connected with productivity of the vegetation formations. Regulation of the productivity of the hydrophite formations in the lake is basic aim of the present nature protected activities and management plans of the wetland systems.

Forest formations from the point of view of ecosystem services have important role in the protection of the wetland system from slope erosion in south, east and especially west part of the wetland system. Some forest formation (*Salix cinerea)* combined with hydrophite formations are key factor for degradation of the lake (closing of water body, increasing of bottom substrate etc). Mixed forest formation of *Salix alba* and *Populus alba* are important habitat for the nesting colonies of waterfowl birds, especially cormorant and heron species.

Development of monitoring system for hydrophite formations and water regime is basic problem connected with future investigations and management of the wetlands system.

Acknowledgement

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Section 3
Disturbances in changing landscapes

Human-caused forest fire in Mediterranean ecosystems of Chile: modelling landscape spatial patterns on forest fire occurrence

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Abstract

Modelling forest fire occurrence has been lacked for the southern hemisphere, in particular for Chilean ecosystems. We developed models to investigate the relationship between forest fire occurrence and landscape heterogeneity in Mediterranean ecosystems of Chile. We used georreferenced forest fires data from 2004 to 2008. Our data of spatial heterogeneity were obtained at multiple spatial scales, including climatic, topographic, human-related, and land-cover variables. We fit a logistic model in order to predict forest fire occurrence as a function of our potential predictor variables. Our best model suggests that the probability of forest fires occurrence is related to high both temperature and precipitation, and lower distance to cities. Our predictions suggest that 46% of the study area has high probability of forest fires occurrence. Our findings can help to take adequate decisions regarding land planning.

Keywords: Disturbance, logistic regression, remote sensing, land planning.

1. Introduction

Fire disturbance is recognized as an important problem because it can devastate natural resources, human property, and threaten human lives (Cardille et al. 2001; Gustafson et al. 2004; González et al. 2005; Ryu et al. 2007). Forest fires result in enormous economic losses because they affect environmental, recreational, and amenity values as well as consume timber, degrade real estate, and generate high cost of suppression (Yadav and Kaushik 2007). Modelling forest fire occurrence (i.e., where and when a forest fire starts) has recently been conducted in the northern hemisphere (Calef et al. 2008; Lozano et al. 2007; Ryu et al. 2007; Vega-Garcia and Chuvieco 2006), however, efforts on the subject are lacking for the southern hemisphere, in particular for Chilean ecosystems. Some studies in Chile have focused in post-fire effects on vegetation dynamics (Navarro et al. 2008; Litton and Santelices 2003), but studies on predicting forest fires occurrence are lacking. Forest fire occurrence has increased in the last years in Chile, being the mean frequency about five thousand forest fires per year. These fires have affected a mean area of about 500 km2 per year (Navarro et al. 2008; CONAF 2009) being the human activity the main cause of fire ignition (CONAF 2009). We developed models to investigate the relationship between forest fire occurrence and landscape heterogeneity in Mediterranean ecosystems of Chile.

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2. Methodology

The study area extends over 892 km^2 and is located in Eastern Central Chile covering parts of the Valparaíso and Metropolitan regions (See Figure 2 a). We selected a landscape with temporal-stability in composition and no other significant processes than fire and succession operating at the landscape level (Vega-García and Chuvieco 2006).

We used georreferenced forest fires data from a 5-year period of fire occurrence from 2004 to 2008. The database consisted of 7,210 observations, out of which 891 were pixels that burned between 2004 and 2008. A distance of 25 x 25 pixels (750 m) was used to compute the co-occurrence matrices, since small windows result in very sparse matrices.

Our data of spatial heterogeneity were obtained at multiple spatial scales, including climatic, topographic, human-related, and land-cover variables from satellite imagery.

We fit a logistic model in order to predict forest fire occurrence as a function of our potential predictor variables. The relationship modeled was that between the binary response variable (one = burned, zero = not burned) and the predictor variables.

3. Result

We selected the best's no correlated predictor variables. Temperature correlated strongly with Elevation (r = 0.75) (See Figure 1 a), so only one of the two variables could be used in the same model. So, we selected Temperature in order to be more biologically meaningful. No significant correlation was found between Temperature and Precipitation (r = 0.31) (See Figure 1 b). Our best model suggests that the probability of forest fires occurrence is related to high both temperature and precipitation, and lower distance to cities (Table 1). The high probability of forest fire occurrence related to high precipitation could be unusual. However, it can be explained because the most precipitation is concentrated in the first 500 masl because the local topographic conditions (See Figure 1 c). Our predictions suggest that 46% (410 km2) of the study area has high probability of forest fires occurrence, being concentrated in the eastern locations of the study area (See Figure 2 b). Our model correctly classified about 73% of our validation dataset.

4. Discussion

The information of this study may be useful for hazard reduction, indicating that risk of forest fire occurrence (Ryu et al. 2007; Vega-Garcia and Chuvieco 2006). Study area is one of the most populated regions of Chile. Therefore, our findings can help to take adequate decisions regarding to land and urban planning.

If climate determines patterns of forest fire occurrence, then when the climatic variables change, forest fire occurrence should change. This might have important consequences for long-term land and urban planning, since prioritization of high probability of forest fire occurrence today might not be effective for the future in the face of climate change.

Exploring new statistical model approach would allow to improving the predictive capability of the models. So, part of our future research will target to this subject.

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Table 1: Best model for predicting spatial variation of forest fire occurrence in the study area.

Variables	Coefficients	Standard error	z value
Intercept	-9.2939	1.6625	-5.54*
Annual mean temperature	0.0437	0.0097	4.43*
Distance to cities	-0.0001	0.0000	-7.26*
Annual precipitation	0.0090	0.0009	9.60*

* $P < 0.0001$
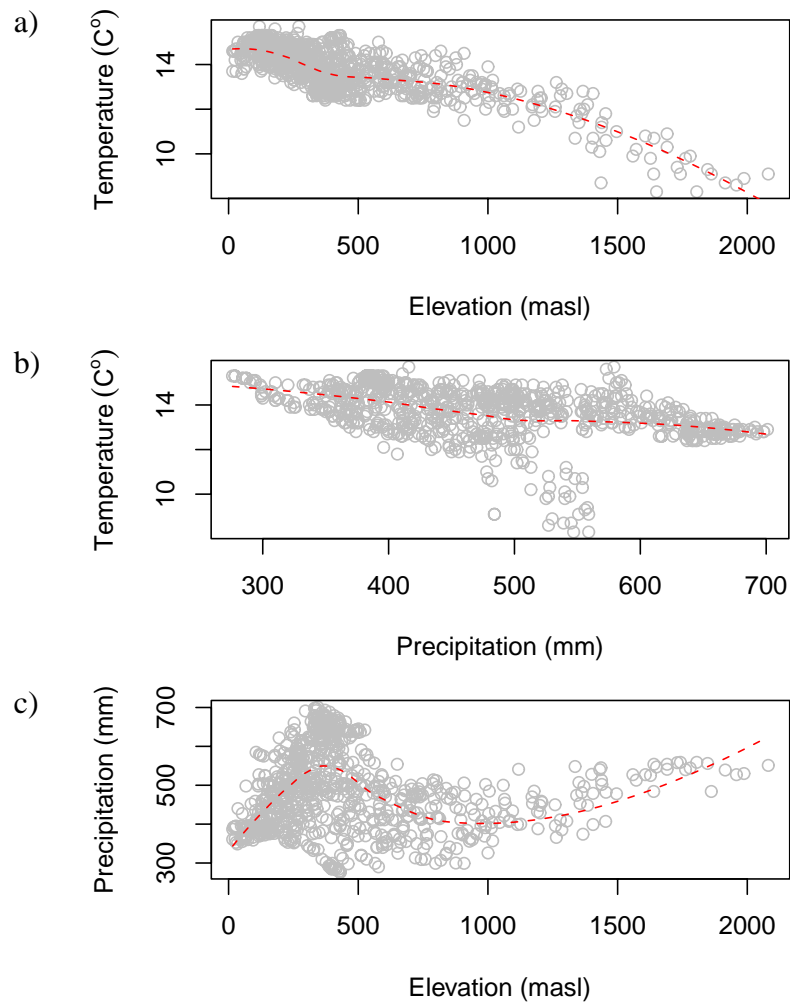
Figure 1: Relationship between predictor variables of forest fire occurrence in the study area. a) Annual mean temperature and Elevation; b) Annual mean temperature and Annual precipitation; and c) Annual precipitation and Elevation.
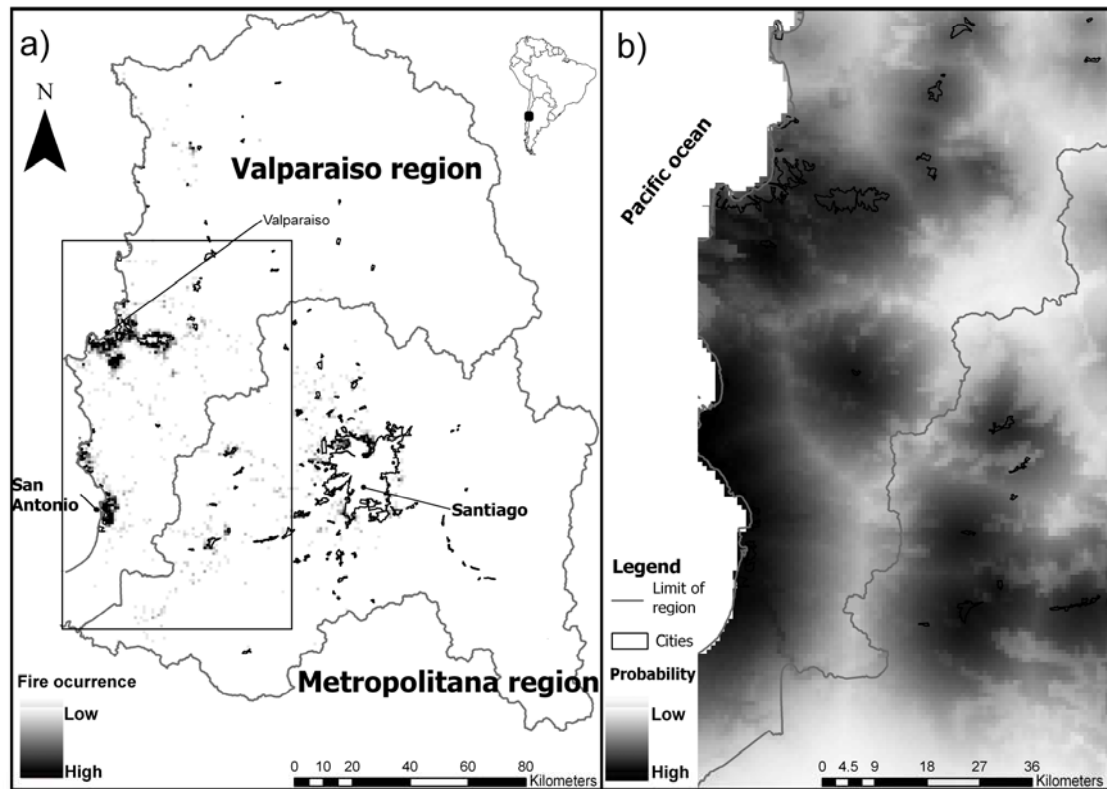
Figure 2: a) Map of study area and records of forest fire between 2004 and 2008, and b) Map of forest fire occurrence probability based on the predictive model.

Are changes in fire regime threatening cork oak-shrubland mosaics?

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Abstract

We simulated the changes of vegetation abundance and richness among mosaics of cork oak woodlands and shrublands using the LASS-Fateland model (Pausas and Ramos, 2004). During simulations, similar mosaics have been submitted to different fire regimes including fire recurrence, fire size, and fire severity. The results showed that cork oak populations are stable under such fire regimes, suggesting that the shift from cork oak to pure shrublands are likely to be due to a combination of disturbances by fires and by droughts.

Keywords: Shrubland, cork oak (Quercus suber L.), fire regime, LASS Fateland, Mediterranean landscape

1. Introduction

Mosaics of shrublands and trees are a common feature in the Mediterranean fire-prone ecosystems such as in cork oak woodlands associated with so-called maquis (Aronson et al., 2009). In these ecosystems, trees interact strongly with shrubs in the context of disturbance by recurrent wildfires. Actually, shrubby understory is a key factor determining the interval between successive fires and the intensity of fires as shrubs are flammable fuels that can rebuild rapidly after disturbance (Baeza et al., 2006). The composition, cover and flammability of shrubby fuels may lead to a high mortality of mature woody seeders (Moreira et al., 2007), but also limit drastically the resprouting of surviving stems (Pausas, 1997) and the establishment of young individuals from seeds (Curt et al., 2009).

Cork oak (*Quercus suber*) is renowned as especially fire-resistant and fire-resilient (Pausas, 1997). However, the legally-protected cork oak ecosystems experience increasing tree mortality and regeneration failure in the Maures massif (southern France), likely due to recurrent wildfires and severe summer droughts. This is hypothesized to cause major population impacts in a context of climate change, as fire recurrence and fire severity should increase. Land and forest managers need the help of simulation tools to predict landscape-scale impact of different fire regimes, and to set up and to test reliable scenarios in order to limit the impact of fires and drought, and for helping cork oak conservation. To test the impact of the size of the patches of cork oak woodlands and of different fire regimes on the stability of the oak-shrubland mosaic we used a simulation approach using data from the field and literature to implement and to calibrate the model.

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2. Methodology

2.1 Study area and species

The study area is the Maures massif located in the southeastern part of France (43°3 N, 6.3°E), which is the largest French area for cork oak (*Quercus suber* L.). This massif is composed of a granitic and metamorphic basement covered with acidic Cambisols. The climate is typically Mediterranean and subhumid xerothermic. The massif is a hotspot for fires, including zones with up to five recurrent fires since 1959 (Curt et al., 2009). The Maures massif has features common to many Mediterranean countries that explain the recurrence of wildfires: the predominance of human-induced fires owing to population and urban growth (Curt and Delcros, 2010), the development of large and intense summer wildfires during dries and windy spells (Pausas, 2004), enhanced by the abundance of flammable vegetation types (Mouillot et al., 2003). The cork oak (*Quercus suber*) populations are protected by the European Union (Habitat directive 92/43/EEC) due to their high conservation value. They are intermingled with shrublands dominated by the resprouter *Erica arborea* and various seeders (*Cistus* spp.).

2.1 Model and simulation plan

In order to simulate the fate of cork oak population, the vegetation dynamics and the spread of fire we used the FATELAND model (Pausas and Ramos, 2006), which is a spatially explicit version of the FATE model (Moore and Noble, 1990) implemented under the LASS software (available at www.uv.es/jgpausas/lass). FATELAND has been used to model the dynamics of Mediterranean vegetation submitted to different scenarios of disturbance by fires in Spanish ecosystems (Pausas and Lloret, 2007). For all simulations we selected four main species that correspond to the most representative and dominant plant types in the study area, and to various plant functional types: a resprouter tree (cork oak, *Quercus suber* L.), a resprouter shrub (heath tree, *Erica arborea* L.), seeder shrubs (rockroses, *Cistus* spp.) and a perennial grass (*Brachypodium retusum* (Pers.) P.Beauv.) that resprouts after fire (Caturla et al., 2000).

We built an artificial landscape of 200 x 200 square cells, each one equivalent to 10 x 10 meters. The total area is thus 400 ha, i.e. an area sufficient to take into account the spatial interactions between species, and coherent with the maximal distance of seed dispersal. On the basis of our field survey of vegetation and fuels (Curt et al., 2009), we simulated two mosaics of cork oak woodlands, shrublands dominated by *Erica arborea* and *Cistus* species, and patches of *Brachypodium* grass. The first one corresponded to small patches of cork oak within the shrubland matrix while the second one corresponded to large patches of cork oak within the shrubland matrix. Both mosaics had a similar total area for cork oak and shrublands, but they had different spatial patterning of vegetation.

All simulations had 110 years duration, the last fire being at year 100 to allow vegetation to recover. In all simulations, the disturbance started at year 10. At the beginning of each simulation, the initial conditions of vegetation were set equal for each mosaic. During simulations, each mosaic was submitted to variable fire regimes including different fire recurrences, fire sizes and fire severities:

- the fire recurrence was simulated by setting different fire intervals, i.e. 10, 20, 30, 40 and 50 years
- the maximum fire size was set to three levels: small fires (25% of the landscape), medium fires (50%) and large fires (75%)

- the fire severity for cork oak was modeled by two levels of fire response: low (i.e. low mortality and high resprouting rate for cork oak) *versus* high (high mortality and low resprouting rate for cork oak)

The persistence of all plants was assessed at the end of the simulations using the total abundance of all cohorts, and the abundance of four cohorts representing the life stages (i.e. seeds, immature individuals, mature trees, and mature high trees). In order to analyze the spatial changes of the mosaics we also compared the spatial patterning of cork oak and of the whole mosaic before and after the simulations. For this purpose we assessed the 'total edge length' (McGarigal et al., 2002), this statistics being expected to be a good indicator of species' spatial interactions (Pausas, 2006). We also tested the spatial autocorrelation for species richness at the end of simulations by computing the Moran's *I* index (Cliff and Ord 1981). The comparison of the effect of different fires regimes on the mosaics was done using multiple analyses of variance (MANOVA) with the variables describing species abundance, richness and patterning as dependent variables and the variables of fire regime as independent variables.

3. Result

The multiple analyses of variance (Table 1) indicated that the overall abundance of cork (i.e. the number of cells in which cork oak was present whatever the cohort) was quite stable among all the simulations runs. It varied from 46.5 to 62% of the landscape (mean value 50.7% with a coefficient of variation of 6.6%) while the area at the beginning of all simulations was 50% of the landscape. The total abundance of cork oak after simulation did not relate to the type of mosaic: large and small patches of cork oak woodlands resulted in similar cork oak abundance under a similar fire regime. Likewise, the different cohorts of cork oak (i.e. from seeds to mature high trees) were not significantly affected by the size of the woodland patches at the beginning of simulation. Conversely, all the variables of the fire regime clearly impacted the abundance of cork oak in the landscape (Table 1): its overall abundance decreased with low fire recurrence and small fires. While the presence of cork oak in the landscape was quite stable among simulations, the different cohorts behaved differently. Seeds were more abundant with a mean fire interval of 30 to 40 years. Immature individuals were more abundant at a 20-years fire interval and with large fires. Mature cork oak trees tended to increase with longer fire intervals but not statistically significantly. High mature trees that form the overstory increased at low fire recurrence, and with low severity and small fires. In all the simulations, lower disturbance by fire (i.e. long fire-free intervals, small fires and low-severity fires) favored the development of mature cork oak woodlands dominated by mature trees, with fewer immature individuals.

Table 1. Multiple analysis of variance of cork oak abundance and landscape metrics as a function of the size of the patches of cork oak woodlands and the fire regime. The total abundance of cork oak and the abundance of the different cohorts were computed as the mean value at the end of the simulations (years 100 to 110). [NS]= non statistically significant (Tukey's HSD test 95%)

	Size of the woodland patches	Fire Recurrence	Fire Size	Fire Severity
Cork oak				
Total abundance	NS	6.59 P<0.0002	13.97 P<0.0001	NS
Seeds	NS	2.82 P<0.0345	3.88 P=0.0270	6.88 P=0.0115
Immature	NS	5.82 P<0.0006	18.20 P<0.0001	NS
Mature	NS	NS	NS	NS
Mature high	NS	3.15 P<0.0217	3.66 P=0.0327	5.60 P=0.0218
Landscape Heterogeneity				
Total Edge	NS	41.39 P<0.0001	56.86 P<0.0001	NS
Moran's I	NS	10.37 P<0.0001	204.57 P<0.0001	9.55 P<0.0032

4. Discussion

Our simulations indicate a clear ability of cork oak populations to persist in two contrasted mosaics with shrublands, even for populations present only in small woodland patches. This is coherent with the high fire resistance and resilience of this species that resprouts efficiently and can survive even after intense wildfires (Pausas, 1997, 2006). Resprouting species such as cork oak are generally less sensitive to fire regime than seeder species (Delitti et al., 2004). However, the fire regime impacts differently the cohorts of cork oak. Seeds and seedlings (i.e. immature individuals) are favored by medium fire recurrence and large fires, presumably because such fires open large and clear areas in shrublands allowing cork oak seedlings to establish or to persist. Conversely, long fire-free periods and small or low-severity fires allow mature high trees to grow and to persist. This would favor the establishment of high cork oak woodlands and progressively eliminate the shrubby understory made of *Erica* and *Cistus*. In such mosaics, disturbances by fires have two contrasted effects on cork oak populations: one the one hand they limit cork oak populations by killing some individuals and on the other hand they favor it by opening gaps in the shrub cover that offer windows of opportunity in space and time for its regeneration (Pons & Pausas 2006). In total, cork oak populations appear stable under such fire regime and in such shrubland communities. Recently, some authors observed shifts in cork oak (Acácio et al. 2009) due to the combination of disturbances by fires and by droughts.

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Forest management and climate, through landscape structure, affect the potential for insect outbreak

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Abstract

The mountain pine beetle (MPB) is endemic to western North American pine forests and is currently causing a very destructive outbreak in western Canada. Historically, expansion further north and east was limited by mountains and winter cold, but during recent warm winters the insect crossed the mountains and it now threatens Canada's eastern forests.

This concern has motivated our study of how landscape structure affects outbreak development and spread. As part of this study, we describe a model of MPB-stand dynamics. Based on recent field work, the model includes a threshold at low density which the local beetle population must overcome to become eruptive. We show how, from the MPB perspective, landscape structure responds to climate and forest management and has strong, indirect affects on the likelihood of eruption. We discuss the recent under-estimation of MPB spread in Alberta by much more complex models.

Keywords: mountain pine beetle, stand density management diagram, Dendroctonus ponderosae, forest landscape structure, outbreak spread

1. Introduction

Besides timber, healthy forests provide a variety of non-timber products and many ecosystem services including maintenance of biodiversity, clean water, and carbon storage. In Canada's forests, change comes primarily in the form of "disturbances". Disturbances occur in many forms (e.g., storms, fire, insects, disease, and logging) and over a wide range of scales (Ayres and Lombardero 2000; Dale et al. 2001). Disturbances leave ecological legacies which determine future species composition, age structure, and spatial heterogeneity of the area (Radeloff et al. 2000) and consequently, facilitate or impede the occurrence of future disturbances (Kulakowski et al. 2003).

Insects are the most diverse class of organisms on earth and the major natural cause of depletion from Canada's forest productivity. Past outbreaks have engulfed extensive areas (Volney and Fleming 2000). Canada's western forests are now experiencing "the largest insect outbreak in

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Canadian history" (Ono 2004). The mountain pine beetle (*Dendroctonus ponderosae*) has been killing mature lodgepole pine over an area extending up to 13 million ha since 1999 (Raffa et al. 2008). The resultant decline in carbon uptake through photosynthesis and increase in emissions from decaying trees has been so great that it has even changed Canada's western forests from a small net carbon sink to a large net atmospheric source (Kurz et al. 2008).

Mountain pine beetle (MPB) can successfully attack most western pines, but lodgepole is its primary host throughout most of its range. Although widespread – occurring from northern Mexico, through 12 U.S. states and 3 Canadian provinces – mountain pine beetle outbreaks in Canada have been mainly restricted to the southern half of British Columbia and the extreme south-western portion of Alberta. (In 1979, an outbreak occurred in the Cypress Hills at the southern junction of the Alberta-Saskatchewan border (Ono 2004)). This restriction is not due to MPB's host tree. Lodgepole pine extends north into the Yukon and Northwest Territories, and east across much of Alberta. Rather, the potential for mountain pine beetle populations to expand north and east has historically been limited by winter cold and mountainous terrain. The substantial shift by mountain pine beetle populations into formerly unsuitable habitats during the past 30 years as a result of warmer winters has recently enabled the beetle to overcome the natural barrier of the high mountains (Carroll et al. 2004).

Pre-requisites for a mountain pine beetle outbreak to occur are an abundance of large, mature pine trees and several years of favorable weather. Fire suppression and selective harvesting (for species other than pine) during the latter half of the previous century have more than tripled the area of mature pine in western Canada. Moreover, mountain pine beetle survival has increased as a result of warmer winters over much of western Canada, allowing populations to invade successfully into pine forests in areas that formerly were climatically unsuitable. Thus, both conditions for an outbreak have coincided, and with enough force to produce the largest MPB outbreak in recorded history. Given the rapid colonization by mountain pine beetles of areas that formerly were climatically unsuitable in recent decades, continued warming in western North America associated with climate change will likely allow the beetle to expand its range further northward, eastward and toward higher elevations.

In the past, large-scale mountain pine beetle outbreaks collapsed due to localized depletion of suitable host trees in combination with adverse weather (e.g., an unseasonably cold period or an extreme winter). The current outbreak may be different. In the absence of unusual weather, this outbreak may persist by continually moving into new habitats as global warming allows access to a small, but continual supply of mature pine, thereby maintaining populations at above-normal levels for some decades into the future (Carroll et al. 2004).

A recent series of benign winters has allowed mountain pine beetle populations to extend their ranges along the northeastern slopes of the Rockies in Alberta – areas in which the beetle has not been previously recorded. This has created a very dangerous situation. The MPB is now approaching the jack pine, *Pinus banksiana*, forests of northern Alberta and Saskatchewan. There is no known biological barrier to populations of the beetles colonizing jack pine if its range expands north to the zone of overlap between jack and lodgepole pines. Because jack pine is susceptible and extends through the rest of the boreal all the way to the east coast, the MPB may be about to gain access to the whole extent of Canada's boreal forest (Raffa et al. 2008).

Although changes in forest landscape structure caused by selective harvesting and fire suppression are often cited as a contributing factor to the current outbreak, the mechanisms involved in the interactions between the landscape structure and the population dynamics of mountain pine beetle remain largely unknown. Indeed, the interactions between the spatial patterns of landscape structures and disturbance processes have been a central question in

landscape and forest ecology. Insect outbreak severity and extent have been shown to be influenced by landscape structure (Coulson et al. 1999; Radeloff et al. 2000; Cairns et al. 2008). There is a long history of modeling MPB population dynamics (Berryman et al. 1984; Powell et al. 1996; Logan et al. 1998; Heavilin and Powell 2008; Powell and Bentz 2009). However, we still have little idea what triggers a stable, low density, endemic population to erupt to outbreak levels which can become self-perpetuating through contagious spread between susceptible stands. Once a population has exceeded the stand-level eruptive threshold, its capacity to contribute to a landscape-scale outbreak will depend on the availability and the quality of susceptible host trees in neighboring stands (Aukema et al. 2006; Safranyik and Carroll 2006). As the resource gets depleted, the landscape structure at a larger scale becomes a critical factor.

2. Methodology

Our over-all objective is to develop a simple, flexible model which can accurately describe the broad characteristics of the spread of MPB outbreaks in time and space over both lodgepole pine and jackpine landscapes. Our goal is to provide a better understanding of the interactions between landscape structure and the dynamics of mountain beetle populations, particularly during the eruptive phase. We hope to identify how landscape properties interact with population dynamics to enable MPB to erupt to outbreak levels and the different scales at which these processes are interacting. The model will also provide a tool to assess the susceptibility of current and future landscapes to mountain pine beetle outbreaks and benchmarks for forest management plans and decision support systems.

2.1 Model development

This model can be thought of as comprising 3 interacting components. The site (sub)model describes the ecological mechanisms that affect the probability that a low density MPB population can escape from its limiting factors and erupt within both a lodgepole pine and a jackpine stand. The landscape structure (sub)model describes how pine stands are distributed over the landscape of concern both in terms of their presence and in terms of the ecological factors which determine the characteristics of their susceptibility to MPB. The dispersal (sub)model describes how the insects leaving one stand are dispersed over the landscape and can thus contribute to triggering eruptions in neighboring or more distant stands.

At the forest stand level, the dynamics are controlled by the interaction between a host pine species stand model and a mountain pine beetle population dynamics model. At the landscape level, the dynamics of the system emerge from interactions between stands and local MPB populations through insect dispersal. The dynamics of the system also depend on the initial characteristics of the landscape (i.e. heterogeneity, patch size, connectivity) and the evolution of its structure according to forest management and natural disturbance scenarios. Ultimately, the simulation models will be implemented in CAPSIS, a simulation platform developed at the Institut National de la Recherche Agronomique (France) to study the dynamics of forest ecosystems.

3. Results and Discussion

This paper focuses on the development of the site (sub)model. Because previous research (Carroll et al. 2004) showed that the stand-level dynamics of MPB populations can be well-

described in the context of stand density management diagrams (Farnden 1996), it was decided to use this approach to model the host pine stands.

Stand density management diagrams (SDMD) are graphical representations of stand development that illustrate the interactions between stocking and other stand parameters such as mean diameter, top height, and volume. In a modeling context, when many stands have to be "grown" simultaneously, SDMDs present the advantage of eliminating the need to perform complex mathematical analyses often used in individual tree, distance-dependent growth and yield models. This SDMD approach also provides needed flexibility and transparency in preparation for modeling MPB spread into landscapes dominated by a different pine species for which there has been no prior experience.

The site (sub)model describes the key ecological mechanisms affecting the growth of MPB populations within even-aged stands of lodgepole pine in the context of SDMDs. This growth is non-linear: at low densities, tree defences, competitors, and lack of suitable habitat severely restrict MPB populations. But as stands age, the trees become more susceptible to mass attack in which upwards of a 1000 MPBs will aggregate to overwhelm the defences of an individual tree. Besides age, other stand properties, particularly tree density, also affect a stand's ability to resist a mass attack. Stands are most susceptible beyond 80 years of age, but by at least 160 years the phloem in their trees has become too thin for a mass-attacking MPB population to successfully reproduce itself.

In this presentation, we describe the site (sub)model and show how it can be used to infer a variety of different possible patterns of spread for MPB outbreaks. We also show that the local stand dynamics can be crucial determinants of the larger landscape patterns that emerge when landscape structure and dispersal dynamics are also considered.

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How important are riparian forests to aquatic foodwebs in agricultural watersheds of north-central Ohio, USA?

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Abstract

In agricultural landscapes restoring riparian forest patches along streams is a watershed management priority. There are questions, however, as to the degree to which aquatic food webs are supported by inputs from small and often isolated forested riparian patches in agricultural landscapes. To examine these contributions we compared the plant communities and stream food webs between forested and non-forested riparian patches in an agricultural landscape and used stable isotope analyses to determine whether the primary source of energy for different levels of aquatic food webs were derived from terrestrial or aquatic sources. We observed no differences in the δ^{13}C signatures of consumers between forested and non-forested riparian areas. Similarly, we also observed few differences in δ^{15}N signatures between forested and non-forested sites for different trophic levels. This suggests that there may be other mechanisms driving the structure of aquatic food webs than basal resources alone.

Keywords: riparian forests, stable isotope analysis, food webs, ecosystem structure

1. Introduction

Riparian forests are dynamic components of the landscape that promote many ecosystem functions vital to the sustainability and productivity of watersheds through their influence on stream water quality, in-stream habitat, food web structure, and ecosystem function (Gregory et al. 1991; Naiman et al. 1993; Wallace et al. 1997). Although riparian areas are subjected to a variety of natural disturbances (e.g., flooding, drought, landslides, and wildfire) that alter habitat structure and biodiversity (Ilhardt et al. 2000), human disturbances (including agricultural practices) can alter riparian forests in complex and often synergistic ways (Gregory et al. 1991). In many agricultural landscapes, riparian forests have been removed or greatly modified. As a result and because of the importance of riparian areas to watersheds, riparian corridors are often protected around streams, and they are a major component of most watershed management and restoration initiatives.

Under ideal conditions, headwater streams are heterotrophic systems where allochthonous (carbon) inputs from riparian forest vegetation provides energy and nutrients for aquatic food

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webs, which in turn, provide the assimilative mechanisms for nutrients including nitrogen and phosphorus (Vannote et al. 1980; Minshall et al. 1985). In most cases, the processing of nitrogen, phosphorus, and organic matter (carbon) is strongly influenced by channel morphology (e.g., sinuosity and connection to an active floodplain), habitat characteristics (e.g., large wood that traps leaves and slows downstream movement) and diversity and structure of the aquatic community. A diversity of organisms in the aquatic food web sequesters nutrients and slows their downstream transport. In contrast, in managed and degraded headwaters, large proportions of inorganic nutrients enhance the growth of algae, which lowers levels of dissolved oxygen, consequently limiting the survival of more desirable invertebrate and vertebrate species. The degree to which this assimilative capacity remains intact is particularly critical in predominantly agricultural watersheds where riparian forests have been removed and nutrient loadings to streams tend to be high. In the absence of organic carbon inputs, as is encountered when riparian vegetation is removed, the capacity of streams to process and retain nutrients can be lowered significantly (Malanson 1993). In these systems, it remains unclear whether in-stream production is an alternative energy source to woody riparian vegetation that structures aquatic food webs.

In this paper, we examine the relationships between basal resources and consumers in small and often isolated riparian forest fragments within a larger agricultural landscape. To accomplish this, we utilize stable isotope analysis to quantify the use of terrestrial and aquatic sources of organic matter by consumers and explore how the presence of riparian forest fragments can affect the source of energy and its availability to aquatic consumers in headwater streams. Use of carbon (δ^{13}C) and nitrogen (δ^{15}N) stable isotopes is a powerful tool to evaluate trophic relationships in aquatic food webs (Peterson and Fry 1987). Because the δ^{13}C composition of animals correspond closely to those of their food sources, it is possible to evaluate the contribution of various sources of carbon to the energy flux of aquatic systems. Such connection between food sources and the consumers can only be done when sources have distinctive δ^{13}C ratios (Hamilton et al. 1992). It has also been shown that in aquatic systems, allochthonous and autochthonous sources of carbon tend to generally have different δ^{13}C signatures, providing a tool to evaluate their incorporation into the aquatic food web. δ^{15}N isotope ratios, in contrast, become more enriched at successive trophic positions.

2. Methodology

2.1 Study area, site selection, and field sampling

We conducted our research in the Sugar Creek watershed, located in northeastern Ohio, USA. The Sugar Creek watershed covers 922 km^2 and is dominated by different types of agriculture, including conventional row-crop production and traditional Amish farming practices (Stinner et al. 1989). The landscape is best described as fragmented, with small isolated riparian forests and woodlots typically comprising less than 10% of the total watershed area. Within this watershed, we selected nine stream reaches dominated by small forested riparian areas and ten stream reaches dominated by non-forested riparian areas.

At each site, we collected three categories of organic materials: (1) autotrophs from the channel (i.e., macroalgae, macrophyte, and epilithon) and the riparian area (i.e., herbaceous vegetation and leaves from trees), (2) detrital material (i.e., coarse particulate organic matter or CPOM, fine particulate organic matter or FPOM, and dissolved organic matter or DOC), and (3) consumers (both macroinvertebrates and fishes). Riparian trees were only sampled at forested sites as they were mostly absent from non-forested sites. All samples were collected in the spring of 2008 once from each location.

For all autotrophs, sampling was conducted by compositing subsamples from different habitats within the selected reach, resulting in one sample per type of material sampled per site. Macroalgae and macrophytes were randomly sampled through each reach. Macrophytes were only present at six and five of the forested and non-forested sites, respectively. Epilithic microfilm material was collected from cobbles with a brush. In addition to microalgae, these samples might have contained some detrital material or heterotrophic bacteria. Thus, these samples are referred to generally as epilithon, whereas the algal component of such sample would be referred to as epilithic microalgae. In the lab, epilithon sample were filtered onto precombusted GFF filters and invertebrates were removed. Samples of herbaceous species were collected randomly in the riparian area. At the forested sites, leaves from the dominant three to four riparian trees were collected. In the laboratory, all material was carefully washed and dried.

Three 1-L water samples were collected at the reach and brought back to the lab. Coarse particulate organic matter (> 1mm), fine particulate organic matter (< 1mm, > 0.47μm) and dissolved organic matter (<0.47μm) were successively obtained through filtration. Composite samples were obtained from the combination of the three 1-L sample to obtain one CPOM sample, one FPOM sample, and one DOC sample per site.

To sample invertebrates, we placed a D-frame net at different locations within the channel and disturbed the sediment upstream. We removed all invertebrates from the net and identified all organisms to family. We selected representative individuals from each functional feeding group (i.e., filterers, gatherers, grazers, shredders, and predators). These individuals were kept alive for at least 24-hr in absence of food, with the expectation that their guts would be emptied out. We thus could expect that the isotopic measurements would reflect body tissues only (rather than what they just ate). At most sites, filterers consisted of Hydropsychidae and Simuliidae, gatherers consisted of Chironomidae and Oligochaetes, grazers consisted of Physidea and Hepta Physidae, shredders consisted of Haliplidae and Tipulidae, and predators consisted of Calopterygidae and Coenagrionidae. Dry material was homogenized with an antistatic mortar and pestle.

The two to four dominant species of fish were collected at each reach. Black-nose dace (*Rhinichthys atratulus*) and creek chub (*Semotilus atromaculatus)* were found at all the sites, while central stoneroller (*Campostoma anomalum*) was sampled at one forested site and three non-forested sites and white sucker was sampled at one forested site and four non-forested sites. Black-nose dace and creek chub are known to be insectivores, while central stoneroller consumes algae and white sucker is an omnivore. Fish individuals were transported on ice to the lab where a piece of tissue was immediately obtained from each fish and oven dried at 60ºC.

2.2 Laboratory and statistical analyses

Prior to analyses, all material was oven dried at 60ºC. Dry material was homogenized with an antistatic mortar and pestle. Subsamples (weight varied depending on material) were loaded into a 4 x 6 mm tin capsule. The measurement of carbon and nitrogen stable isotope ratios of particulate organic matter (i.e., all materials except DOC) was performed on an elemental analyzer (EA) (Carlo Erba CHN EA 1108, now Thermo Fisher Scientific, Waltham, MA) coupled to a Finnigan Conflo III Interface and a Themo Finnigan Delta V Advantage isotope ratio mass spectrometer (Bremen, Germany). Air dried samples were weighted in tin capsules and combusted at a temperature of 1000ºC in the EA under a stream of oxygen. The evolved CO_2 and N_2 (for $\delta^{13}C$ and $\delta^{15}N$, respectively) was transferred to the Conflo III Interface and subsequently reached the IRMS where the $\delta^{13}C$ and $\delta^{15}N$ values were determined. CO_2 and N_2 reference gases were used as gas standards and measured within every single sample run. Every 20th sample was Acetanilide which served as a stable isotope ratio reference material. The Acetanilide used in our study was purchased from Arndt Schimmelmann, Indiana University.

Isotope ratios are expressed as $\delta^{13}C$ and $\delta^{15}N$ values per mille [‰] relative to the international reference standard VPDB using NBS 19, L-SVEC, IAEA-N-1 and IAEA-N-2. Standards deviations of $\delta^{13}C$ and $\delta^{15}N$ replicate analyses were 0.2 ‰ and 0.2 ‰, respectively.

DOC samples were analyzed for $\delta^{13}C$ using an O.I. Analytical Model 1010 TOC Analyzer (OI Analytical, College Station, TX) interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer (Sercon Ltd., Cheshire, UK). This analysis was conducted at the UC Davis Stable Isotope Facility, in the Department of Plant Sciences. A 20-mL aliquot of sample was transferred into a heated digestion vessel and reacted sequentially with phosphoric acid then with sodium persulfate to convert DIC and DOC each into a pulse of CO_2. The two sequential CO_2 pulses liberated by the chemical treatments are carried in a helium flow to an infra-red gas analyzer (IRGA), then to the isotope ratio mass spectrometer where the $^{13}C/^{12}C$ ratios are measured and compared to ratios of laboratory standards calibrated against NIST Standard Reference Materials.

We compared $\delta^{13}C$ and $\delta^{15}N$ values of dominant basal resources (autotrophs and detrital materials) between forested and non-forested streams using a t-test. Likewise, to examine differences in stable isotope signatures for macroinvertebrate functional feeding groups and dominant fish species between forested and non-forested riparian areas, we also utilized a t-test.

3. Results

We detected no statistically significant differences in $\delta^{13}C$ values of dominant autotrophs and detrital material between forested and non-forested streams (Figure 1A). Algae $\delta^{13}C$ values were the most depleted, ranging from -40.5‰ to -22.3‰ while $\delta^{13}C$ values of the epilithon were the most enriched (ranging from -23.3‰ to -15.1‰), followed by FPOM $\delta^{13}C$ values (ranging from -23.0‰ to -11.3‰). With values ranging collectively from -32.5‰ to -23.6‰, $\delta^{13}C$ values of CPOM, riparian vegetation (tree and herbaceous), and macrophytes were similar (Figure 1A.).

We did detect significant differences in $\delta^{15}N$ values of basal resources (Figure 1A). Specifically, we found that macrophytes and CPOM were enriched in the non-forested sites compared to the forested sites (t-test; $P = 0.01$ and 0.01, respectively). No differences in $\delta^{15}N$ values of the other autotrophs or detrital material were detected between forests and non-forested riparian areas.

Overall, consumer $\delta^{13}C$ values across all species are best characterized as enriched, with $\delta^{13}C$ values ranging between -28.0‰ and -20.2‰ and $\delta^{15}N$ values between 3.2‰ to 8.5‰ for all macroinvertebrate functional feeding groups (Figure 1). Both filterers and grazers had higher $\delta^{15}N$ values associated with non-forested riparian areas than forested riparian areas (t-test; $P = 0.01$ and 0.02, respectively). Similarly, $\delta^{13}C$ values ranged from -22.0‰ to -26.2‰ and $\delta^{15}N$ values from 10.5‰ to 12.7‰ for selected fish species, with creek chubs having significantly more enriched $\delta^{13}C$ values in the non-forested riparian areas (t-test; $P = 0.01$). These values are similar to the values for FPOM, CPOM, and riparian plants (Figure 1).

4. Discussion

Our results, which were only collected once and do not capture seasonal variation in isotopic signatures, suggest that there are not marked differences in the primary sources of energy supporting aquatic food webs among forested and non-forested headwater streams in this agricultural watershed. Neither the primary consumers (e.g., grazers) nor higher-level consumers (e.g., black-nose dace) showed differences in $\delta^{13}C$ signatures among forested and

non-forested reaches. This may be related to the fact that we did not observe clear differences between $\delta^{13}C$ signatures for some of the autochthonous resources (epilithon) and allochthonous resources (CPOM and riparian plants). It has been observed elsewhere that variation in stream flows, dissolved CO_2 concentrations, and $\delta^{13}C$ concentrations in dissolved inorganic C can result in higher than expected algal $\delta^{13}C$ values that overlap with detrital $\delta^{13}C$ values which tend to be more consistent both spatially and temporally (Finlay 2004). Consequently, disentangling energy pathways in this system may require additional study or the use of other stable isotopes such as hydrogen (δD) (Finlay et al. 2010).

We did observe differences in levels of consumer ^{15}N enrichment between the forested and non-forested riparian areas. However, we did not observe these differences with the higher-level consumers as anticipated. We had hypothesized that the increased diversity of basal food web resources associated with the forested sites would result in $\delta^{15}N$ signatures of higher-level consumers. The fact that we did not detect such a relationship suggests a possible linkage with diet quality and stoichiometry associated with the different environments rather than trophic position. Similar linkages have been suggested by others observing similar patterns in streams of Arkansas (Dekar et al. 2009). This pattern may also be related to seasonality and differences associated with diet (i.e., more reliance on algae and macrophyte sources during the spring as these basal resources may have higher C:N ratios than detrital sources). However, more research on these mechanisms is clearly needed to better understand the patterns of ^{15}N enrichment in these headwater streams and how that may relate to riparian management and restoration.

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A. Basal Resources
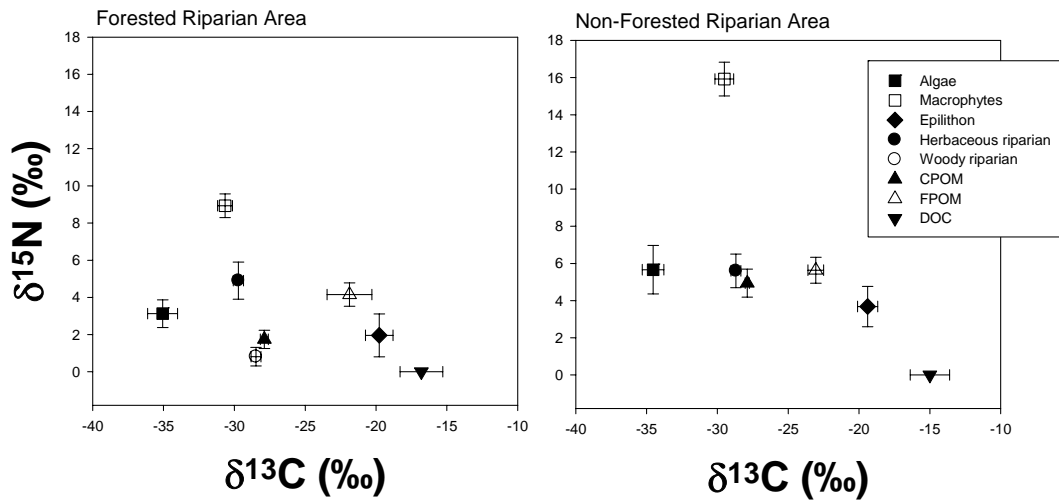
B. Consumers
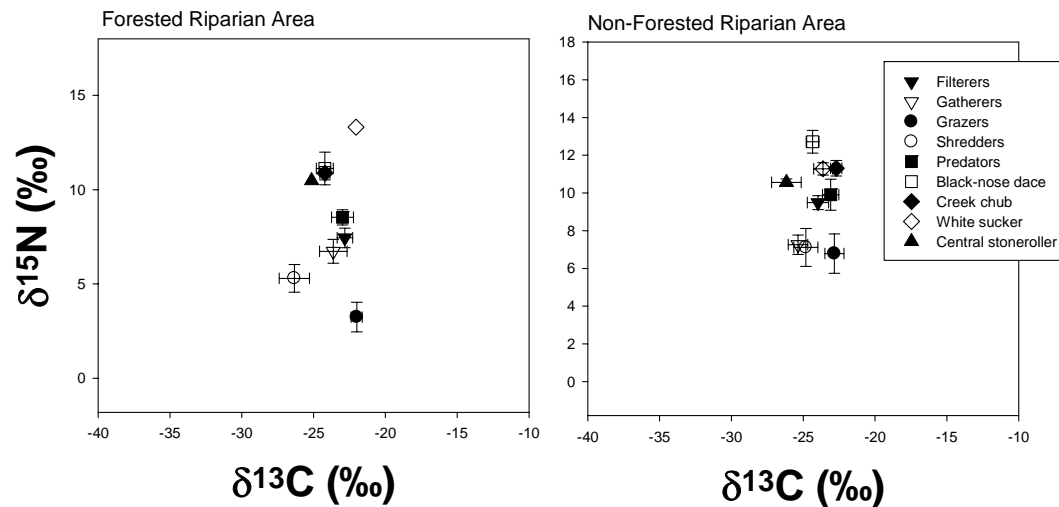
Figure 1. Stable isotope food web plots for forested and non-forested riparian areas, Sugar Creek watershed, northeastern Ohio for the spring of 2008. Symbols represent the mean $\delta^{13}C$ and $\delta^{15}N$ values ($\pm$ 1 SE) for each basal resource (A) and consumer taxonomic grouping (B). Note there were no woody riparian basal resources sampled for the non-forested riparian areas.

Merger of three modeling approaches to assess potential effects of climate change on trees in the eastern United States

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Abstract

Climate change will likely cause impacts that are species specific and significant; modeling is critical to better understand potential changes in suitable habitat. We use empirical, abundance-based habitat models utilizing decision tree-based ensemble methods to explore potential changes of 134 tree species habitats in the eastern United States (http://www.nrs.fs.fed.us/atlas).To help interpret and add value to these outputs, we assigned and calculated Modification Factors for disturbance and biological factors that cannot be specifically assessed with the empirical RandomForest approach. We also use a spatially explicit cellular model, SHIFT, to calculate colonization potentials, based on the abundance of the species, the distances between occupied and unoccupied cells and the fragmented nature of the landscape. By combining results from the three efforts, we are estimating potential impacts that can be used to aid in management decisions under climate change. These tools are demonstrated for one species, black oak (*Quercus velutina*), in northern Wisconsin.

Keywords: Climate Change, RandomForest, Species Distribution Modeling, Eastern United States, Trees

1. Introduction

The ranges of tree species in eastern North America have generally shifted northward as the climate has warmed over the past 14,000+ years since the last ice age (Webb 1992). Evidence is mounting that tree species, along with many other organisms, are continuing this northward movement, some at very high rates (Hoegh-Guldberg et al. 2008). There is also increasing evidence of broad expanses of tree mortality that can be attributed to drier and hotter conditions, often predisposing the forests to insect pest outbreaks (e.g., mountain pine beetle in western North America) (Allen et al. 2010). Habitats for individual species have, and will continue to, shift independently and at different rates, resulting in changing forest community compositions over time (Webb 1992). Such shifts are likely to occur in the coming decades in the eastern United States, so that some species will decline in suitable habitat while others will increase to various degrees. While it is likely that certain habitat will become suitable for some species not currently present, it is less clear how rapidly – or even whether – those species will migrate into the region without active human intervention (Higgins and Harte 2006). Studies on six eastern United States species showed that, at the rate of migration typical of the Holocene period (50 km/century in fully forested condition), less than 15% of the newly suitable habitat has even a remote possibility of being colonized within 100 years (Iverson et al. 2004). The relatively rapid nature of the projected climate shifts, along with the limits on the rate at which trees can migrate over a landscape, especially in the current and future fragmented state of forests, constrain the rate of 'natural' migration.

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We approach modeling impacts of climate change using a combination of statistical species distribution models (DISTRIB), literature-based conceptual models (MODFACs), and cell-based spatially explicit models (SHIFT) to quantify colonization probabilities (Fig. 1). The work presented here is based on modeling the primary individual tree species of the eastern United States, with results focused on the northern Wisconsin region. We briefly describe the methods used and then present a brief evaluation and example of potential changes for one tree species, black oak (*Quercus velutina*), along with several other interpretive measures that complement the models, to assist in further evaluation of vulnerabilities and potential management options.

2. Methodology

2.1 DISTRIB model development

To create the models, current climate variables (1960-1990) are used in statistical model development, and then are swapped with the future climates (~2070-2100) according to several global circulation models (GCMs) and emission scenarios. We used two emission scenarios developed for the Intergovernmental Panel on Climate Change (IPCC): a high level of emissions that assumes a continued high rate of fossil fuel emissions to 2050 (A1fi), and a lower emission scenario that assumes a rapid conversion to conservation and reduced reliance on fossil fuels (B2) (Nakicenovic and al. 2000). The scenarios are also based on the output from two representative GCMs: the HadleyCM3 model (Pope 2000), and the Parallel Climate Model (PCM) (Washington et al. 2000). We present the HadleyCM3 model projections under the high emissions scenario (HadHi) as the most extreme warming case in our analysis, and the PCM model under the low emissions scenario (PCMLo) to represent the case with the least warming.

We use the DISTRIB model, a statistical-empirical approach using decision-tree ensembles to model and to predict changes in the distribution of potential habitats for future climates (Fig. 1) (Prasad et al. 2006), Iverson et al. 2008b). For species information on a total of 134 tree species, we use the USFS Forest Inventory and Analysis (FIA) data to build importance value estimates for each species. We use 38 environmental variables – 7 climate, 9 soil classes, 12 soil characteristics, 5 landscape and fragmentation variables, and 5 elevation variables – to statistically model current species abundance with respect to the environment. Because the processes involved are nonlinear with numerous interactions, we use non-parametric machine-learning approaches using decision-tree ensembles to predict and provide valuable insights into the important predictors influencing species distributions. Specifically we used a 'tri-model' approach: RandomForest for prediction, bagging trees for assessing the stability among individual decision-trees and a single decision tree to assess the main variables affecting the distribution if the stability among trees proved satisfactory (Prasad et al. 2006, Iverson et al. 2008). The result is an estimate of the potential future suitable habitat.

Because models vary in their ability to predict we provide an index of the reliability for each species. For example, species with highly restricted ranges with low sample size often produce less satisfactory models as compared to more common species (Schwartz et al. 2006). This pattern results in quite large differences in the reliability of the predictions among species and highlights the need to consider how the model captures the speceis distribution. The 'tri-model' approach gives us the ability to assess the reliability of the model predictions for each species, classified as high, medium or low depending on the assessment of the stability of the bagged trees and the R^2 in RandomForest. This high rating occurred for 55 of the 134 tree species in our models. Even if the model reliability was medium or low, RandomForest predicts better without overfitting due to its inherent strengths compared to a single decision-tree (Cutler et al. 2007).

2.2 Modification Factors

The DISTRIB model does not address biological or disturbance factors that may influence a species' response to climate change. We conducted a literature assessment of these modifying factors and developed a scoring system to address 9 biological and 12 disturbance modification factors (MODFACs) that influence species distributions. Biological factors we evaluated include the species' capacity to regenerate after fire, regenerate vegetatively, establish as seedlings, disperse, as well as the species' response to competition for light, elevated CO_2 for productivity and water use efficiency, and specificity to specific environmental habitats or edaphic conditions. For distubance factors, we considered the species' response to invasive plants, insects, browse, disease, temperature gradients, fire topkill, wind, ice, pollution, floods, droughts, and harvesting. We also rated their level of uncertainty and future relevance under climate change (e.g., droughts will become more problematic under most future scenarios). These factors, when considered alongside the speces models, can be used to modify how one interprets the potential for increasing or decreasing future importance of a species. Each species is given a set of default scores based on the literature, and each factor can be changed by managers as they consider local conditions. With knowledge of site-specific processes, managers may be better suited to interpret the models after MODFACs have been considered. The MODFACs can then be used to modify the interpretation of the potential suitable habitat models. The goal of this effort is to provide information on the distribution of species under climate change that accounts for the natural processes that influence the final distribution. In addition, this approach encourages decision-makers to be actively involved in managing tree habitats under projected future climatic conditions.

2.3 SHIFT model development

Finally, with SHIFT we are evaluating selected species for their potential migration potentials from where they exist currently to where, of the new suitable habitat to emerge, they may be able to colonize over the next 100 years (Fig. 1). SHIFT calculates colonization potentials based on the abundance of the species, the distances between occupied and unoccupied cells, the quality of the habitat, and the fragmented nature of the landscape. The long distance dispersal, captured by an inverse power function, also depends on stochasticity. By combining output from DISTRIB and SHIFT, we may not only obtain an idea of how the suitable habitat may move, but also some idea on how far the species may move across the fragmented habitats of the region. We calibrate movement at the approximate (generous) migration rate of 50 km per century, according to paleoecological data from the Holocene period (e.g., (Davis 1981). Details of the method (although under revision now because of newly available computing approaches) are presented in several publications (Iverson et al. 1999; 2004; Schwartz et al. 2001).

3. Results and Discussion

3.1 DISTRIB model

Of 134 species modeled in the eastern United States, we found a total of 73 species of interest for the region in northern Wisconsin. Using the estimates of potential changes in suitable habitat, we sorted the species according to their potential to gain, lose, have no change, or enter into the region from outside. As such, we classify them into 8 vulnerability classes which can be influenced by climate change classes ranging from most vulnerable to least vulnerable:

Extirpated (Extirp): These species are in northern Wisconsin currently, but all suitable habitat disappears by 2100. [1 species]; Large Decline (LgDec): Show large declines in suitable habitat , especially under the high emissions scenarios [12 species]; Small Decrease (SmDec): Show

smaller declines, mostly apparent in the high emissions scenarios. [6 species]; No Change (NoChg): Show roughly similar suitable habitat now and in the future. [6 species]; Small Increase (SmInc): Have an increased amount of suitable habitat in the future as compared to current, especially with the higher emissions. [4 species]; Large Increase (LgInc): Have much higher estimates of suitable habitat in the future as compared to current, especially with the higher emissions. [17 species]; New Entry Both (NewEntBoth): Have very rarely been currently detected via FIA sampling in northern Wisconsin, but show potential suitable habitat entering the region, even under the low emission scenarios. [11 species]; New Entry High (NewEntHi): Have very rarely been detected via FIA sampling in northern Wisconsin, but show potential suitable habitat entering the region, especially under higher emissions. [16 species]

We chose to select one example species from class 6, large increaser (LgInc), to illustrate the process researchers and managers may pursue to help chart out a range of mangement choices in the face of climate change. Our example species, black oak (*Quercus velutina*), has high model reliability so we can have higher confidence in the modeled expansion of suitable habitat from nearly absent to the entire northern Wisconsin range (Fig. 2a), with an increase in suitable habitat under both low (4-fold increase, Fig. 2b) and high (6-fold increase, Fig. 2c) emission scenarios according to our model.

3.2 Modification Factors

The literature assessment of black oak revealed that it is quite resistant to drought and fire topkill (both projected to increase under climate change), but not so much as compared to many other oaks. It is moderately affected by diseases (which may also increase) and it can succumb to successive defoliations by gypsy moth. It can regenerate quite well from seed or sprouts with the likely increased fire under climate change. And it is rather a generalist with respect to temperatures as well as edaphic and environmental habitats, all of which are advantageous for a species projected to have increased habitat. Overall, both the biological and disturbance modifying factors suggest that the species could do slightly better than modeled from DISTRIB and that it may be well suited for the newly emerging habitats of northern Wisconsin.

3.3 SHIFT model

The preliminary output of 100 repetitive runs of the SHIFT model (1 run = 1% probability of colonization) for black oak shows an expansion of areas with even a small probability of colonization of roughly 120-160 km into the new suitable habitat within 100 years (Fig. 2d). Obviously, variations in colonization probability relate to the current abundance of the species next to the range boundary (Fig. 2d), and the quantity and nature of the forest habitat in the expanding zone (Fig. 2e). The outputs give us a picture of the relatively small and slow expansion of the species, given the constraints of the current habitat and the paleoecologically derived migration rate of 50 km/century. Of course, should humans intervene to assist in the migration, the picture could potentially change dramatically.

4. Conclusions

The combination of these three approaches to assessing the likely impacts of climate change provide a more thorough analysis and, we hope, a tool set that managers can begin to use in the course of their adaptive management decisions in the face of climate change. With DISTRIB, we provide potential changes in individual species' suitable habitat under various climate models and scenarios of human responses to this crisis. With the modifying factors, we assess each species' capacities and vulnerabilities to adapt to various changing conditions and disturbances. And with SHIFT, we provide an indication of the rate of 'natural' migration

through the fragmented habitats now existing. We intend to use SHIFT as well to perform 'experiments' of landscape manipulation and assisted migration to assess these potential strategies under climate change.

We also show the vast differential in outcomes between a low carbon future (PCMlo) and high carbon future (HADhi) with respect to habitats for one species (it is the case for most species), and thus the critical need for a global effort to reduce carbon emissions.

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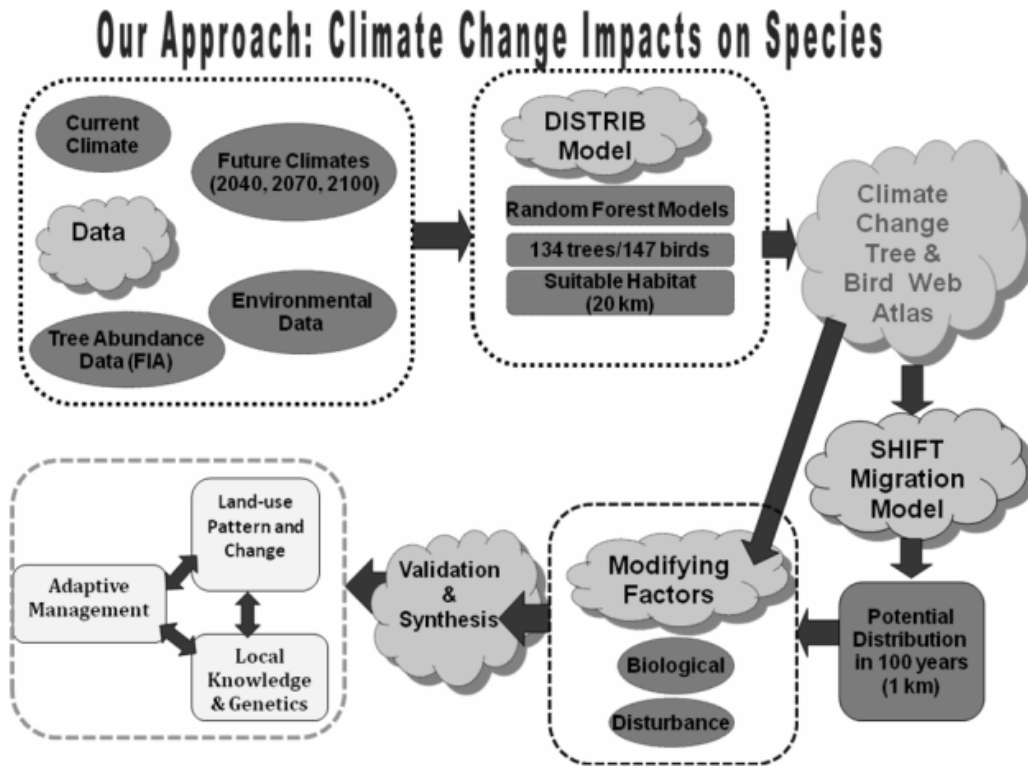
Fig. 1. Schematic showing approach to modeling potential impacts of climate change on trees and birds in the Eastern United States.
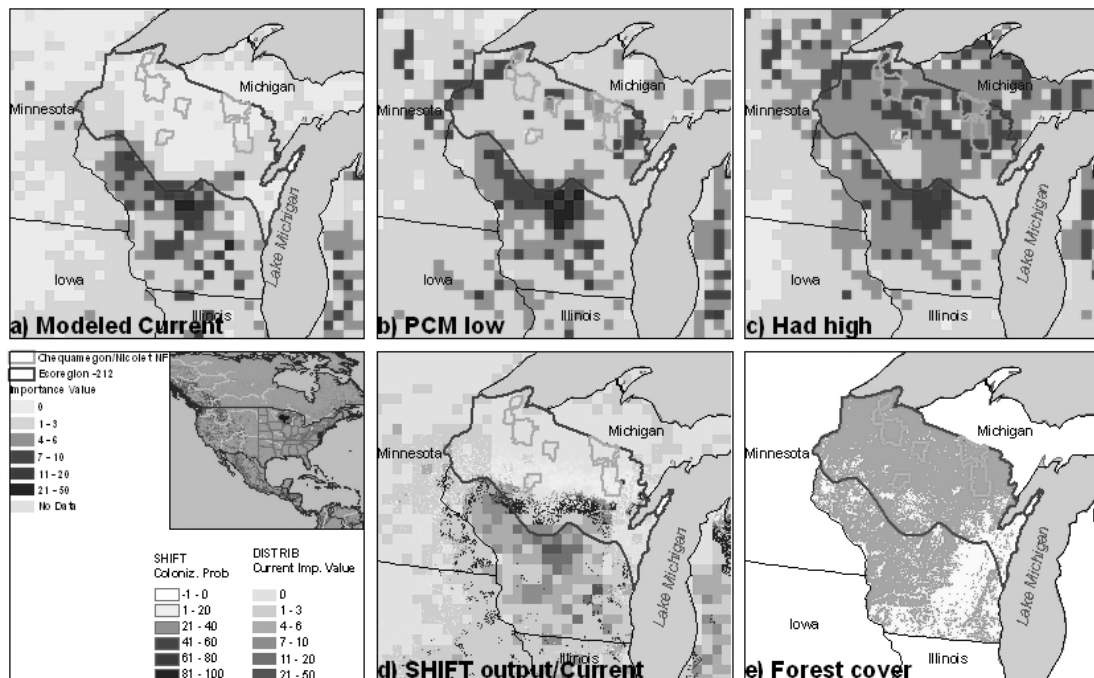
Fig. 2. Potential habitat changes for black oak; a) current distribution; b) future habitat under PCM low (humans track low carbon emissions); c) future habitat under Had high (humans continue to expand carbon usage); d) SHIFT colonization probability on current distribution; e) forest cover of Wisconsin region (gray=forest).

Immediate effects of typhoon disturbance and artificial thinning on understory light environments in two subtropical forests in Taiwan

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Abstract

We compared changes in understory light environments immediately following two typhoons, and artificial thinning (25% and 50% of stems removed) in two subtropical forests. Both typhoon disturbance and artificial thinning enhanced understory light availability in Taiwan, but the enhancement following thinning, 42%, was considerably greater than that following typhoon disturbance, < 25%. Understory light availability increased 45% and 120% after 25% and 50% thinning, respectively. The diffuse nature of canopy disruption following typhoon disturbance relative to the patchy and binary canopy removal associated with artificial thinning was likely the reason for their very different impacts on understory light environments. It appears that artificial thinning with more than 25% of stems removed increases understory light availability to a level that does not naturally occur in low-elevation forests so that forest development following artificial thinning is likely to be different from that following typhoon disturbance.

Keywords: typhoon disturbance; artificial thinning; understory light environment; Fushan Experimental Forest

1. Introduction

The availability of light to understory plants is critical in determining patterns of the understory plant community (Fahey and Puettmann 2007). Because light availability beneath undisturbed forest canopies is typically low, enhancing understory light availability can increase the growth and survival of both shade-tolerant and -intolerant tree seedlings (Chazdon and Fetcher 1984; Oliver and Larson 1996). Disturbances that lead to enhancement of understory light availability create opportunities for seedlings to grow into the mid-canopy and overstory and therefore play a key role in determining the structure and function of forest ecosystems. Although artificial thinning may create spatial and temporal heterogeneities in the understory light environment and promote the growth of understory plants (Yanai et al. 1998; Wang et al. 2008), the comparison of its impacts with wind disturbances, to our knowledge, has not been adequately documented. Such comparisons are critical to evaluate whether artificial thinning results in patterns and processes that are comparable to those following natural disturbances.

Typhoons are the most common natural disturbance in many low-elevation, subtropical forest ecosystems, such as those in Taiwan with an average of three to four typhoons striking Taiwan annually (Wu and Kuo 1999). Any silvicultural practice that intends to maintain natural levels of light heterogeneity and species diversity in low-elevation forests must consider the role that typhoon disturbance plays in regulating natural patterns and processes of these ecosystems.

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In 2006, an experimental thinning on a *Cryptomeria japonica* plantation in central Taiwan was initiated as an attempt to improve the structural heterogeneity and biodiversity of the forest (Sun 2007). This was the first large and comprehensive experimental thinning in Taiwan, and the study included assessment of a wide variety of biotic and abiotic consequences (e.g. vertebrate and invertebrate diversity, recruitment of tree species, microclimate, decomposition, and soil respiration) of forest management practices. Although the *C. japonica* plantation under investigation is located at a moderate elevation (1500-1700 m), the study aimed to produce recommendations for island-wide application (Sun 2007).

The objectives of the current study are to 1) characterize the forest understory light environment before and after the experimental thinning, and 2) compare the impacts of artificial thinning in the *C. japonica* plantation with those from typhoon disturbances in a mixed evergreen hardwood forest at Fushan Experimental Forest in northeastern Taiwan (Fig. 1). In both the *C. japonica* plantation and the Fushan Experimental Forest, we measured understory light availability immediately before and after artificial thinning and typhoon disturbances to determine whether artificial thinning results in patterns of understory light environments comparable to those following typhoon disturbances characteristic of many low-elevation forests in Taiwan.

2. Methodology

2.1 Study site

2.1.1 *Cryptomeria japonica* plantation: The Zenlun Experimental Forest

The *C. japonica* forest plantation is located in central Taiwan between 1500 m and 1700 m elevation. The natural vegetation in this area was clear-cut approximately 50 years ago and replanted with *C. japonica*. The mean annual precipitation at the plantation is 3800 mm, and the mean monthly temperature is 17.5°C (Wang et al. 2007). The mean tree height was approximately 17 m in 2006 (Chiu 2007 unpublished data).

In 2006, twelve 100 x 100 m plots were established at Zenlun Experimental Forest following the design of large forest dynamic plots at the Center for Tropical Forest Science of the Smithsonian Tropical Research Institute (Losos and Leigh 2004). The 12 plots were evenly and randomly assigned to three treatments: unthinned, 25% thinning, and 50% thinning. Each plot was divided into a grid of 100 10 x 10 m subplots, which were grouped into 25 20 x 20 m operating plots. In the 25% thinning, one of the four subplots in each operating plot was randomly assigned for clear-cutting; two non-adjacent subplots were randomly assigned for cutting in operating plots assigned a 50% thinning. We established one 100-m transect perpendicular to the elevational contours at the center of each of the 12 plots. In order to monitor seasonal variation of understory light environment before thinning, transects at Zenlun Experimental Forest were established one year before thinning. All transects were less than 3 m from the edges of the thinning subplots; none of our sampling transects ran through the center of the thinned subplots.

2.1.2 Natural forest: the Fushan Experimental Forest

The Fushan Experimental Forest is a mixed evergreen hardwood forest dominated by Fagaceae and Lauraceae and located in northeastern Taiwan at elevations between 500 and 1200 m. Typhoons mainly occur between July and September, with infrequent typhoons as early as May and as late as December. On average, 1.4 typhoons strike the Fushan Experimental Forest each year (Mabry et al. 1998). The mean annual temperature at Fushan is 18.6°C, and the mean annual relative humidity is 96% (Hsia and Hwong 1999). The forest is multistoried with

scattered tree ferns (Alsophila podophylla Hook (Cyatheaceae)) and herbaceous cover. We measured light availability every five meters along a 300-m transect along the eastern ridge of experimental watershed #1 established in 1994.

2.2 Methods

Understory light environments were investigated using hemispherical photography (Rich 1990; Lin and Chiang 2002). Hemispherical photographs were taken at 1.5 m above the ground, at 5-m intervals in both forests. Photographs were analyzed to estimate global site factor (GSF), the proportion of solar radiation reaching a given location, relative to a fully exposed location with no obstructions (Rich 1990) using Hemiview 2.1 (Delta-T 2000).

Two typhoons, Herb in 1996, and Toraji in 2001 were used to evaluate the immediate effects of typhoon disturbance on understory light environments. According to the Central Weather Bureau of Taiwan, both typhoon Herb was a strong typhoon (maximum wind velocity > 51 m.sec-1), and typhoon Toraji was a medium-intensity typhoon (maximum wind velocity 33-51 m.sec-1; Table 1).

3. Result

Light indices significantly increased after both typhoon disturbance and artificial thinning (Fig. 1, paired t-test all p-values < 0.001). In the unthinned plots, mean post-thinning GSF was significantly lower than the mean pre-thinning GSF (paired t-test p < 0.01). The effect of typhoon disturbance was variable, depending on the strength of the typhoon. The mean percent changes in understory light indices were significantly greater after typhoon Herb (24%) than after typhoon Toraji, (7.8%) (Fig. 1, Bonferroni multiple comparisons, both p-values < 0.005).

Artificial thinning caused disproportional increases in understory light indices. The 25% thinning caused an approximately 42% increase 0.25, while the 50% thinning resulted in an approximately 120% increase reaching 0.36 (Fig. 2). The increase in understory light indices was greater after the 25% thinning (approximately 42% enhancement) than after the strong typhoon Herb (approximately 25% enhancement) (one-way ANOVA, p <0.001, Fig. 1).

The mean pre-thinning GSFs in the *C. japonica plantation* (0.16-0.17) were lower than the mean pre-typhoon GSFs in the Fushan Experimental Forest (0.18-0.26 among the typhoons). Regardless of the differences in pre-disturbance understory light indices, the magnitude of the ranges of pre-thinning GSF in the *C. japonica* plantation were comparable to that of pre-typhoon GSF for the two typhoons in the natural forest at Fushan (Fig. 1). After the artificial thinning at Zenlun, regardless of the thinning intensity (i.e. 25% or 50%), the ranges GSF were considerably larger than the ranges after the two typhoons in the natural hardwood forest at Fushan (Fig. 1).

Following typhoon disturbance few micro-sites with low light prior to the typhoon showed decreases in post-typhoon understory light indices, but substantial proportions of the high light (pre-typhoon) micro-sites showed decreases in understory light indices (Fig. 2). Light indices also decreased on some micro-sites after 25% thinning in the *C. japonica* plantation but the proportion was much lower than that after typhoon disturbance and no micro-sites showed decreases in understory light indices after 50% thinning (Fig. 2). In addition to the differential response between high light and low light micro-sites, many micro-sites with very similar pre-typhoon/thinning light indices had very different responses to both typhoon disturbance and artificial thinning. Many adjacent points (i.e. micro-sites with similar pre-typhoon/thinning light availability) had very different post-typhoon/thinning light indices (Fig. 2).

4. Discussion

There was a positive relationship between typhoon strength and increase of understory light availabilities following typhoons. Typhoon Herb was a category three typhoon and the strongest to impact Taiwan in the last 3 decades (Longshore 2008). It caused a decrease in the canopy leaf area index from 2.99 to 2.40 or 20% on the transect (Lin et al. 1999). The 25% artificial thinning should have also resulted in an approximately 25% removal of canopy leaf area because all trees located in the thinned subplots were felled. However, the resulting enhancement of understory light indices (approximately 42%) was significantly greater than that which followed typhoon Herb (approximately 25%). Note that the magnitude of understory light enhancement following typhoon Herb was comparable to the magnitude of canopy leaf removal and was likely the result of the spatially distributed effect of typhoon disturbance on canopy structure. In contrast, thinning removes whole clusters of trees to create gaps of $100m^2$ that are open to the sky and resulted in disproportional increases in understory light availabilities which must be taken into consideration if artificial thinning is used in attempts to enhance understory light availability to a pre-determined level because the reduction of tree basal area does not provide a good estimate of increases in canopy transmittance (Hale 2003).

In addition to the disproportional increases in understory light availabilities, the much greater understory light enhancement following 25% artificial thinning compared to the strongest typhoon in the last three decades indicates that thinning of 25% or greater is likely to create understory light environments that do not exist naturally in these forests. The light availability following artificially thinning, 25%-36% of levels in the open, could lead to a very different trajectory of forest regeneration.

The very different patterns of post-typhoon GSF for micro-sites that varied in pre-typhoon GSF (Fig. 2) may reflect differences in vulnerability of tree canopies. The increase in GSF is certainly due to the opening of the forest canopies caused by typhoon disturbance. The low light micro-sites were likely under taller and/or denser tree canopies than the high light micro-sites. The decrease in GSF after typhoon disturbance in many high-light micro-sites probably resulted from the larger effect of canopy closure between two repeated measurements than the effect of typhoon disturbance in these high-light micro-sites. However, typhoons as intense as Herb in 1996 can completely obliterate this effect of seasonal growth.

After 25% thinning there were still many micro-sites showing decreases in GSF (Fig. 1) suggesting that the growth potential of micro-sites with high light availability was substantial. Thus, if such micro-sites are not in or near the thinned subplots, the effect of seasonal growth cannot be completely offset by thinning by 25% or less.

The very different responses to artificial thinning among micro-sites with similar pre-thinning understory light indices (Fig. 2) resulted from their difference in distances relative to the thinned subplots. Micro-sites near or on the edges of the thinned subplots certainly exhibited large enhancements of understory light availability. Micro-sites further away were less affected, and the effect of artificial thinning on understory light availability may even be smaller than the effect of tree growth between the two repeated measurements.

In the natural forest at Fushan Experimental Forest, differences in topography and species composition are possible causes for the variable impact of typhoon disturbance on micro-sites of similar pre-typhoon light indices. The disruption to forest canopies and, in turn, to understory light environments were scattered in space resulting in spatially variable impacts on understory light availability. Thus, the effect of both typhoon disturbance and artificial thinning on understory light environments exhibited large spatial variation.

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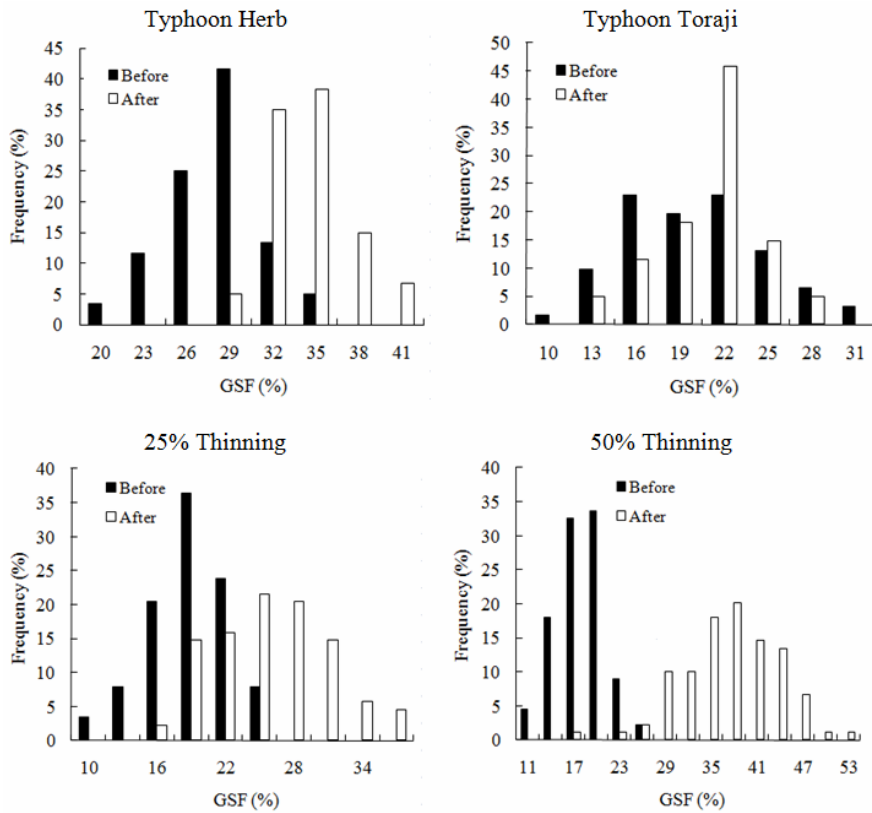
Fig. 1. Frequency distribution of light availability before and after typhoon disturbance and artificial thinning.
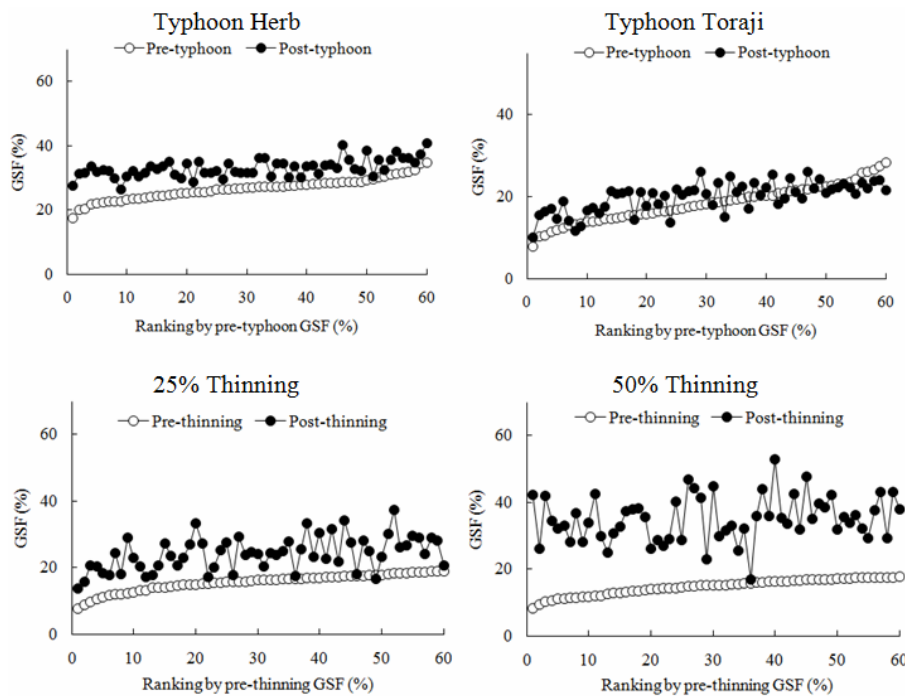
Fig. 2. Light availability before and after typhoon and thinning light availability. Measurements for each sampling position were sorted based on the rank order of the beforetyphoon/thinning light measurements.

Impact of hemlock decline on successional pathways and ecosystem function at multiple scales in forests of the central Appalachians, USA

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Abstract

Hemlock woolly adelgid (HWA) is an invasive, exotic insect causing widespread mortality in *Tsuga canadensis* (L.) Carr forests of the eastern United States. *T. canadensis* is considered a foundation species that dominates ravine and riparian forests across the central and southern Appalachian Mountains. We are working to clarify how the loss of *T. canadensis* will affect ecosystem function in forests of the central Appalachians at both local and landscape scales. Using a chronosequence approach, we are examining forests within regions classified as long-term invaded (> 10 years), recently invaded (5-10 years), and intact (not invaded). Initial analyses indicate hemlock is particularly dominant immediately adjacent to streams, with few other species in any of the vegetation layers. As this evergreen with poor quality leaf litter declines, light availability and decomposition rates are increasing, changing the successional pathways of these forests and providing resources for additional species including invasive, non-native plant species.

Keywords: Central Hardwood Forest, Ecological disturbance, Hemlock woolly adelgid, invasive species, Tsuga canadensis

1. Introduction

The forested landscape of eastern North America has been reshaped over the past two centuries by introduced pests and pathogens (Lovett et al. 2006). *Tsuga canadensis* (L.) Carr has been an influential canopy tree species throughout these forests from the last major glacial maximum approximately 10,000 ybp (Allison et al. 1986, Heard and Valente 2009). Yet, an invasive insect may eliminate it from most of its range within the next few decades. Described as a foundation species (Ellison et al. 2005), the demise of *T. canadensis* will result in widespread changes throughout forests of eastern North America. Throughout its range extending from the southern Appalachian Mountains north to New England, the upper Great Lakes and eastern Canada, *T. canadensis* dominates ecosystem processes. This evergreen conifer contributes a unique landscape component, adding beta and gamma diversity in a matrix of largely deciduous forests. This may be particularly important in the central and southern portions of its range, where *T. canadensis* is largely restricted to riparian and cove forests along headwater streams. In the majority of cases, it composes over half of the basal area and there is little functional redundancy with any of the co-occurring deciduous hardwoods.

Introduced in Virginia in the 1950's, the pest insect hemlock woolly adelgid (*Adelges tsugae* Annand*;* hereafter HWA) has spread from northern Georgia to southern Maine and continues to

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move westward in Pennsylvania (Figure 1). HWA feeds on the parenchyma cells of xylem rays, which causes the death of branches and leads to mortality in *T. canadensis* (McClure 1991). There is no evidence that *T. canadensis* or *T. caroliniana* Engelm., a species endemic to the southern Appalachians, have any resistance to HWA. Thus complete mortality occurs in 4-15 years (McClure 1991; Orwig and Foster 1998). Evans and Gregorie (2007) estimate HWA to spread at a mean rate of 12 km yr^{-1}, but both the spread and effects are accelerated in southern, warmer portions of the range (Ford and Vose 2007).

On-going *T. canadensis* mortality is undoubtedly altering forest dynamics including species composition, diversity, and nutrient and energy exchanges. *T. canadensis* forms a foundation that supports unique species assemblages, including cold-water fishes, birds, and macroinvertebrates (Ellison et al. 2005). Across the *T. canadensis* range, pollen records following an historic population decline 5,000 ybp provide useful insight into species likely to respond to hemlock mortality, including *Betula, Acer* and *Quercus* species (Heard and Valente 2009). However, communities that develop following *T. canadensis* mortality may be region-specific, thus creating greater dissimilarity across portions of the landscape once dominated by hemlock (Ellison et al. 2005; Orwig et al. 2008). Much of the current understanding of the impact of *T. canadensis* mortality is centered in the Northern Hardwoods forest province. Yet, a large portion of the *T. canadensis* range lies within the Central Hardwoods forest, a province extending from West Virginia to Alabama and west to Missouri and Wisconsin (Fralish 2000).

We are working to clarify the contemporary impact of this introduced disturbance across the central Appalachians. The objective of our on-going study is to quantify changes in plant community structure and ecosystem function in headwater stream riparian forests of the central Appalachian Mountains. For the broader study, we are using a chronosequence of time since HWA invasion to examine the following questions:
1. How will or does *T. canadensis* mortality impact headwater streams at local scales, moving from the stream bank upslope?
2. How much variation can we expect in these changes both across the central Appalachians?
3. How do our results compare to understanding from the northeastern U.S. and southern Appalachian Mountains?
4. What can we predict in terms of forest composition and function over time as *T. canadensis* mortality progresses and forests transition to an alternate ecosystem?

Before HWA arrives, we are quantifying the vegetation and environmental relationships in *T. canadensis* dominated ravines important for natural heritage and recreation on the unglaciated Allegheny Plateau of southeastern Ohio. Therefore, in this paper we focus on our first question: How will or does *T. canadensis* mortality impact headwater streams at local scales, moving from the stream bank upslope? According to the projected rate of spread (12 km $^{-1}$ year, Evans and Gregorie 2007) and the current USDA Forest Service map of HWA invasion (Figure 1), Ohio may be invaded within the next few years.

2. Methodology

For the broader study, areas have been identified in the central Appalachian region, including sites within the Allegheny Mountains of Virginia and West Virginia, and the Allegheny Plateau region of eastern Ohio. Using the United States Department of Agriculture (USDA) Forest Service HWA distribution map and information available from local land managers, we have identified and acquired research permits for study areas in the states of:

1. Virginia (Jefferson and George Washington National Forests), where HWA has been present for 25-30 years and hemlocks in invaded stands are likely dead (based on the 4-15 year mortality timeframe; McClure 1991);
2. West Virginia (New River and Gauley River National Recreation Areas, Monongahela National Forest), where HWA has recently invaded (2-5 years) and trees are declining; and,
3. Ohio (Lake Katherine State Nature Preserve, Sheick Hollow State Nature Preserve, Hocking State Forest) where HWA is not yet present.

In this paper, we focus on data collected in the Unglaciated Allegheny Plateau physiographic province of southeastern Ohio (Brockman 1998). This province of deep cliffs and valleys cut into the sandstone bedrock supports the majority of *T. canadensis* within Ohio (Black and Mack 1976). Three of our steam reaches were located at Lake Katharine, an 817-ha State Nature Preserve, four were located within the 3,924-ha Hocking State Forest, and one at Sheick Hollow, a 61-ha State Nature Preserve. The climate in the area is continental with cold, snowy winters (mean = 0°C) and warm, humid summers (mean = 21.6°C) with an average rainfall of 102 cm distributed evenly throughout the year (Kerr 1985; Lemaster and Glimore 1989). All areas were second-growth forest ravines with hemlock approximately 50% or more of the basal area. Any areas with evidence of recent human disturbance (logging roads, stumps) were excluded.

We sampled vegetation using a series of five 100-m^2 circular plots (5.64 m radius) centered 10, 30, and 50-m from small streams and 15 m apart. The species and d.b.h. (diameter at breast height, 1.67 m) of all woody vegetation was recorded. Stems 2.5 - 10 cm d.b.h. were classified as saplings. All stems > 10 were coded as dominant (full canopy in sun), co-dominant (portions of canopy in sun), intermediate (top of canopy not overtopped), or sub-canopy (overtopped). For analyses, the five subplots in each transect were added together for analyses for a 500-m^2 scale. To understand community characteristics at different slope positions across the ravines, we also analyzed functional diversity using species guilds developed for the Central Hardwood Forest of the USA by Sutherland et al. (2000). As we are focused on *T. canadensis* as a foundation species currently subjected to species-specific mortality, we separated it into its own functional group for analyses.

Mean species and functional richness and diversity were compared by transect using one-way analysis of variance (ANOVA) tests. In cases where means differed, the three transects were subjected to Tukey's mean separation test. All analyses were calculated using PASW statistics 18 software (SPSS Inc, Chicago, IL)

3. Results

Our results indicate that in ravines of the Unglaciated Allegheny Plateau of Ohio, *T. canadensis* is highly dominant with few other species in the canopy, sub-canopy, or sapling layers (Table 1). Hemlock basal area did not vary by transect, and neither did overall basal area. Although there was not a strong separation (Canopy species richness F = 2.57, P = 0.100, d.f. = 2), *Betula lenta* L. and *Liriodendron tulipifera* L., as well as *Fagus grandifolia* Ehrh., were more common adjacent to the stream. Sutherland et al. (2000) categorize *B. lenta* and *L. tulipifera* as a part of a long-lived, shade intolerant functional group, indicating they are gap-dependent in hemlock ravines. On the other hand, *F. grandifolia* is part of the same extremely shade tolerant, slow-growing, and long-lived functional group that includes *T. canadensis* (Sutherland et al. 2000). Moving from the stream upslope, there was also a slight increase in canopy functional richness (F= 3.95, P = 0.035, d.f. = 2). This was largely due to increases in *Quercus* and *Carya* species, which Sutherland et al. (2000) group into the red oak- hickory (i.e. *Quercus rubra* L., *Q. coccinea* Münchh. and *Carya* spp.) and the white oak (*Q. alba* L., *Q. prinus* L.) groups due to differing germination requirements. Along the 30-m transect, the shade-tolerant *Acer-Ulmus*

group was also more abundant, largely due *A. rubrum* L. and a few scattered *U. rubra* Muhl. In the sub-canopy, a slight increase in species richness ($F = 3.87$, $P = 0.037$, d.f. = 2) and diversity ($F = 3.10$, $P = 0.066$, d.f.= 2) equated to slightly increased functional richness ($F = 3.02$, $P = 0.070$, d.f. = 2). Somewhat mirroring the canopy, *B. lenta* was more common in sub-canopy at 10 m while *A. rubrum* and *Q. prinus* were more frequent in the sub-canopy along the 50-m transect. The sapling layer was the most depauperate with mean species richness below three species. Saplings were overwhelmingly hemlock and were less abundant adjacent to the stream. Following *T. canadensis, A. rubrum* and *F. grandifolia* were the most common species in the sapling layers, but still at very low numbers (mean below 2 stems per plot).

4. Discussion

On the Unglaciated Allegheny Plateau of southeastern Ohio, *T. canadensis* dominates steep ravines formed in sandstone bedrock. These ecosystems are characterized by low species and functional diversity in the canopy, sub-canopy and sapling forest layers. While these forests remain outside the current HWA invasion, the spread continues and will likely reach Ohio within the next few years. The species that replace *T. canadensis* will be quite different functionally. Sutherland et al. (2000) characterize *T. canadensis* as part of a group including *Acer nigrum* Michx. f*., A. saccharum* Marsh.*, Carpinus caroliniana* Walter, *Fagus grandifolia, Ostrya virginiana* (Mill.) K. Koch , *Oxydendrum arboretum* (L.) DC*, Tilia americana* L. and *T. heterophylla* Vent*.* These shade tolerant, long-lived species are currently sparse or absent in *T. canadensis* ravines. Runkle and Whitney (1987) suggest that in this region, poor quality, low pH soils may be responsible for the lack of these species typically dominant in mesic habitats of the Central Hardwoods region such as *Acer saccharum* and *Tilia* spp. This functional group is also challenged by mortality of *F. grandifolia* due to beech bark disease, caused by an interaction between the pest *Cryptococcus fagisuga* Ling, and the exotic fungi *Nectria coccinea* var. *faginata* Lohman, Watson, and Ayers and *N. galligena* Bres. This disease is currently causing widespread mortality in the northeastern US and continues to spread westward.

HWA will shift ravine and riparian forests into a different ecosystem state, driven by different forest functional groups. In Northern Hardwood Forests of the northeastern USA, *T. canadensis* is being replaced largely by *Betula lenta* (Ellison et al. 2005; Orwig et al. 2008). *B. lenta* is currently a minor component of *T. canadensis* ravines in Ohio, however, it is an opportunistic species well adapted to exploit canopy gaps (Orwig and Foster 1998; Catovsky and Bazzaz 2002). Ford and Vose (2007) also identify *Lirodendron tulipifera* as a canopy replacement species in the southern Appalachians. Sutherland et al (2000) group *B. lenta, L. tulipifera* as relatively shade-intolerant and long-lived. Also included in this group are *Juglans nigra* and *Platanus occidentalis* which occur infrequently at our plots, but respond well to disturbance.

Our results also indicate that HWA mortality may have differing impacts at local scales. At upper slope positions, we found a trend of increasing species richness in the sub-canopy and canopy, although sapling species richness remained low. This was largely due to increases in species of *Quercus* and *Carya.* Species in these groups are responsive to disturbance (Small et al. 2005) and may also exploit gaps created by the death of individual hemlock stems. Thus, upper slope positions may transition differently than areas immediately adjacent to streams. As we collect additional data across our mortality chronosequence, these patterns will be refined for the central Appalachian region.

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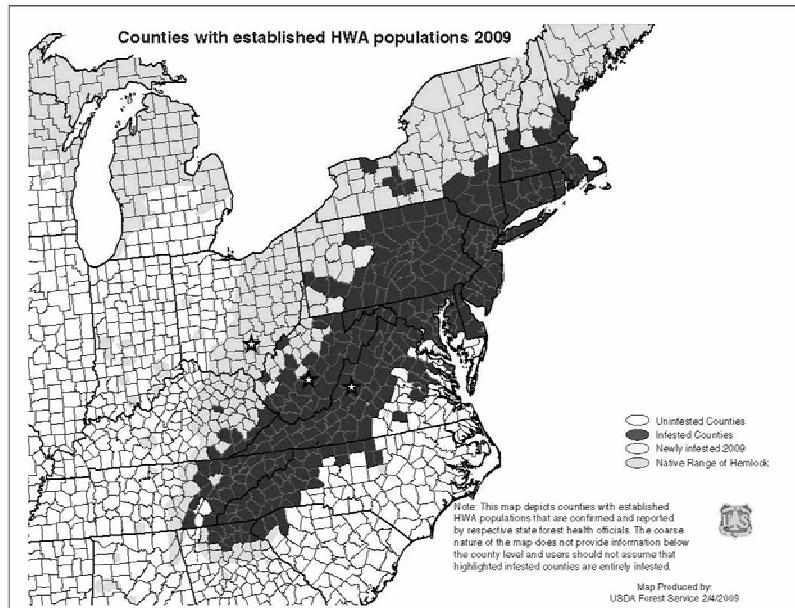
Figure 1: USDA Forest Service 2009 map of hemlock woolly adelgid spread across the range of *T. canadensis*. Study sites have been added with a star, moving west to east: Ohio, West Virginia, and Virginia.

Table 1: Comparisons of richness and diversity in *Tsuga canadensis* ravines at three transects centered upslope at 10, 30, and 50 m from headwater streams in Ohio, USA. Comparisons of means were calculated with one-way analysis of variance. Significant results are indicated: ** α = 0.05, * α = 0.1. Sub-canopy species richness $F = 3.87$, $P = 0.037$; Sub-canopy diversity $F = 3.10$, $P = 0.066$; Sub-canopy functional richness $F = 3.02$, $P = 0.070$; Canopy species richness $F = 2.57$, $P = 0.100$; Canopy functional richness $F = 3.95$, $P = 0.035$. In all cases d.f.= 2. Means separation as determined by Tukey's test is indicated by letters.

	10 m	30 m	50 m
Sapling species richness	1.63 ± 0.18	2.5± 0.68	2.38± 0.50
Sapling species diversity	0.20 ± 0.06	0.40 ± 0.19	0.42 ± 0.17
Percent saplings *Tsuga canadensis*	93.6 ± 2.3	86.6 ± 6.5	77.0 ± 10.4
Sub-canopy species richness**	2.50 ± 0.38[a]	3.38 ± 0.38[ab]	4.13 ± 0.48[b]
Sub-canopy species diversity*	0.48 ± 0.14[a]	0.58 ± 0.08[ab]	0.93 ± 0.17[b]
Sub-canopy functional richness*	2.50 ± 0.48[a]	3.25 ± 0.37[ab]	3.88 ± 0.13[b]
Sub-canopy functional diversity*	0.40 ± 0.14[a]	0.45 ± 0.11[ab]	0.81 ±0.13[b]
Canopy species richness*	4.00 ± 0.27 [a]	4.63 ± 0.32 [ab]	5.13 ± 0.44 [b]
Canopy species diversity	1.22 ± 0.09	1.23 ± 0.10	1.31 ± 0.11
Canopy functional richness**	3.63 ± 0.26[a]	4.13 ± 0.23[ab]	4.11 ±0.26[b]
Canopy functional diversity	1.14 ± 0.09	1.11 ± 0.09	1.11 ± 0.08

Indirect estimation of landscape uses by *Lama guanicoe* and domestic herbivorous through the study of diet composition in South Patagonia

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Abstract

Herbivory is central in ecosystem function studies, and herbivores influence over regeneration and vegetation composition through browsing. Understanding diet selection behavior along the year is important to predict herbivore impacts on regeneration and vegetation dynamics under different scenarios of forest and grazing management. The objective was to evaluate diet composition of herbivorous, and correlates it to the use of different vegetation types along the year. Study was conducted in 100 km² of Tierra del Fuego Island (Argentina) where 205 floristic surveys were obtained. Feces of native (*Lama guanicoe*) and domestic (*Bos taurus* and *Ovis aries*) herbivorous were collected. Four laboratory samples per species and season were analyzed, each one composed by five fecal collection. Samples were mixed, dried and ground in a mill (1 mm) for micro-histological analysis. Browsing occurred all around year, where native and domestic herbivorous alternate the uses of different environments. Native species preferred *Nothofagus pumilio* forests, except in winter, where domestic species had major predominance. Beside this, all herbivorous species included grasses in their diet, which were found in open environments (grasslands and peatlands). The knowledge of diet and plant distribution at landscape level allows us to propose management strategies for native and domestic herbivorous.
Keywords: browsing, forest management, fecal micro-histological analysis, Nothofagus, Argentina.

1. Introduction

Herbivory is central in ecosystem function studies, where large herbivores can produce important floristic and structural changes in forested landscapes, influencing plant productivity and species diversity (Augustine and McNaughton 1998; Skarpe and Hester 2007). In South Patagonia, these forested landscapes are mosaics of different site types, where timber-quality forests rarely constitute large, continuous masses since these are mixed with openlands and associated non-timber-quality forest stands (Lencinas et al. 2008), e.g. grasslands, peat-lands, *Nothofagus antarctica* forests and *N. pumilio* low quality forests. Beside this, the harvesting of *N. pumilio* forests impacts over richness and cover of the understory (Martínez Pastur et al. 2002). For this, understanding diet selection behavior along the seasons is important to predict herbivore impacts on regeneration and vegetation dynamics under different scenarios of forest and grazing management. *Lama guanicoe* (guanaco) is the only one large native herbivore (Bonino and Fernandez 1994), which compete with domestic herbivores across the landscape (Bonino and Sbriller 1991). The objective was to evaluate diet composition of large herbivorous, and correlate them to the use of different vegetation types along the year.

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2. Methodology

The study was conducted in 100 km² of Tierra del Fuego Island (Argentina) (54°20' SL, 67°52' WL), where open lands covered 40.0% of the area (grass-lands 36.5% and peat-lands 3.5%), forests covered 59.8% (*Nothofagus antarctica* forests 19.3% and *N. pumilio* forests 49.5%, classified as primary unmanaged 26.8%, recently harvested 9.1% and old harvesting 13.6%), and lagoons and lakes covered 0.2% (Fig. 1). Recently harvested forests (1-5 years) were cutted using a variable retention method (Martínez Pastur et al. 2009), which include non-harvested aggregated retention areas (30% of the stand) and harvested areas with dispersed retention (70% of the stand). Old harvesting (>5 years) was done through selective cuts. Climate is characterized by short, cool summers and long, snowy and frozen winters. Mean monthly temperatures vary from about -7ºC to 14ºC. Absolute temperatures range from -17ºC in July to 22ºC in January. The growing season extends for about 5 months, and only 3 months per year are frost-free. Precipitation is near 400 mm per year, and average wind speed is 8 km.h^{-1}, reaching up to 100 km.h^{-1} during storms (Lencinas et al. 2008). A total of 205 floristic surveys were obtained recording the cover percentage of vegetation in different site types. Vascular plants (Dicotyledonae, Monocotyledonae and Pteridophytae) were taxonomically classified by species and determined their origin (native or exotic), following Moore (1983) and Correa (1969-1998). Beside this, each species was classified according their relative abundance in common (more than 0.02% covers in average for the entire census) or rare (less than 0.02%).
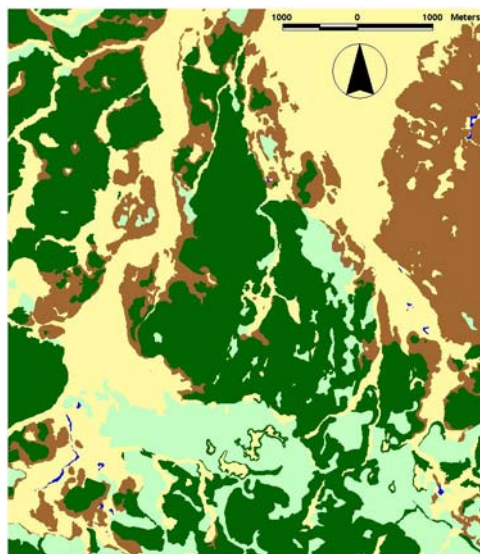
Figure 1: Study area, where: yellow = open lands, brown = *Nothofagus antarctica* forests, green = *N. pumilio* forests (dark green = primary unmanaged, green = recently harvested, pale green = old harvesting), and blue = lagoons and lakes.

Feces of native (*Lama guanicoe*) and domestic (*Bos taurus* and *Ovis aries*) herbivorous were collected along the four seasons (spring, summer, autumn and winter). In each sampling, four areas including different site types were selected, and five feces were collected and mixed to complete one pool sample (n = 4 per season per herbivorous species). Pool samples were oven-dried at 60ºC for 48 h, grounded to <1mm in a Willey-type mill, de-pigmented with alcohol 70º, colored with safranina and mounted on five microscope slides of 24 x 40 mm in glycerin-jelly (Williams 1969; Latour and Pelliza Sbriller 1981). Botanical composition of feces was determined by identifying plant epidermal (Sparks and Malechek, 1968) and non epidermal fragments (Sepúlveda et al. 2004) according to the micro-histological analysis method. Twenty random field observations per slide were performed, thus, a total of 100 fields per pool sample

were obtained. Quantification of the species components of the diets was achieved through the frequencies of each species following Holechek and Gross (1982). Plant epidermal fragments were identified examined using 100x magnification based on their morphological characteristics. *Nothofagus pumilio* and *N. antarctica* were identified through the stoma distribution patterns in the epidermis and swellening of cuticle and trichomes (Ragonese 1981). Data were analyzed trough a comparison with a detrended correspondence analysis (DCA) for the environment type or herbivorous species using plant species values obtained in the different sampling or census

3. Results

Plan diversity (Table 1) greatly changed among the studied vegetation types, and large diversity was shared among the environments (Fig. 2A). Beside this, open environments (mainly grasslands) presented more exclusive species than the other environments. Harvested forests increased their diversity with time, including many exotic species (Fig. 2B) compared to the primary unmanaged forests.

Table 1: Plant richness and their codes used for the vegetation type analysis.

Name	Code	Name	Code	Name	Code
Acaena magellanica	ACMA	*Colobanthus quitensis*	COQU	*Pernettya pumila*	PEPU
Acaena ovalifolia	ACOV	*Coronopus dydimus*	CODY	*Phaiophleps biflora*	PHBI
Acaena pinnatifida	ACPI	*Cotula scariosa*	COSC	*Phleum alpinum*	PHAL
Achillea millefolium	ACMI	*Cystopteris fragilis*	CYFR	*Phleum pratense*	PHPR
Adenocaulon chilense	ADCH	*Dactylis glomerata*	DAGL	*Plantago barbata*	PLBA
Agoseris coronopifolium	AGCO	*Deschampsia antarctica*	DEAN	*Poa annua*	POAN
Agropyron pubiflorum	AGPU	*Deschampsia flexuosa*	DEFL	*Poa nemoraris*	PONE
Agrostis magellanica	AGMA	*Draba magellanica*	DRMA	*Poa pratensis*	POPR
Agrostis perennans	AGPE	*Dysopsis glechomoides*	DYGL	*Polygonum aviculare*	POAV
Agrostis uliginosa	AGUL	*Elymus agropyroides*	ELAG	*Pratia longiflora*	PRLO
Alopecurus magellanicus	ALMA	*Empetrum rubrum*	EMRU	*Pratia repens*	PRRE
Alopecurus pratensis	ALPR	*Epilobium australe*	EPAU	*Primula magellanica*	PRMA
Arenaria serpens	ARSE	*Erigeron myosotis*	ERMY	*Ranunculus biternatus*	RABI
Azorella lycopodioides	AZLY	*Euphrasia antarctica*	EUAN	*Ranunculus fuegianum*	RAFU
Azorella trifurcata	AZTR	*Festuca gracillima*	FEGR	*Ranunculus maclovianus*	RAMA
Berberis buxifolia	BEBU	*Festuca magellanica*	FEMA	*Ranunculus uniflorus*	RAUN
Berberis empetrifolia	BEEM	*Galium antarcticum*	GAAN	*Ribes magellanicum*	RIMA
Blechnum penna-marina	BLPE	*Galium aparine*	GAAP	*Rubus geoides*	RUGE
Bolax gummifera	BOGU	*Galium fuegianum*	GAFU	*Rumex acetosella*	RUAC
Bromus unioloides	BRUN	*Gamochaeta spiciformis*	GASP	*Sagina procumbens*	SAPR
Calamagrostis stricta	CAST	*Gentiana postrata*	GEPO	*Schizeilema ranunculus*	SCRA
Calceolaria biflora	CABI	*Gentianella magellanica*	GEMG	*Senecio magellanicus*	SEMA
Caltha sagitata	CASA	*Geum magellanicum*	GEMA	*Senecio vulgaris*	SEVU
Capsella bursa-pastoris	CABU	*Gunnera magellanica*	GUMA	*Stellaria debilis*	STDE
Cardamine glacialis	CAGL	*Hieracium antarcticum*	HIAN	*Stellaria media*	STME
Carex capitata	CACA	*Holcus lanatus*	HOLA	*Taraxacum gillesii*	TAGI
Carex curta	CACU	*Hordeum comosum*	HOCO	*Taraxacum officinale*	TAOF
Carex decidua	CADE	*Hordeum secalinum*	HOSE	*Tetroncium magellanicum*	TEMA
Carex fuscula	CAFU	*Juncus scheuzerioides*	JUSC	*Thlaspi magellanicum*	THMA
Carex gayana	CAGA	*Leucanthemum vulgare*	LEVU	*Trifolium repens*	TRRE
Carex macloviana	CAMA	*Luzula alopecurus*	LUAL	*Triglochin concinna*	TRCO
Carex magellanica	CAMG	*Lycopodium magellanicum*	LYMA	*Triglochin palustris*	TRPA
Carex sorianoi	CASO	*Nanodea muscosa*	NAMU	*Trisetum spicatum*	TRSP
Carex subantarctica	CASU	*Nothofagus antarctica*	NOAN	*Uncinia lechleriana*	UNLE
Cerastium arvense	CEAR	*Nothofagus pumilio*	NOPU	*Veronica serpyllifolia*	VESE
Cerastium fontanum	CEFO	*Osmorhiza chilensis*	OSCH	*Vicia magellanica*	VIMA
Chiliotrichum diffusum	CHDI	*Osmorhiza depauperata*	OSDE	*Viola magellanica*	VOMA
Cirsium vulgare	CIVU	*Oxalis magellanica*	OXMA		

All the herbivorous mainly grazed in open environments all around the year, and were possible to find the same plant species in their feces analysis (e.g., *Carex* sp.) in all seasons (Table 2, Fig. 3). Beside this, in spring, *Lama guanicoe* consumed also *N. pumilio* saplings and *Misodendrum*, which were found in forested environments and specially in *N. pumilio* forests, while domestic herbivorous eaten species of open environments and *N. antarctica* forests too. In example, *N. antarctica* saplings, *Cotula scariosa* or *Luzula alopecurus* (Fig. 3A).
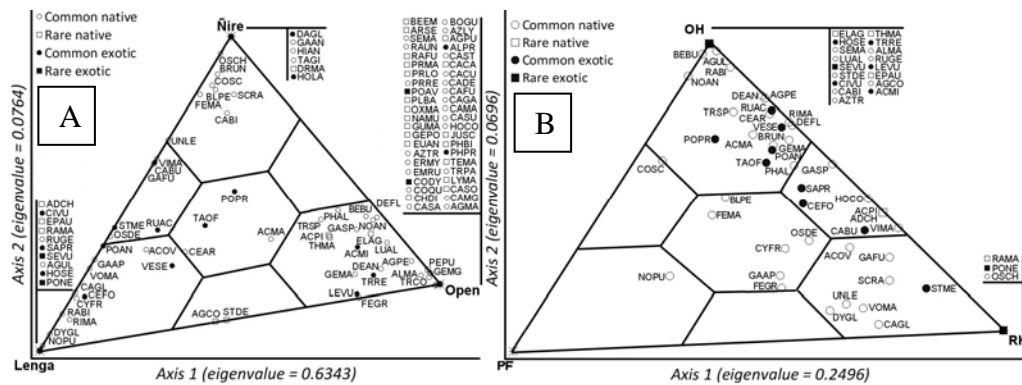
Figure 2: DCA for the analysis of plant species distribution: (A) among *Nothofagus pumilio* forests (Lenga), *N. antarctica* forests (Ñire) and grasslands and peat-lands (Open); (B) among primary unmanaged *N. pumilio* forests (PF), recently harvested forests (1-5 years) (RH) and old harvesting (>5 years) (OH). Codes for plant species appeared in Table 1.

In spring, while *L. guanicoe* consumed mainly species of *N. pumilio* forest, domestic herbivores incorporated more components of open areas and *N. antarctica* (Fig. 2A). However, in summer more species were shared among all herbivorous in their diets (Fig. 2B) mainly from the open environments. In autumn, *Lama guanicoe* consumed species from *N. pumilio* forests and open environments, while domestic herbivorous eaten species of open environments and *N. antarctica* forests (Fig. 3C).
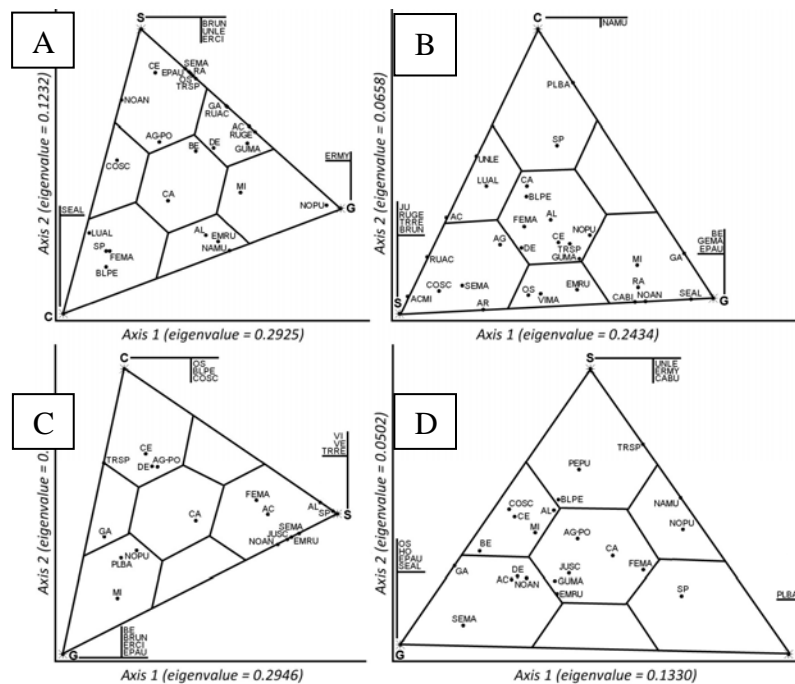
Figure 3: DCA for the analysis of diet feces composition of guanacos (G), cows (C) and sheeps (S) according the seasonal sampling (A = spring, B = summer, C = autumn, D = winter). Codes appeared in Table 2.

Finally, during winter (Fig. 3D), domestic herbivorous consumed plants from *N. pumilio* forest and open environment species (e.g., *N. pumilio* saplings, *Plantago barbata* and *Trisetum spicatum*), while *L. guanicoe* preferred species from open environments (e.g., *Senecio magellanicus* or *N. antarctica* saplings). Thus, native and domestic herbivorous alternated the

uses of the different environments around the year, where an incompatibility of seasonal uses was observed.

Table 2: Annual percentage of plant genus or species registered in diets, and their codes used for the analysis.

Species	Code	G	C	S
Acaena	AC	1.6%	1.2%	2.9%
Achillea millefolium	ACMI	0.0%	0.1%	1.2%
Agrostis	AG	5.7%	8.7%	10.0%
Alopecurus magellanicus	ALMA	3.1%	2.9%	3.7%
Arjona	AR	0.1%	0.0%	0.2%
Berberis	BE	3.1%	0.5%	1.1%
Blechnum penna-marina	BLPE	0.9%	1.6%	1.5%
Bromus unioloides	BRUN	0.1%	0.0%	0.4%
Calceolaria biflora	CABI	0.1%	0.0%	0.0%
Capsella bursa-pastoris	CABU	0.0%	0.0%	0.0%
Carex	CA	16.8%	29.3%	20.5%
Cerastium	CE	2.3%	4.2%	3.3%
Cotula scariosa	COSC	0.7%	0.5%	2.3%
Deschampsia	DE	9.0%	8.1%	7.4%
Empetrum rubrum	EMRU	2.8%	1.7%	1.3%
Epilobium australe	EPAU	0.3%	0.0%	0.5%
Erigeron myosotis	ERMY	0.2%	0.0%	0.1%
Erodium cicutarium	ERCI	0.1%	0.0%	0.2%
Festuca magellanica	FEMA	3.6%	9.6%	7.2%
Galium	GA	1.2%	0.4%	0.5%
Geum magellanicum	GEMA	2.9%	0.0%	0.0%
Gunnera magellanica	GUMA	0.7%	0.3%	0.5%
Hordeum	HO	0.5%	0.0%	0.0%
Juncus	JU	2.6%	2.0%	4.4%
Luzula alopecurus	LUAL	0.2%	2.1%	1.2%
Misodendron	MI	10.7%	3.6%	5.7%
Nanodea muscosa	NAMU	0.1%	0.2%	0.1%
Nothofagus antarctica	NOAN	2.7%	1.6%	3.8%
Nothofagus pumilio	NOPU	19.1%	10.1%	7.3%
Osmorhiza	OS	0.3%	0.0%	0.6%
Pernettya	PE	0.6%	0.5%	1.8%
Plantago	PL	2.1%	1.4%	0.5%
Ranunculus	RA	0.3%	0.0%	0.1%
Rubus geoides	RUGE	1.3%	0.0%	1.1%
Rumex	RU	0.1%	0.0%	0.1%
Senecio allophyllus	SEAL	0.6%	0.1%	0.0%
Senecio magellanicus	SEMA	1.1%	0.3%	2.4%
Trifolium repens	TRRE	0.0%	0.0%	0.4%
Trisetum spicatum	TRSP	0.4%	0.9%	1.1%
Uncinia lechleriana	UNLE	0.0%	0.2%	0.2%
Veronica	VE	0.0%	0.0%	0.1%
Vicia	VI	0.2%	0.0%	0.5%
Sphagnum	SP	1.9%	7.8%	3.6%

4. Discussion

Lama guanicoe is a generalist species, which can adapt to a wide spectrum of environments (Raedeke 1980; Puig et al. 1997), from closed forests where mainly consumed leaves and sprouts of *Nothofagus* saplings (Martínez Pastur et al. 1999; Pulido et al. 2000) to sub-alpine grasslands (Rebertus et al. 1997), where grasses and sedges are the main food. Domestic herbivorous mostly include grasses in their diet, but also can consumed saplings in adverse conditions, mainly in winter when forest are preferred among other site types because provides them with protection. *Lama guanicoe* avoid presence of domestic herbivorous, using environments free of them, independently of the season. This native species is a natural component of these native forests, but the impact in the unmanaged and harvested stands can increase according to the livestock density in the area. The knowledge of diet and plant distribution at landscape level allows us to propose management strategies for native and domestic herbivorous, minimizing the impact to the forestry activities.

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Effects of endozoochorous seed dispersal on the soil seed bank and vegetation in the woodland area

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Abstract

In the framework of nature conservation and restoration, some experts found the potential of endozoochorous seed dispersal in a semi-natural landscape. Predicting seed input by large herbivores through germination test of seeds in dung is needed to figure out the role of large herbivores. The contribution of large herbivores to ecological restoration sites can be determined by gathering quantitative information of the dung seed content and compared it with soil seed bank content and aboveground vegetation in grazed and ungrazed woodland area. The seed density and species richness of two areas as well as dung content were evaluated by germination test in the green house to find out effect of grazing regime. The result show that cattle grazing had a positive effect on distribution of vegetation from lawn area to woodland area. Species richness in graze area is higher than ungrazed one. Grazing reduced the cover of grazing sensitive and transport exclusive species to grazed woodland area. Grazing affected the number of seeds in the soil seed bank sample in the woodland area by creating gaps, stimulating losses by germination. In conclusions, seed density and species richness in the soil seed bank are less directly affected by large herbivore but direct effect on above ground vegetation.

Keywords: endozoochorous, seed dispersal, herbivores, vegetation

1. Introduction

Seed dispersal can be defined as the movement of seeds from one place to another by agents including wind, water and animals. Seed dispersal is a bottleneck for vegetation development and restoration of isolated (semi) natural relict of nature conservation areas, particularly for species with short-lived seed banks (Pywell et al. 2002). Therefore studies on seed dispersal have become an important issue in plant ecology in general and restoration management in particular. In the framework of nature conservation and restoration, seed dispersal by livestock has been examined by Bakker et al. (2005), Malo and Suarez (1995a), Mouissie et al. (2005), Couvreur et al. (2005), Cosyns et al. (2005b) who showed the potential of endozoochorous seed dispersal in a semi-natural landscape. The contribution of large herbivores to ecological restoration sites can be determined by gathering quantitative information on the dung seed content. Predicting seed input by large herbivores through germination test of seeds in dung is needed to figure out the role of large herbivores.

Seed dispersal contributes to the diversity of plant species in the seed bank. Large herbivores consume large numbers of seed (Malo and Suarez 1995b) and move long distances, due to their extensive home-ranges (Haskell et al. 2002). Bakker and Olff (2003) found 183.1 ± 21.1 seedlings per 100 gram dung of cattle in September and 9.8 ± 2.1 seedlings per 100 gram dung of rabbit in the same month. Most nature conservation areas in The Netherlands consist of open area (heathland and grassland) and woodland. In some part of this area, large herbivores like cattle and horses are used as management tools. Defoliation, treading and excretion are direct effects of large herbivores on the vegetation. Modification of the plant environment is indeed an indirect effect (Bokdam and Gleichman 2000). Usually large herbivores graze in open areas but

they ruminate and defecate in woodland area. In the Wolfhezerheide cattle spend most non-foraging time (56%) in woodland area (Bokdam 2003). This causes seed disperse from open areas that are dominated by 'lawn species' to woodland areas that are dominated by forest species. The large herbivores may have an important influence on the soil seed bank in the woodland area through endozoochory. Pakeman et al. (2002) gave evidence of a relation between soil seed bank and dung seed content. Dung deposition by cattle influences plant dynamics through the combined effects of seed input and gap formation i.e. dung itself as a potential regeneration site or as a precursor of gaps by suppressing vegetation (Cosyns et al. 2005a). The present of grassland species in the gaps of woodland area confirmed the contribution of endozoochory to the soil seed bank. In the Wolfhezerheide Nature Reserve, cattle and rabbits are the herbivores that play an important role in seed dispersal. Large numbers of seeds are potentially dispersed via cattle and rabbit dung. In this study, endozoochorous seed dispersal affect species richness in the vegetation directly and soil seed bank indirectly. Different seasons contribute different species richness and the number of seed in the soil seed bank.

2. Methodology

2.1 Study site and experimental design
This study was carried out in the nature reserve 'The Wolfhezerheide' (120 ha) (Naturmonumenten 1996; (Bokdam 2003). This area is located in the Veluwe in the centre of The Netherlands (51° 47'N; 5° 41'E) and owned by Vereniging Natuurmonumenten. The reserve consists of 30 ha forest and 90 ha open area. The soils are mainly acid (pH KCl 3–3.5) and podzolic, developed in Pleistocene fluvio-glacial sand and cover sand (Bokdam 2003). *Calluna vulgaris, Deschampsia flexuosa* and *Molinia caerulea* are dominant plant species in the open area. *Pinus sylvestris* and *Betula spp.* dominate the forest area. Since 1983, grazing management has been applied in this area. The general approach in this research was observational by using a fence line study technique where the fence is used to divide the study area in a grazed and a non-grazed area.

2.2 Data collections
Data collection of this study consists of vegetation composition, cattle dung and soil seed bank. Vegetation data were collected from grazed and ungrazed woodland sites. Pairs of sites with a size of 5 x 5 m (25 m^2) were chosen opposite to each other on either side of the fence, with ten replicates resulting in ten relevés in the grazed area and ten relevés in the ungrazed area. The present of each species in a relevés was estimated by its cover and used to assess the similarity between vegetation in the grazed and ungrazed woodland area. The numbers of species in both sites are also compared to find out the differences in plant species diversity. Cattle dung samples were collected from two seasons. Dung sample (141 gram) was air dried in the greenhouse at the prevailing temperature (25-28°C) for 2 weeks before storing them in the cooler at 5°C for two weeks. After the cool period, trays were placed in the greenhouse for the germination test period. In addition, the soil seed bank was sampled with composite samples of the litter layer plus the top five centimeter of the mineral soil were collected from the plot where the vegetation was studied. Each composite sample consists of ten cores (2.5 cm in diameter x 25 cm deep) is taken randomly within a plot. Soil samples were sieved to remove coarse gravel, roots and vegetation. The samples were spread in trays with one cm thickness (672 g or 0.8 L) on top of a three cm thick layer of coarse river sand. A cold treatment (6°C) was given to the samples for two weeks to break dormancy and improved germination of the seeds (Olff et al. 1994).

2.3 Seedling emergence technique
For germination test in the green house, the weight and volume of the soil and the dry dung samples were determined. After cold stratification treatment, the trays were placed in a greenhouse with day temperature of 20°C and night temperature of 18°C (12/12 hr day-night

light regime) and air humidity 70%. The trays were placed under a hood of plastic foil to reduce evaporation and contamination of seed within the greenhouse. The emerging seedlings were identified by using identification keys (Muller 1978).

2.4 Data Analysis

The data were analyzed using SPSS 12.01, a statistical software for Windows (SPSS 2003).

3. Results

3.1 Cover, species richness, species compositionand lawn species in the vegetation

The average cover of vegetation in the grazed area is higher than in the ungrazed area (48.865% vs. 69.972 %). A paired sample T-test executed to figure out different on cover vegetation between them. The result showed significant difference on cover vegetation between vegetation ungrazed and grazed woodland area (t = -2.481; N = 10; P = 0.035). The species and total number of species in the pooled of vegetation is higher in the grazed area than in the ungrazed area (32 vs. 20 species). The Pair T-test tested the significance of the difference between the average species richness of ungrazed and grazed plots. It showed a significant difference in the number species between two treatments (areas) (t = -4.017; N = 10; P = 0.003). The average number of species per plot in the grazed area (11.3 ± 1.585) is higher than in the ungrazed area (5.5 ± 0.373). Ungrazed and grazed areas had 35 species in total and 17 species in common. Lawn species in this study are herbs and dwarf shrubs with Ellenberg value for light larger than six. In total, 14 lawn species found in both ungrazed and grazed vegetation of woodland area. Both of them shared five of lawn species (*Agrostis capillaries, Deschampsia flexuosa, Galium saxatile, Rubus fruticosus agg, Taraxacum officinale)*. Nine species out of 14 were found only in the grazed area and two species (*Holcus lanatus* and *Senecio jacobea*) were dispersed by endozoochory. 31.47% is total cover of lawn species in ungrazed area and 65.08% in grazed area. Total frequency of lawn species in ungrazed is 2.1 and 5.2 in grazed area.

3.2 Seed density, species richness, species composition and lawn species of summer and winter dung

A total of 986 seedlings emerged from the winter dung, while 7680 seedlings sprouted from the summer dung samples (six litres, dry weight 2115 gr). The parametric test for two independent samples showed significant difference on the number of seeds between winter and summer (t=-5.504; N=20; P=0.000). Total number of species of winter dung samples is higher than in summer dung samples (25 vs. 17 species)*. A parametric test for two independent samples T-test showed a significant difference in the average number of species between winter and summer dung (F = 0.005; N = 25; P = 0.009). In the species richness, in total 34 species were found in winter and summer dung one and only eight species in common. From a total of 25 species in the winter dung, 17 species did not occur in the summer dung. Nine species of summer dung did not occur in the winter dung. In total, 24 lawn species were found in both seasons. Six lawn species were shared in ungrazed and grazed (*Calluna vulgaris, Holcus lanatus, Lolium perenne, Polygonum aviculare, Senecio jacobae, and Veronica arvensis)*. 13 species (out of 24) were exclusively found in the winter dung and five exclusively in the summer dung. The number of seeds of lawn species was higher (509.73) in the summer dung than in the winter (92.4), but the frequency was higher in winter dung (8.1) than in the summer (5).

3.3 Seed density, species richness,species composition and lawn in the soil seed banks.

A total of 601 seedlings (representing 22 species) emerged from soil samples ungrazed forest area, 360 seedlings with 23 species from the grazed forest area. Six species (*Genista anglica, Jasione montana, Lamium purpureum, Plantago major* and *Sonchus oleraceus* and *Polygonum persicaria) were* only found in the grazed woodland. Five species (*Hypericum perforatum, Oxalis corniculata, Rumex acetosella, Vaccinuium mytillus and Veronica arvensis)* occurred

only in the ungrazed woodland. In total, 19 lawn species found in both soil seed bank. Two lawn species (*Cirsium vulgare* and *Veronica arvensis)* only present in ungrazed area while five species (*Genista anglica, Juncus buffonius agg, Plantago major, Sonchus oleraceus* and *Lamium purpureum)* only present in grazed area. However only *Jasione montana, Lamium purpureum & Sonchus oleraceus* were found in the dung and those species dispersed during the winter. Number of seeds is higher in the soil seed bank ungrazed area than soil seed bank grazed area but frequency of lawn species in soil seed bank of grazed area is higher than ungrazed area. Total frequency lawn species in grazed area (4.6) is higher than ungrazed area (4.2)

4. Discussion

4.1 The effects of cattle on woodland vegetation
Cattle play an important role in the vegetation which show by species richness as well as cover was higher in the grazed woodland vegetation than ungrazed ones. Many of these are the characteristic species of pasture and heathland (*Senecio jacobaea, Cerastium fontanum, Danthonia decumbens, Plantago lanceolata, Poa pratensis, Ranunculus repens, Rumex acetosella, Trifolium repens),* clearings *(Senecio sylvaticus*) or fringes *(Rubus idaeus, Teucrium scorodonia*). Grazing reduced the cover of grazing-sensitive species: *Ceratocapnos claviculata, Dryopteris carthusiana, and Vaccinium myrtillus. Agrostis capillaris* has the same average cover in grazed and ungrazed but species frequency in grazed area is higher than in ungrazed area. In addition, *Deschampsia flexuosa* and *Galium saxatile* had the same species frequencies but average cover of species was higher in grazed vegetation. This evidenced present contribution of cattle-dispersed lawn species in the woodland area by creating understory gaps, stimulate germination and growth of lawn species in the understory vegetation of the woodland. Seven species of dung samples (*Erigeron Canadensis, Epilobium* sp, *Juncus bufonius agg, Lolium perenne, Medicago lupulina, Ranunculus acris*) were absent from aboveground vegetation in the grazed area due unable to cope with the environmental condition and predators. It seemed that the number of species aboveground is not influenced by the number of species in the soil seed bank, as the numbers of species in the soil seed bank depend on the number of persistent seeds. The floristic composition of the seed bank is not a mirror reflecting the vegetation composition, but rather a record of a long-term turnover of species and many different events which in various periods of time influence the input and output of seeds (Falinska 1998).

4.2 Contribution of endozoochorous seed dispersal to lawn species establishment
The dung deposited by herbivores (cattle) increased the diversity in the grazed woodland vegetation that could cause by cattle facilitated the arrival of species from open area to the woodland area and good condition provided by dung for germination. Dung creates places free from vegetation (gaps) with high nutrient availability (Dai 2000) and dung with sufficient water- retention capacity provide a safe site for a number of species particularly those from nutrient-rich habitat that able to grow fast and root in underlying soil (Mouissie 2005). The right conditions for germination and establishment, which could be linked to the change in nutrient concentrations, were provided by dung and might have also generated positive effects on the germination of some of the species present in the soil seed bank (Traba et al. 2003). Eleven light demanding species (*Danthonia decumbens, Poa pratensis, Rumex acetocella, Ranunculus repens, Rosa canina Rubus idaeus, Sorbus ocuparia, Sinecio sylvaticus, Sambucus nigra, Teucrium scorodonia, Trifolium repens)* from grazed vegetation were absent in the species dung sample. Those species might be unpalatable or not providing seeds during the study period. Endozoochorous seed dispersal explained the exclusive occurrence of *Cerastium fontanum, Holcus lanatus, Plantago lanceolata, Poa trivialis and Senecio jacobaea* the in grazed vegetation. Most of them were exclusively present in the summer dung, except for *Holcus lanatus* which was found in both seasons. Those species are light demanding (L- value≥6). Total cover and total frequency of lawn species is higher in vegetation of grazed area than in the

ungrazed area. This might indicate contribution of large herbivore on the establishment of lawn species.

4.3 The contribution of endozoochous seed dispersal to the soil seed bank

The seed density in ungrazed woodland are is higher than in grazed woodland. The expectation was in contrast because cattle contribute the number of seeds into the grazed area. One reason for the higher number of seed in ungrazed soil could be the thickness of litter layer. The litter layer in the ungrazed (36 cm) area is thicker than in the grazed area (30.5 cm). Litter increased seed longevity (Rotundo and Aguiar 2005) and when the litter layer is thick, this can lead to the conservation of seed in the soil (Jensen 1998). Furthermore, trampling by cattle can bury seeds deeply so they were not present in the top soil samples (30 cm deep). McDonald et al. 1996 stated that grazing allows the incorporation of seeds deeply in the soil. Twelve species of summer dung sample absent from soil seed bank ungrazed and grazed woodland area. The summer dung species needed more light (L Ellenberg's value >6) and have the same requirement levels of moisture and nitrogen. Winter dung might contribute more to the species richness of the soil seed bank than the summer dung did. This could be the case as during the winter, limited foods were available for the cattle which led them to consume more different plants species. On the contrary in the summer, the cattle preferred the most palatable species, mostly grasses which were abundant during this season. Grass species have a low seed longevity index and low densities in the soil. Total seed density of lawn species was higher in soil seed bank ungrazed area than grazed area, however total frequency of lawn species in soil seed bank grazed area is higher than ungrazed. This might indicate role of cattle on distribution of lawn species which showed by more lawn species was found in soil seed bank grazed area than ungrazed area. *Jasione montana, Lamium purpureum & Sonchus oleraceus* dispersed by cattle during the winter and only found in soil seed bank grazed area.

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Anthropogenic landscape changes and the conservation of woodland caribou in British Columbia, Canada

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Abstract

Conservation and management of caribou across Canada is now a high priority due to increasing rates of decline associated with greater levels of landscape change and anthropogenic disturbance. Two of the most pressing threats to caribou are habitat loss and predation; both effects are a direct result of large-scale forestry, energy, and mineral development. Mountain, northern and boreal caribou are three ecotypes of woodland caribou (*Rangifer tarandus caribou*) found in British Columbia. Across most of the province, the federal government has listed all three ecotypes of woodland caribou as "threatened", but recovery planning for caribou in the province has met with only limited success. This literature review will provide a foundation to further understand how landscape change is contributing to declines in woodland caribou populations and how continued research will aid in favorable decisions for the long-term survival and management of this keystone species of the North.

Keywords: Rangifer tarandus caribou, industrial disturbance, population decline, conservation, predation

1. Introduction

The North would not be what it is today, without caribou. *Rangifer tarandus* is considered to be a single species throughout the world and includes both domestic reindeer and wild caribou (Hummel and Ray 2008). The term "reindeer" often refers to domesticated members in Europe, while "caribou" is reserved for wild members of the same species in North America. Caribou and reindeer reside in most of the world's north, above the 50th parallel in North America and the 62nd parallel in Eurasia, respectively (Hummel and Ray 2008).

In the northern extent of their range, caribou congregate in large social communities, take part in major migrations from their wintering to calving grounds, and are commonly referred to as "barren-ground" caribou. Towards the south, characteristics change and herds remain at low densities, have shortened migrations, and are often classified as "sedentary". Caribou have been classified into three primary ecotypes across North America based upon their behavioral and ecological differences: mountain, boreal forest, and migratory tundra (Hummel and Ray 2008). Woodland caribou (*Rangifer tarandus caribou*) is a sub-species found across each of the three ecotypes of North American caribou.

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2. General Ecology of Woodland Caribou in British Columbia

Similar to the federal system for North American caribou, British Columbia (B.C.) classifies woodland caribou into three ecotypes: mountain, northern and boreal (Heard and Vagt 1998). Mountain caribou rely on old-growth subalpine and rugged alpine habitats in the central and southeastern portions of the province. During winter, these caribou forage on abundant arboreal lichens (*Bryoria* spp. and *Alectoria sarmentosa*) as deep snow restricts there access to terrestrial lichens or vascular plants (Stevenson and Hatler 1985; Seip and Cichowski 1996; Jones et al. 2007). Moving to higher elevations to access forage in the winter is an effective strategy for avoiding predators (Seip and McLellan 2008).

Caribou of the northern ecotype prefer terrestrial lichens (*Cladina mitis* and *Cladonia* spp.) that are found in lower-elevation pine forests or alpine habitats (Heard and Vagt 1998; Johnson et al. 2004; Jones et al. 2007). Depending on snow conditions and lichen abundance, these caribou will also forage on arboreal lichens (*Bryoria* spp.) during the winter months (Johnson et al. 2004). Northern caribou have highly variable wintering strategies between years, populations and individuals; some caribou will winter on high, wind-swept alpine ridges, while others prefer wintering in lower-elevation pine-lichen forests (Bergurud 1978; Terry and Wood 1999; Johnson et al. 2004; Jones et al. 2007).

The boreal ecotype is found in the northeastern portion of the province and prefers black spruce (*Picea mariana*) fen/bog complexes, and tends to avoid well-drained areas (Stuart-Smith et al. 1997; Dzus 2001). A lack of topographic relief prevents boreal caribou from making elevational migrations as demonstrated by the mountain and northern ecotypes (Stuart-Smith et al. 1997; Culling et al. 2006). Ground lichens (*Cladina stellaric*, *C. mitis* and *C. rangiferina*) become the dominant food source in winter (Schaefer 2008). Boreal caribou now occupy less than half of their historical range across the continent (Schaefer 2008).

3. Threats to Populations of Woodland Caribou

The abundance and distribution of woodland caribou has been on the decline across North America since European advancement and colonization (Bergerud 1974; Seip 1992; Vors et al. 2007). Conservation and management of caribou across Canada is now a high priority due to increasing rates of decline associated with greater levels of landscape change and anthropogenic disturbance (Wittmer 2004; Vors and Boyce 2009). Two of the most pressing threats to caribou are habitat loss and predation; both effects are a direct result of large-scale forestry, energy, and mineral development (Schaefer 2003; Vors et al. 2007).

Predation is suggested as the leading cause of mortality for woodland caribou in North America with wolves serving as the primary predator in this multi-carnivore ecosystem (Bergerud 1974; Fuller and Keith 1981; Stewart-Smith et al. 1997; Kinley and Apps 2001; Gustine et al. 2006). Caribou are thought to minimize the risk of predation by using habitats that are spatially separated from predators (Bergerud et al. 1984; Stuart-Smith et al. 1997; Cumming et al. 1996; Johnson et al. 2004; Latham 2009). During the calving season, for example, caribou in the mountainous regions of B.C. and west-central Alberta reduce predation by moving to higher elevations (Bergurud et al. 1984; Seip 1992; Johnson et al. 2002). Similarly, boreal caribou in northeastern B.C. use predator refugia such as lakeshores, small islands of mature black spruce, thick alder stands saturated with water, and old burn sites adjacent to wetlands during the calving

season (Culling et al. 2006). Studies in Ontario also show an increased use of islands and lake shorelines during the spring (Bergerud 1985; Cumming and Beange 1987).

Many declines in ungulate populations have been attributed to habitat degradation (Leopold and Darling 1953; Bradshaw and Hebert 1996). Landscape change and an increase in the abundance of other ungulate species now limit the ability of caribou to effectively space-away from predators (Rempel et al. 1997; Wittmer 2004; Latham 2009). Since the early 1900s, moose (*Alces alces*) have expanded their distribution throughout B.C. resulting in a numerical and distributional response of wolves (Bergerud and Elliot 1986; Seip 1992; Spalding 1990). Known as "apparent competition", primary prey species such as deer and moose do not compete directly with caribou for forage or space, but support larger number of wolves that prey on caribou opportunistically (Holt 1977; Bergerud and Elliot 1986; Seip 1992; Wittmer et al. 2005; Latham 2009).

Recent studies in B.C. and Alberta have demonstrated that industrial activities and associated linear features, including roads, trails, geophysical exploration lines, pipelines, electrical right-of-ways, cutblocks, and oil and gas wells can negatively affect woodland caribou populations (Bradshaw et al. 1997, James and Stuart-Smith 2000, Smith et al. 2000, Dyer et al. 2001, Sorensen et al. 2008). These features can alter the movements, distributions, and population dynamics of both caribou and wolves. Timber harvesting is one of the primary agents of habitat change. Large-scale harvesting reduces the amount of habitat for caribou and increases the area of early successional forests favored by moose and other ungulate species (Fuller and Keith 1981, Rempel et al. 1997, Johnson et al 2004, Nitschke 2008). There is rising concern about how advancing threats from industry are influencing the ability of sub-populations to survive. Small populations, like the mountain caribou in the southern portions of B.C., have become isolated from neighboring herds and are at greater risk of extirpation from random variation and stochastic events (Heard and Vagt, 1998).

Recent evidence suggests that disturbance from recreational activities may also be contributing to the decline of northern and mountain caribou herds (Seip et al. 2007). Recreational tenures for commercial purposes have increased in both area and number across the province; these tenures allow greater access into caribou habitat for snowmobiles and helicopter ski (heli-ski) operations (McNay and Giguere 2008). As recreational activities expand across alpine areas used by caribou, herds are forced into less favorable habitats that increase accidental mortalities from avalanches, increase energy demands used to move across steep terrain and deep snow, as well as increase the risk of predation (Seip et al. 2007).

4. Management of Woodland Caribou

Across most of B.C., the federal government has listed all three ecotypes of woodland caribou as "threatened". Management goals continue to focus on monitoring population levels, restoring and maintaining appropriate sex and age ratios, and include a required inspection for all human harvested caribou (populations of northern and boreal ecotypes that are not considered threatened). In order to continue developing the most effective conservation strategies for species-at-risk, professionals must rely on the philosophy of their discipline, scientific and traditional ecological knowledge (TEK) from indigenous communities, as well as educated opinions that come from expert peers (Stephenson 1982; Mountain Caribou Technical Advisory Committee 2002).

All provinces and territories in Canada must adhere to federal endangered species legislation. For species listed as "endangered" or "threatened", SARA (Species at Risk Act 2003) requires that the responsible jurisdiction, or authority, develop and implement a Recovery Action Plan. These recovery plans address immediate threats to the species and protects or enhances the species residence and critical habitat. Two advisory committees were formed in B.C. to provide

strategic direction for the recovery of caribou in the province and multiple Recovery Implementation Groups (RIGs) develop Recovery Action Plans that address the specific conservation needs of collections of herds.

Recovery planning for caribou in B.C. has met with only limited success. The Mountain Caribou Technical Advisory Committee has produced a document outlining the threats and a strategy for the recovery of mountain caribou in B.C (Mountain Caribou Technical Advisory Committee 2002). Both the North-Central and the Hart and Cariboo Mountains RIGs have developed recovery action plans that make specific conservation recommendations for establishing self-sustaining populations of caribou. In 2003, the Central Rocky Mountain RIG was temporarily suspended and there are no committees designated for implementing recovery strategies for boreal caribou in B.C.

5. Future Directions in Research

As we progress into the future, continued research in caribou ecology remains crucial. Populations of woodland caribou should be continuously monitored and surveyed across Canada. If we are unclear on the health and overall status of caribou, it challenges our understanding of how to properly implement habitat protection. Studies should continue looking into relationships between landscape disturbance and habitat change, woodland caribou and increasing numbers of elk, deer, and moose populations. Additional studies focusing on the predator-prey dynamics of wolves with their primary prey will provide insight into alternate management strategies where caribou populations are dramatically declining. Moose-wolf interactions, for example, are a key component that shape caribou population dynamics. Future research should also include predation studies that specifically focus on the spatial distribution, habitat selection and hunting patterns of wolves and other influential carnivores (e.g., bears and cougars) living in caribou habitat. Intensive efforts in the conservation of woodland caribou will continue to grow as changing predator-prey relations are exacerbated by landscape change due to advancing human developments.

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Modeling feedbacks between avalanches and forests under a changing environment in the Swiss Alps

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Abstract

Forest-avalanche feedbacks are important forces shaping subalpine treeline ecotones. Under rapid and drastic environmental change, these feedbacks can develop unexpected dynamics. Merging forest and avalanche models provides a tool to analyze such feedbacks, and to envision management scenarios for protection forests. We modeled and analyzed these feedbacks for Davos (Switzerland), where land abandonment and temperature change are the main drivers of environmental change. We developed a spatially explicit model for avalanche release zones inside forests, based on slope steepness, crown coverage, gap size, and forest type, and incorporated it into the forest-landscape model TreeMig. Preliminary results reveal that (1) TreeMig is sensitive to the proposed changes in disturbance simulation, (2) a simplified vegetation model shows feedback effects with an avalanche subroutine, and (3) the intermediate disturbance hypothesis partly applies to avalanche influence on forests. The merged model TreeMig-Av is presented and scenarios of forest-avalanche interaction under environmental change are interpreted.

Keywords: treeline dynamics, avalanches, environmental change, feedback effects, forest landscape models

1. Introduction

In subalpine treeline ecotones, avalanches have a strong influence on vegetation dynamics. The influence of the vegetation on avalanche dynamics, however, is often modeled as a binary decision variable excluding potential avalanche release in forested areas. Yet it is well known that avalanches can initiate inside forests, especially in sparsely vegetated forests near the treeline. So far, there have been only few studies analyzing the interactions between forests on avalanches, with focus on long-term forest dynamics (Cordonnier 2008). Modeling avalanches in a forest-landscape model should provide a tool to analyze the future development of forests, avalanches, and their feedbacks, under changing environmental influences. Our goal is to develop a simplified spatially explicit avalanche module, and to implement it in TreeMig (Lischke et al. 2006), a forest-landscape model based on the gap model ForClim (Bugmann 1994). One of the main goals is to analyze simulations of forests interacting with land use change and climate change, under the influence of avalanches as spatially connected disturbances. Previous versions of TreeMig accounted only for single-cell disturbances. Output variables of interest include changes in biomass, species composition, structural composition, avalanche occurrence, etc. Simulating the protection function of forests against avalanches is a

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new option in TreeMig, and is the main ecosystem service simulated here, using land use change scenarios in combination with climate change scenarios as input.

Snow avalanches are a key disturbance in forest ecosystems in the Swiss Alps, and their interactions with forest dynamics, such as mortality and regrowth, have strong influences on subalpine forests and their ecosystem services. These feedback effects are especially important for the location, spatial patterns, and structure of upper alpine timberlines. Avalanches can start both above and below timberlines, and feedback effects can differ between the two initiation types. While avalanches starting far above timberlines can destroy forests below without being influenced much, avalanches starting below timberlines can be strongly modified by the vegetation. For the avalanche release probability inside forests, stand structure and gap size are important factors in addition to the variables commonly used to predict avalanche release outside of forests, namely topography, weather, and snow conditions (Bebi et al. 2009). Including the vegetation-based variables in an avalanche release module leads to feedback effects between avalanche release probability and the mortality and regenerative success of forests. Yet how these interactions will be affected under scenarios of changing snowpack and forest cover is less clear. Merging forest and avalanche models provides a tool to analyze such feedbacks, and to envision management scenarios for protection forests under climate and land-use change.

Due to the spatial connectivity of avalanches, we expect this disturbance type to have a stronger influence on the spatial pattern at treelines than the single-cell disturbances previously simulated in TreeMig. Avalanches are expected to depress treelines to lower altitudes than climate would allow, and to increase fragmentation of the vegetation (Patten et al. 1994), but there are only few attempts at including avalanches in forest-landscape models (Cordonnier et al. 2008). In TreeMig, modeled influences on treelines do not differ from influences on lowland areas, except indirectly via climatic variables and differences in seed availability. Most allometries or processes, such as growth curves, competition for light and space, dispersal, or disturbances, are modeled the same way for all areas. We plan to answer the question of how treelines will develop under environmental change, and how their spatial patterns are influenced by avalanches, by using TreeMig as a tool for scenario development. To achieve this, the model needs to be adapted specifically to include more treeline-relevant factors, and to allow for different processes in different simulation areas. Both growth- and size-related allometries for treelines are improved, and a process-based feedback loop between avalanches and forest regeneration is implemented.

2. Methods
2.1 Avalanche modeling

The avalanche module is divided into avalanche release and avalanche flow, each further divided into the respective process inside or outside of forested areas. Three of the resulting four components (release outside forest, flow inside forest, and flow outside forest) are based on the avalanche model RAMMS (Rapid Mass Movements; Christen et al. 2008). The fourth component, avalanche release inside forested areas, was built as a probabilistic module based on regression analysis of historical avalanche data (1985-90) and related forest data (Meyer-Grass and Schneebeli 1992), according to the method used by Bebi et al. (2001). Using only variables that can be calculated from TreeMig output, we performed a Generalized Linear Model (GLM) on the historical avalanche data.

The GLM was used to estimate the dependence of the binary avalanche release variable on predictor variables describing the vegetation, in addition to the geophysical and meteorological variables often used for avalanche release prediction outside forested areas (e.g. topography,

snow profile, temperature). The distinct weather conditions within a few days of the event, which in reality strongly influence avalanche release probability, were not included due to the larger time scale of TreeMig (1 year steps). To be compatible with TreeMig, the avalanche module also uses one year steps. A random component was added to the probabilistic release module instead of explicit weather related variables, to simulate short-term (within-year) weather variability. The historical avalanche and forest data used as input was stratified into coniferous and broadleaf forest, and the GLM is run separately for each forest type.

The selection criteria to include variables in the GLM were (a) significant improvement of variance explained, (b) sensitivity of at least some of the variables to climatic or land use change, and (c) the possibility to calculate or estimate the variables from TreeMig output. To implement the equation resulting from the GLM in the avalanche module, the values for slope angle were taken from the Swiss digital elevation model (DEM) at 25m resolution (Swiss Federal Office of Topography), and maximum gap size and other forest-related variables were calculated allometrically from TreeMig output. For example, crown projection could be calculated from TreeMig output using the percent cover equations established by Lischke and Zierl (2002).

2.2 Mortality and regeneration modeling

The increased mortality of trees standing in an avalanche path will be modeled based on a meta-model of RAMMS, which is currently in development. In TreeMig, different model versions will be compared, using either full mortality of all trees in the avalanche path, or partial mortality based on tree size and species. For preliminary versions of the avalanche subroutine in the forest-landscape model, mortality will be set to one, and adapted later to include the RAMMS meta-model output.

To simulate regeneration after avalanche disturbances, the dispersal, germination, establishment, and growth subroutines of TreeMig will be used (Lischke et al. 2006). Here, growth is modeled in height class increments, with a maximum possible growth rate per species, modified by environmental factors such as light, temperature, precipitation, or local disturbances. As trees are in competition for light, an increased light availability due to avalanches changes the growth potential of surviving seedlings or freshly germinated seeds.

TreeMig is set up so that primary succession in the destroyed cells is given by potentially remaining seeds or seedlings, dispersal distance from mature forest, and germination and growth response to environmental conditions. Seedlings that survive the avalanches will have higher growth rates due to the lower competition and higher light levels, making seedling shade tolerance and the shading function highly critical. To increase the accuracy of the seedling growth, we will partition the lowest height class (previously including all individuals 0-1.37m height) into 4 smaller classes, and improve the shading subroutine. Furthermore, the previously strict allometry between size and growth, both simulated in units of height classes, will be improved by allowing more variability between size and growth. This is especially important at treelines, where individuals are often found to be relatively old, but short, with a relatively high stem diameter.

2.3 Merging of model components

The four components of avalanche release and flow inside and outside of forested areas will be implemented in the forest landscape model TreeMig, and analyzed for sensitivity, scaling effects, and model uncertainties. To implement the avalanche module in TreeMig, both the avalanche submodel and the growth and regeneration subroutines require careful calibration.

Furthermore, to be able to model avalanches in sufficient detail, the cell size will be reduced from 100m side length to 25m. To ensure applicability of the forest-landscape model with reduced cell size, we will compare model runs with both cell side lengths.

The feedback effects will emerge once the avalanche release probability, flow dynamics, destruction, and regeneration subroutines are set up. These will have to be fine-tuned for current climatic and land-use conditions to make sure that there are no runaway effects, which could develop due to the positive feedback cycle between forests and avalanches. Keeping the environmental conditions constant, we will make sure there is a balance between avalanches and forest dynamics, by tuning the avalanche and forest parameters involved. Once the feedbacks are established, we will compare the output to current treeline positions and patterns, to estimate the precision of the model.

In a sensitivity analysis, environmental conditions are again kept constant while disturbance intensity (frequency and magnitude) are varied, and the influence on output variables such as total biomass per area, location and pattern of treelines, and species composition will be analyzed. The merged model TreeMig-Av will then be applied to the study area of the Davos municipality, in the eastern Swiss Alps. The model will be validated against historical avalanche frequency data and compared to the output of other models such as those used for avalanche risk mapping. IPCC AR4 climatic change scenarios and different land use scenarios will then be used to simulate avalanche release and forest cover scenarios for the next centuries, and to analyze how the feedback effects develop under the changing environmental conditions.

3. Preliminary and expected results

In the GLM, the final variables used for the estimation of avalanche release inside forests are similar between the two forest types: While the coniferous forest model equation uses slope angle, crown projection, and maximum gap size, the broadleaf forest equation uses slope angle, crown projection, and proportion of coniferous trees instead of the gap size.

A sensitivity analysis in the current version of TreeMig, with single cell disturbances, showed that it is sensitive to changes in disturbance frequency and magnitude. Changes in these variables led to changes not only in total biomass, but also species composition and structural diversity in the affected cells. Furthermore, the single cell disturbance regime was compared to spatially connected disturbances on a transect, which confirmed the expected difference in regeneration patterns after the two disturbance types. The main feature of the spatially connected disturbance type is the potentially larger distance of a recently disturbed cell to the nearest vegetated cell, from where seeds may disperse into the disturbed cell. Regeneration dynamics therefore strongly depend on accurate simulation of dispersal kernels and size of the disturbed area.

The Intermediate Disturbance Hypothesis (IDH) was shown to apply to TreeMig's disturbance rates at the single cell level, and for connected disturbances along the one-dimensional transect, and is expected to also apply to spatially connected disturbances in two-dimensional space. Highest species diversity was found at intermediate disturbance frequency and magnitude. The exact location of the peak diversity along the two axes, however, was influenced by altitude, i.e. by limitations given by climatic variables. For example, where growth and survival is limited by climate, a relatively high disturbance frequency could lead to the disappearance of the forest altogether. Here, the peak of diversity would shift to lower values of disturbance frequency. The IDH applies to species composition but not necessarily to forest structure (size distribution), as avalanches can increase the number of smaller trees relative to the larger trees. Applicability of IDH to structural diversity will further be studied using the adapted version of TreeMig.

Potential release areas (PRAs) were simulated in the avalanche release subroutine as results of the GLM equations, and are influenced by the avalanche flow dynamics and the subsequent forest regeneration. The forest has a strong influence in reducing PRA occurrence, but we found that the forest structure is just as important. Sparsely vegetated areas, which under some definitions may still be classified as forests, can only reduce PRAs up to a certain point, but can not avoid avalanches altogether. Furthermore, a forest cannot stop an avalanche once it reaches full speed and strength, which can happen for example when avalanches are initiated far above forests.

Avalanches are expected to have a stronger influence on vegetation at higher altitudes, due to the increased release probability at higher altitudes, and the downhill flow direction. Forests at higher altitudes should therefore experience more disturbances by avalanches. As these forests are also climatically more limited in regeneration, they should be more sensitive to disturbances. Regarding the IDH, diversities of forests at high altitudes are strongly influenced by disturbances, and may not be ably to maintain the same diversity without avalanches (Rixen et al. 2007). However, climate change could further shift the maxima along the axis of disturbance intensities, and therefore also influence forest diversity and structure.

4. Conclusions

Including an avalanche module in a forest-landscape model provides a useful tool, and improves model predictions for the avalanche protection function. Compared to models that include vegetation only as a binary variable, our merged model is able to predict PRAs relatively well, even though it does not consider the same physical or short-term weather variables most avalanches models use. The purpose of our merged model is not to explicitly account for single avalanche events, but to generate scenarios of trends for forest-avalanche feedbacks, forest protection abilities, and their development over time under changing environment. We expect that the proposed changes in TreeMig will lead to an improved representation of subalpine forest and treeline ecotones for different climate change scenarios, and therefore to a better judgment of how effective different forests are in terms of avalanche protection under various environmental scenarios. This should then contribute to improved long-term decision support for forest management of the study area.

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Section 4
Biodiversity conservation and planning in changing landscapes

Ecotourism and controlling forest stand damages
Case study: Varzegan district North West Iran

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Abstract

This paper aim to show using ecotourism how can protection the lands, forest stands and biodiversity or not? In addition to preserving forest ecosystems and biodiversity, natural protected areas in Arasbaran are homelands for people, largely indigenous, who traditionally base their resource management on a multiple use strategy. We analyzed land use and land cover changes in the Varzegan district in the Arasbaran northern west Iran, where Varzegan recently incorporated ecotourism to their set of economic activities. We evaluated changes in land use using vegetation maps from 1997 to 2002 based on Enhanced Thematic Mapper (ETM+), land sat 7 and predicted vegetation cover in 2010 by developing a cellular automata and Markovian chains model. So we selected 2 parts at study area for controlling of damages and monitoring of ecotourism effects on it. We used two scenarios to predict land cover in 2010: (a) forest ecosystems and biodiversity implemented at the same rate; (b) forest ecosystem and biodiversity decreases due to the growing demand of ecotourism. Both scenarios predict slight change in the area. Our results provide guidelines for managing natural resources managements, suggesting that forest stand protection, biodiversity conservation and ecotourism are compatible activities.

Key words: Ecotourism, Biodiversity, Varzegan, Forest stands.

1. Introduction

Remote sensing techniques have recently recived lots of attentions in agriculture and natural resources. Natural resources and environmental conservation need a lot of attention especially on under devloped countries. Using remote sensing techniques and sateliate data for evaluation of environmental changes is rapidly growing.
Ecotourism industry is of importance in land conservation and income. Natural resources, especially forest ecosystems in Arasbaran have many ancient parameters for ecotourism using.

2. Methodology

2.1 Study area

The study area is located in North West of IRAN and the North Eastern of the East Azerbijan province, which called Arasbaran, is a mountainous area with elevation between 300 and 2700 meters above the see level and very near to the Caspian Sea.

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The area is located between $38^{\circ}.38'$ and $38^{\circ}.52'$ latitude and between $46^{\circ}.03'$ and $46^{\circ}.15'$ longitude. It covers diversity of elevation, slope, population and land use and includes a variety of Seashore Rivers, etc. There are above 785 plant species in this forest that 97 species of them are woody (Sagheb et al, 2004).

Arasbaran includes 11 basins. Varzegan is one of them, which is our study area. Aras river is in the Northern boundary of the study area. Varzegan basin includes about 58500 ha, which is 9.40 percent of Arasbaran,s total area.

Temprate front Mediterranean and Siberian climate causes accumulation of snow in the crest of the mountains in winter. The study area is under the influence of the Mediterranean climate and also Caspian and Caucasus climates. Nearest meterology station to the area is kaleibar station which is 1300 m, above the sea level. Average rain fall in this station in a 20- year period was 461mm.

45% of the raining was in spring, 23% in autumn, and 22% in winter and % 10 in summer.

Maximum monthly evaporation is %85 in spring. Average yearly temperature is different so that it may be up to $12^{\circ}c$, it would be $17^{\circ}c$ in low elevations and $5^{\circ}c$ in high elevations.

Average temperature in the warmest days of the year is $24^{\circ}c$ in low land and $12^{\circ}c$ in high lands. Average temperature in the coldest days of the year is $10^{\circ}c$ in low lands and $-2^{\circ}c$ in high lands. Minimum temperature may be up to $-29^{\circ}c$, in the study area . Based on Due Martteene method the climate situation in Ilighinehchay Basin is: Semihumid with cold summers (Akbarzadeh and Babie. K 2002) (Sagheb et al, 2007) (Sabeti.H, 1976).

The area is bounded among Ararat, Sahand and Sabalan mountains and their activities and tectonical frequency formed collection of lime and igneous stones among them marn, shale, tuff and conglomerate can be seen.

This collection belongs to tertiary which has been formed due to high motion alpine mountain.

There are a large amount of basalt and tracite among them.

There are lime pans in Ghare Dagh Mountains too.

Surface of lands are covered with brown soils. There are many springs in the study area which are emerged from the crest of rocky mountain.

Raining mostly is snow in study area which its low evaporation has caused some rivers to emerge from high land and enter to Aras river. The main river is ilghineh chay which is the same name as the basin.

Quality of waters is so good that can be used for human being, wildlife and agriculture without any limitation (Akbarzadeh, 2007) (Mukhdum, 2000).

2. Methodology

The socioeconomic analysis was aimed at examining current land-use practices and their spatial distribution, as well as the different land-use strategies implemented by households within the NPA (natural protected areas). This analysis was needed to identify the forces behind LUCC(land use / cover changes) in VARZEGAN, since landscapes are transformed by natural resources appropriation and implementation of productive activities, in addition to ecological processes. Our intention with this analysis was to reveal the ecological, economic and social conditions under which the VARZEGAN ecosystem is managed. Socioeconomic data was collected between September 2008 and October2009.

Data collection was done via participant observation, informal and semi-structured interviews, and a survey with semi-closed questions.

 All the above were conducted with the assistance of a bilingual interpreter who was not from VARZEGAN and whose native and second languages were Turkish and Persian, respectively.

Data collection was designed to gather both quantitative and qualitative information. Semi-

structured interviews were carried out in 29 of the 30 households inside the NPA, and were focused on household activity implementation. Special emphasis was placed on gathering data on plots (distance to house, surface area, crops, activities implemented and labor allocation). An additional 23 semi-structured interviews were carried out to gather data on household home gardens (variety of species and uses). Informal interviews and semi-closed questions were used to evaluate their views on ecotourism activities in the area. Emphasis was placed on informant perceptions of the possibility of allocating more time to new economic activities (ecotourism) instead of traditional ones.

 Finally, a semi-structured interview was held with a tourist agency executive interested in working in VARZEGAN. Future LUCC scenarios were projected using socioeconomic analysis data, and the factor of possible land tenure changes in VARZEGAN.

 To build these scenarios, we classified study area into 2 groups: (a) forest ecosystems and biodiversity implemented at the same rate; (b) forest ecosystem and bio diversity decreases due to the growing demand of ecotourism.

Characteristic vegetation in the VARZEGAN NPA is medium deciduous forest in different successional stages, although small patches of seasonal grassland are also present. Vegetation maps were generated using various tools and Spot 5 data, to validate the different described land use and vegetation succession categories in VARZEGAN. Initially, a 2002 Etm+ panchromatic image was interpreted and digi- talized. The visual interpretation of land use categories and vegetation successional stages, as well as the mapping of the different trails in the NPA were aided by performing ground verifications and by conducting participatory mapping exercises with local inhabitants. They have a vast knowledge of plant species, forest successional stages and land-use history which could be translated into spatial references given the scale at which we were working at. By these processes were defined the following land use and vegetation successional stages categories: agricultural units (0–1 year); four forest successional stages (2–7; 8–15; 16–29; and 30–50 years); old-growth forest(>50years); Later, a 2005 SPOT image (5m ground resolution) was interpreted using the same categories for land use and vegetation successional stages defined for the 2002 map. Additionally, for thisimageweusedbands2, 3and4todigitalize, anddifferentiate among textures, forms and color patterns (IDRISI15, Ilwis3.0). The successional stage category was assigned correctly in 90% of the sites.

3. Result

1. Tourism in the NPA will increase mainly because of agreements between local inhabitants and one or more tourists.

2. Protection of area is seen more strongly, because degradation rate in these areas is lower than the others.

In the first projection scenario (Scenario 1), land use cover maps for 1999 and 2003 were projected to 2007 and then to2010under the assumption that the change observed between1999 and 2003 would occur at the same pace from 2003 to2007.

The second scenario (Scenario 2) was run in which the probabilities of observed change were altered according to socioeconomic analysis results and current land tenure policy in the NPA. In Scenario 2 we decreased by 8% the future probability that all succession categories would change to a new agriculture.
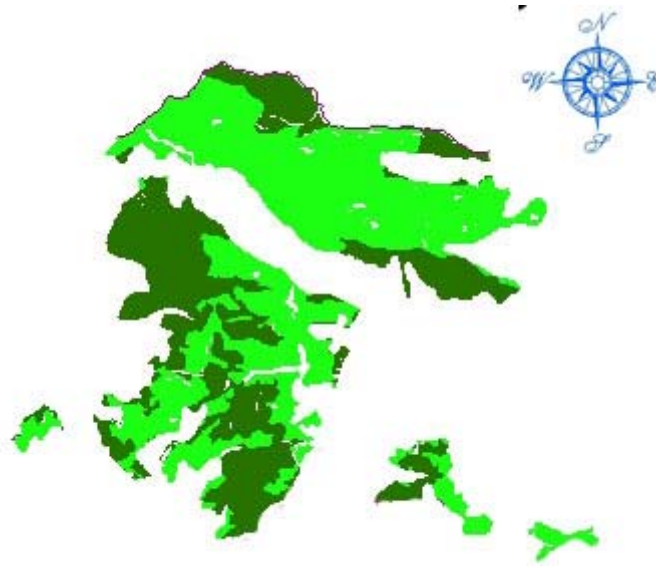
Figure 1: Map of Study Area group A: Dark Green B: Light Green

3. Discussion

This hypothetical reduction was based on the results of the socioeconomic analyses, which suggested a tendency for households to devote increasingly more time to ecotourism and less to agriculture and traditional activities, as well as a tendency of local inhabitants to emigrate and abandon their agriculture.

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Fine-scale mapping of High Nature Value farmlands: novel approaches to improve the management of rural biodiversity and ecosystem services

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Abstract

High Nature Value farmlands (HNVf) are defined as rural lands characterized by high levels of biodiversity and extensive farming practices. These farmlands are also known to provide important ecosystems services, such as food production, pollination, water purification and landscape recreation. Recently, this concept has been introduced in Rural Development Programmes related to biodiversity preservation in traditional agricultural landscapes. However, there are no specific rules concerning the practical use of the concept, particularly on the identification of potential HNVf areas at a local scale. This application becomes important for farmland biodiversity protection in the context of multi-scale agricultural development.

We present a novel approach for HNVf mapping, which provides an improved local discrimination of farmlands according to their contribution for the conservation of rural biodiversity and ecosystem services. Our approach is based on a multi-criteria valuation of habitat types based on the national land cover map and agrarian censuses. It is considered applicable in other EU countries since comparable datasets are usually available. This methodology is also expected to provide the backbone of a standard, cost-effective methodology for HNVf monitoring, with an emphasis on the impacts of land use change on species, habitats and landscape function.

Keywords: ecosystem services, local scale, HNVf, mapping, rural biodiversity

1. Introduction

Biodiversity is an important product of agricultural landscapes, but in many European farmlands species richness has been declining (Billeter *et al.* 2008). Furthermore, research and policy on biodiversity conservation and agricultural management have not progressed very well (Moonen and Bàrberi 2008). Since rural landscapes are dominant in most European countries and the European Union (EU) has established ambitious goals concerning the halting of biodiversity loss (Pereira and Cooper 2006; EEA 2006a, 2006b; Fontaine 2007), it is imperative to establish

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sound frameworks to monitor agricultural impacts on biodiversity, by selecting the best general indicators (EASAC 2005; EEA 2005, 2006b, 2007) and at the same time paying attention to the specificity of different agro-ecosystems. It is important to understand the relationships between landscape, biodiversity and land use to manage the land and to develop consistent plans for the future maintenance or enhancement of the current resources (Jongman et al 2006).

More than 50% of Europe's most highly valued biotopes occur in low intensity farmland (Bignal and McCracken 1996). Over the last few decades biodiversity losses in farmlands were, in great extent, due to large scale rationalization and intensification of agricultural production and, on the other hand, many marginal and extensively farmed areas have either been improved or abandoned, both resulting in the reduction on habitats and species diversity (EEA 2004).

2. High Nature Value Farmland

Among the many initiatives to prevent biodiversity decline, the identification and mapping of High Nature Value Farmlands (HNVf, low-intensity traditional agricultural areas, such as the *montados* in Portugal) is surely one of the most valuable (Andersen *et al.* 2003; EEA 2004; Paracchini *et al.* 2006; Cooper *et al.* 2007; Poux and Ramain 2009). Besides gathering information about these areas, a major objective is to take conservation measures to protect hotspots of biodiversity (EEA 2004).

HNVf is a concept applied on rural lands characterized by the existence of high levels of biodiversity, and by extensive farming practices (EEA 2004). Recently, this concept, originally introduced by Baldock (Baldock D *et al.* 1993) as farming systems with low-inputs of chemicals and of management practices, was also adapted to the forestry sector in the framework of Rural Development Plans (Beaufoy and Cooper 2008).

Europe is characterized by unique and variable rural landscapes, heritage of many centuries of cultural and natural history (EEA 2004). Many of them can be considered as HNVf. According to Andersen (Andersen *et al.* 2003), there are three types of High Nature Value farmland:

Type 1: farmland with a high proportion of semi-natural vegetation;

Type 2: farmland with a mosaic of habitats and/or land uses;

Type 3: farmland supporting rare species or a high proportion of their European or world populations.

In Europe (EU 15), about 15-25% of the utilized agricultural area (UAA) is considered as HNV farmland. The majority of this area is located in the Southern Europe, and in Portugal the percentage of HNV farmland is estimated at about 37% of the total UAA (EEA 2004).

Another important concept associated with HNVf is HNV farming, used in more recent documents (Beaufoy and Cooper 2008). It refers not only to the land use (farmland) but also to the associated farming management practices. In the context of Rural Development Programs, the HNV farming indicator is an obligation of the EU states in order to assess whether the objectives of rural programmes are being achieved under the strategy of Pillar 2 of the CAP (Beaufoy and Cooper 2008). These indicators were developed, not only to describe and characterize where HNVf is located, the farmland systems and practices as well as species and habitats of conservation concern (baseline indicators), but also to survey HNVf, contributing to monitor agricultural impacts on biodiversity (result and impact indicators). Member States are committed to identify and maintain HNV farming, and it is important for all countries to identify these systems in order to implement targeted economic support measures (Beaufoy 2009). Ultimately, HNVf associated with high levels of biodiversity can also be related with the concept of ecosystem services, since in these traditional agricultural areas ecosystems provide a range of important ecosystem services such as food, water purification, soil formation, and recreation.

3. Mapping HNVf across Europe

3.1. Problems with existing methodologies

Ecological, historical and cultural differences in farming landscapes among countries require region-specific rules to identify HNVf. This paper addresses this problematic and presets a new methodology to map HNVf at a local level, considering the importance of this identification to the improvement of rural natural and economic environment.

The standard procedures for mapping HNVf in Europe include the use of land use data (CLC - Corine Land Cover), with classes based on an Environmental Stratification (Metzger *et al.* 2005)When available, the methodology also suggests the use of complementary information on farming practices, altitude and latitude, soil quality, climatic condition, steepness of slope at national level to improve the cartography (Paracchini *et al.* 2006). However, the resulting maps cannot be used to draw conclusions on the presence of HNV farmland at the local level, but only at the regional level (Paracchini *et al.* 2006). In fact, scale is very important when trying to map HNVf, because different agro-ecological processes operate at different scales that must be taken into account.

For HNVf identification at the local scale the application of a downscaling exercise using a bigger scale land use map seemed to be a good option. In Portugal, local-scale land cover/use analysis is based on the COS products (Portuguese land cover map, 1:25.000), obtained from the interpretation of aerial photos. However, there is no satisfactory direct relationship between the CLC and COS classifications (table 1), and an HNVf map based on the application of the regional-scale methodology to a COS map would exhibit more than twice the extent of HNVf area than a map obtained using the CLC dataset. So, differences in land cover classifications in maps with different scales may result in very different maps for a same area. Overall, this implies that the methodology for identifying and mapping HNVf should be revised in order to adapt it to multi-scalar exercises.

3.2. Local scale HNVf mapping – proposal of a new methodology

In order to best consider those areas that could be excluded when applying the CLC methodology, a new refined methodology has been developed to identify HNVf at local scales. The national land cover dataset (COS) is the central dataset in this novel methodology.

The first step is to define the "total farmland area", considering not only the pure agricultural and agro-forestry areas, but also small patches of neighbouring forest and semi-natural areas spatially and functionally linked with croplands. We defined the maximum areas of 5ha for forests and 1ha for semi-natural areas. Herewith, we are placing the farmland not as fragments with restricted boundaries, but in its context as a continuous place where biodiversity circulates among habitats.

Even if the methodology considers two different levels of analysis, the patch level and the civil parish level, the final HNVf map should be presented at the less detailed scale (the parish level), in order not to lose information in the transition among scales. Moreover, as a landscape concept, HNVf should not be mapped directly at the individual patch of COS, but using context attributes such as landscape metrics and other features of the farming landscape and of the territory itself (Figure 1). Landscape attributes include those related to landscape composition and to landscape structure. Available data on farming (from agrarian censuses) were also added at the parish level, to identify the importance of primary sector of activity in each parish. Finally, natural value was taken into account, using available data on regional biodiversity and ecosystems from a previous project (FCUP 2009).

Mean values were calculated for all parameters and for each parish, based on "total farmland area". To isolate any surrogacy among variables a correlation analysis (e.g. using the Spearman index) should be carried out. Finally, a global HNV score is obtained for each patch or parish by reclassifying the selected parameters into five classes using equal breaks, and then by averaging their values. The final scale ranges from 1 (low nature value farmland) to 5 (high nature value

farmland). The objective is thus not to identify HNVf *vs.* non-HNVf areas, but instead to provide a hierarchic zoning of nature value. The parish-level HNVf map is obtained from the area-weighted mean value of farmland patches inside the parish, and the final score is expressed without considering the total extent of each parish.

3.3. Testing the new framework in Northern Portugal

The region chosen to test the methodology was the Baixo Tâmega, in the north of Portugal, a mosaic of different agrarian systems and landscapes that have, in most cases, been suffering abandonment in the last few decades. Nonetheless, there are some areas with more specialized and intensive agricultural systems, mostly related to wine production along the Douro and Tâmega valleys. There are also non-cultivated areas, mostly in mountain areas, with semi-natural vegetation associated with extensive grazing.

Due to the regular presence of semi-natural vegetation types, most of these farmlands are classifiable as HNVf areas (Andersen *et al.* 2003). The final maps (figure 2) provide complementary views of HNVf distribution in the area. In fact, the patch-level map identifies HNVf areas in most of the study area except for the eastern mountain areas (where forestry prevails), but the parish-level map identifies small farmland areas in these mountains as the ones with the highest nature value.

4. Discussion

The concept of HNVf, areas associated with low intensity farming, has become very important regarding agrobiodiversity protection under the Rural Development Programs. It is already used in many European countries from different perspectives, and is starting to be more and more included in the political agricultural context. This could mean economic support to these areas, through European financial instruments.

Land cover, farming characteristics and species distribution data are the central datasets in the common approach to the identification of HNVf at European and national levels. The availability and the quality of farming and species datasets is a recurrent problem. In fact, mapping methodologies using land cover datasets at different scales can provide very distinct HNVf maps.

A new refined methodology based on land cover data, landscape features, farming attributes and natural value/conservation data was designed to map HNVf at a local scale. The use of datasets on nature value including information on the valuation of ecosystem services inferred from land-use dataset is considered an advantage. In the literature, HNVf is stressed to promote biodiversity in agroecosystems. In our novel methodology, we suggest a stronger emphasis on a landscape perspective and on the ecosystem services provided by semi-natural areas close to cropland.

This methodology appears as an important instrument in the identification of HNVf areas to support policy implementation in the framework of agrobiodiversity protection. It can be used either spatially, comparing the extent of potential HNVf areas among different regions, or temporally, comparing changes in extent of HNVf in one region at different times as a monitoring effort. Additionally, we expect with future research to check the possibility to adapt this methodology in other EU countries, where local land cover datasets are usually available.

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Table 1 – Land cover/use classes used to identify farmland areas when using wither the CLC or the COS classifications

CLC – Lusitanian region	COS
Pastures	Annual crops associated with permanent crops (orchards, vineyards and olive groves)
Land principally occupied by agriculture	
Agro forestry areas	Orchards and orchards associated with olive groves, vineyards and annual crops
Moors and heathlands	
	Olive groves and olive groves associated with orchards, vineyards and annual crops
	Vineyard and vineyards associated with olive groves, orchards and annual crops.
	Agro forestry areas
	Complex and partial cultural systems
	Semi-natural areas
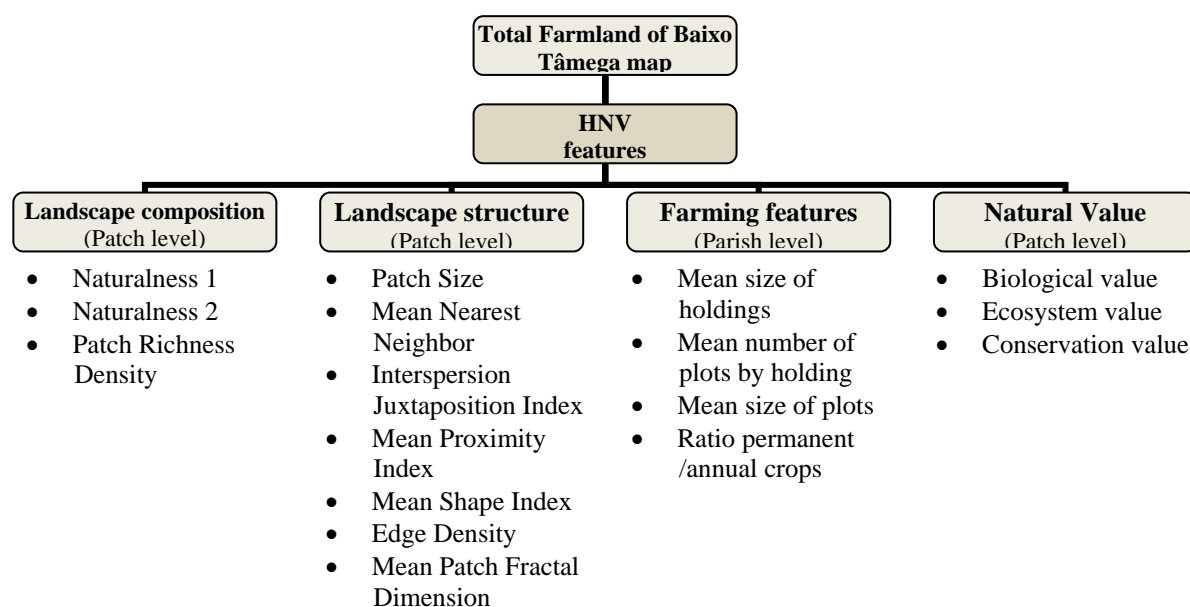
Figure 1 – Groups of parameters included in the new methodology to map HNVf at a local scale
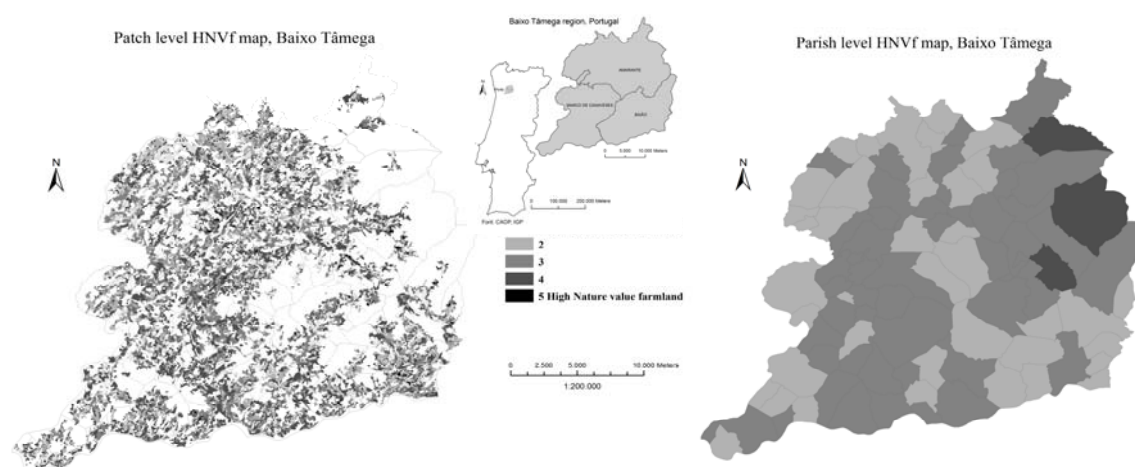
Figure 2 – Patch and Parish HNVf map using the new methodology

Wood macrolichen *Lobaria pulmonaria* on chestnut tree crops: the case study of Roccamonfina park (Campania region - Italy)

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Abstract

Integrating at landscape level the information coming from local environment indicators can help monitoring environmental quality in conservation programs. *Lobaria pulmonaria* is a lichen species widely used to evaluate the spatio-temporal continuity of forest cover and to assess environmental quality in areas of high biogeographical interest. In the *Lobaria* project of the Società Italiana Lichenologica, wood macrolichens were sampled on Chestnut woods in a regional park of Campania Region (Italy). A geographical datasets of lichen distribution, land use, topographical and climatic characteristic was built in GIS environment. Multivariate analysis was conducted to highlight the relationships between lichen distribution and environmental quality. The results show that the agronomic management practiced in this area enabled the establishment of stable conditions over time and the development of species indicator of undisturbed areas. A general framework to analyse landscape-level changes over the area is proposed in this paper.

Keywords: Lobaria, lichens, chestnut, landscape, monitoring.

1. Introduction

No areas was left on our planet that did not experience changes, directly or indirectly connected to human activities. The assessment and monitoring of forest resources for environmental policy and management is recognized to be of prime importance (Loppi et al., 1999). Epiphytic lichens are an integral component of forest ecosystem and represent a characteristic part of the total biodiversity. Habitat fragmentation and other human land use variables, such as urbanization, intensity of agricultural or pastoral use, and forestry management, are increasingly important as predictors of lichen species distribution (Will-Wolf et al., 2002).

In fact, lichens react to disturbances and habitat alterations for several reasons. Firstly, some lichen species are dependent on favorable microclimatic conditions. Some epiphytic lichens, particulary the rarer ones, are stenotopic and require a long habitat continuity, for example substrates such as old or large trees (Friedel et al., 2006). Many epiphytic lichens are strongly affected by forestry practices, particularly logging (Nascimbene et al. 2007). For example, cyanolichens are considered a guild of species extremely sensitive to intensive forest management and so they are good indicators of forest continuity. This is the case of the flagship species *Lobaria pulmonaria* (L.) Hoffm., whose populations was drastically reduced in the recent decades (Nascimbene et al., 2007).

The aim of this work was to analyze the effects of chestnut tree crops management practices on *Lobaria pulmonaria* populations, and on lichens diversity in a natural reserve of Southern Italy.

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2. Materials and methods

The study was carried out in Roccamonfina's Park a reserve located in the northen part of Campania, South Italy. According to the phytoclimatic classification (Nimis & Martellos, 2008), the area is intermediate between humid sub-Mediterranean and humid Mediterranean. The mean annual temperature is 15.7°C and the mean annual rainfall 950 mm. Forests in this area are dominated by chestnut tree crops (*Castanea sativa* Miller).

The monitoring study was carried out between March and July 2008. Sixteen 30x30 m plots were selected, spaced 300-500 m inside four stations differing for forest cover and management. In the center of each plot, 6 trees colonized by *Lobaria pulmonaria* were sampled and geo-referenced. On the selected trees, the presence of all epiphytic lichens was recorded from the trunk base to a height of 180 cm. Species nomenclature and phytoclimatic classification follow Nimis & Martellos (2008).

In addition we calculated *Lobaria pulmonaria* area with the aid of 40x40 cm sampling grids divided into 1x1 cm contiguous quadrants:

%=(total area of Lobaria pulmonaria/ lateral area of trunk)*100

Cartographic processing was carried out using ArcGis 9.3, Ilwis 3.4 and Idrisi Kilimangiaro GIS integrate software. Kriging was the interpolation method used to obtain a geostatistic correlation of the nearest randomly surveyed values inside the plots and to produce an estimate of minimum least squares variance, as a continuos map. The interpolation procedure, followed a pattern analysis that allowed to define the range of action of the algorithm (barriers), in order to minimize disturbance of adjacent areas not subject to survey. Four separate continuos grids, strictly related to the single plot, were subsequently elaborated to present *Lobaria pulmonaria* coverage percentage maps.

Floristic data were analyzed with multivariate statistical methods (Podani 2007), namely a classification analysis (cluster analysis) and an ordination analysis (PCA, Principal Component Analysis), using SYN-TAX 2000 software. Cluster analysis was performed with group average link method (upgma) with chord distance for binary data as the dissimilarity coefficient, in order to identify the classification dendrogram. For ordination analysis a centred PCA was applied, obtaining the biplot of the species-stations dispersion and the screeplot showing the percentage of variability explained by each of the detected axes.

Ecological indices were calculated to detect local trends related to pH of the substratum, solar irradiation, aridity, eutrophication and poleophoby referring to the Italian Lichen System (Nimis & Martellos, 2008).

3. Results

A total of 74 lichen species were recorded during the survey on the 96 sampled trees, four of which were new findings for Campania region (*Calicium abietinum* Pers., *Lobarina scrobiculata* (Scop.) Nyl., *Physconia subpulverulenta* (Szatala) Poelt v. *subpulverulenta*, *Platismatia glauca* (L.) W. L. Culb. & C. F. Culb). Most of the lichens (83.56%) presented a coccoid green alga as photobiont, whereas few of them had cyanobacterium (15.07%) or *Trentepohlia* (1.37%). Foliose lichens prevailed (50%), followed by crustose (39.18%) and fruticose (10.82%).

Concerning phytoclimatic classification, temperate species prevailed (41.25%), divided in temperate (26.25%), mild temperate (10%) and cold temperate (5%). Then followed the sub-oceanic species (22.5%), and holartic (17.5%). The remaining 18.75% was divided in several phytoclimatic groups, among which the mediterranean.

Two clusters for the stations (hereafter cluster A and B) and five for the species (hereafter cluster 1 to 5) were identified by classification analysis (Figure 1). The PCA (Figure 2) confirmed the groups identified by the *cluster analysis*.
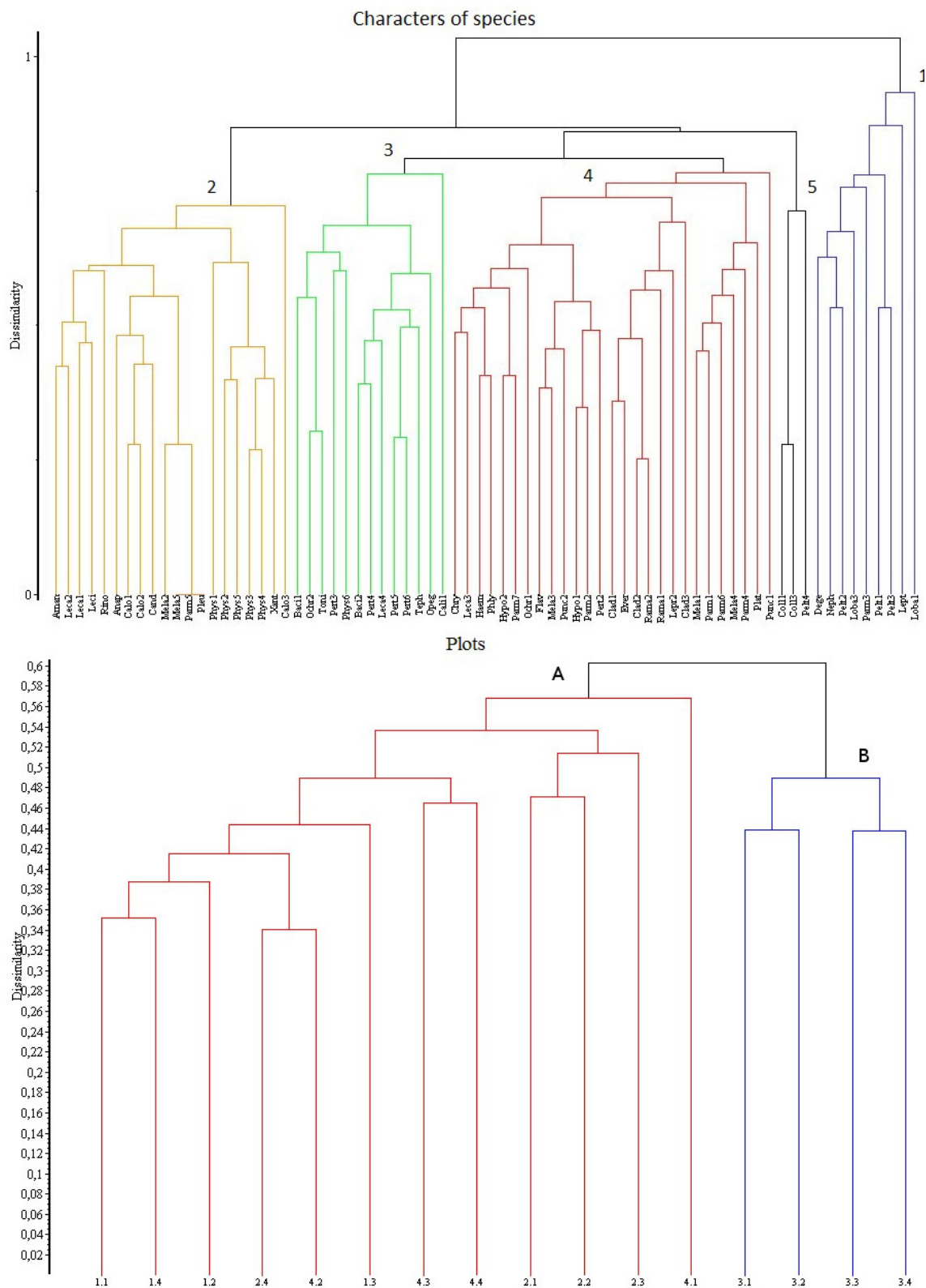
Figure 1 Dendrograms showing the main clusters of species (above) and stations (below)
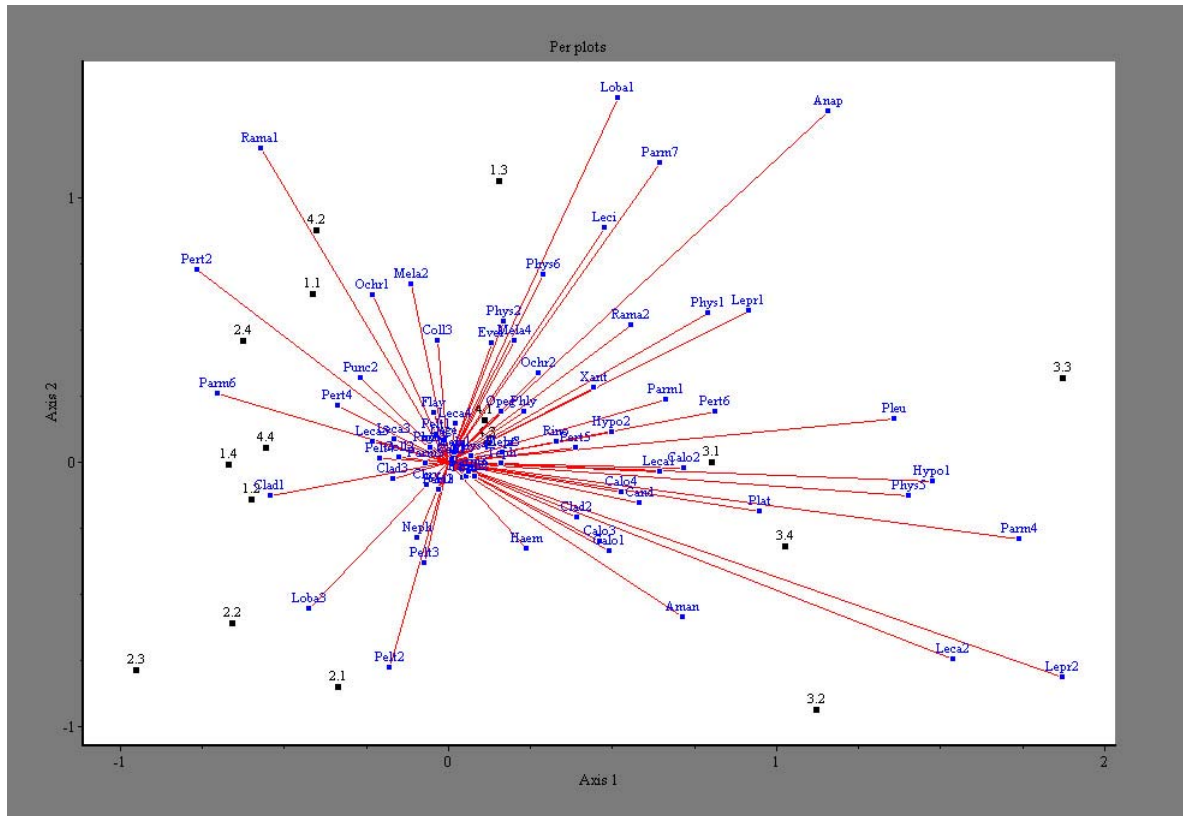
Figure 2: Biplot showing the main axis of PCA ruled on species and stations

Stations
Cluster A includes the stations 1, 2 and 4, located at relatively lower elevations. Cluster B includes four plots located at higher elevation and is characterized by the presence of almost exclusive species such as *Hypogymnia physodes*, *Platismatia glauca*, *Physconia subpulverulenta* v. *subpulverulenta* e *Parmelina pastillifera,* and some other species that are represented with a higher frequency relative to the other cluster, such as *Leprocaulon microscopicum* and *Lecanora chlarotera.*

Species
Cluster 1 includes lichen species of the *Lobarion pumonariae* alliance, such as *Lobaria amplissima* var. *amplissima* (the spesies with the highest frequency in the sampled area), *Lobarina scrobiculata*, *Degelia plumbea*, *Peltigera collina*, *Nephroma laevigatum*, *Leptogium cyanescens.*

Cluster 2 is dominated by species of the *Xanthorion paretinae* alliance, with some species of *Lecarion subfuscae*: *Lecanora clarotera*, *Lecanora carpinea*, *Lecidella elaeochroma*, *Physcia adscendens*, *Physconia distorta*, *Xanthoria parietina*, *Punctelia subrudecta*. These species are typical of heliophilous, xerophilous, nitrophilous communities distributed in anthropized environments, where they show a good resistance to pollution.

Cluster 3: Species of Graphidion scriptae: *Opegrapha atra*, *Ochrolechia balcanica*, *Pertusaria amara*, *Pertusaria hymenea.* These are communities of crustose pioneer lichens, usually found in forest environments and rarely in anthropized areas, that precede in the succession or sometimes coexist with the species of *Lobarion* and *Parmelion*.

Cluster 4: species of *Parmelion parlatae* and *Xanthorion parietinae* alliances: *Flavoparmelia caperata*, *Parmotrema perlatum*, *Hypogymnia physodes*, *Parmelia sulcata*, *Parmelina tiliacea.* These are species of mesophilous and sub-acidophilous communities, less adapted to dry and nitrified environments compared to *Xanthorion*, but relatively more sensitive to pollution,

though in some case they are found in anthropized areas if atmospheric humidity allow their presence.

Cluster 5 includes several species that may be considered closer to *Lobarion pulmonariae* than to *Parmelion perlatae* or to *Xanthorion parietinae*.

Cartographic analysis

Four maps of *Lobaria* percent cover were obtained for the sampled stations. *Lobaria* cover values ranged between 0.009 and 35%, clustered in nine classes in the maps (Figure 3). The species did not show very high cover values, except in one of the plots of the first station.
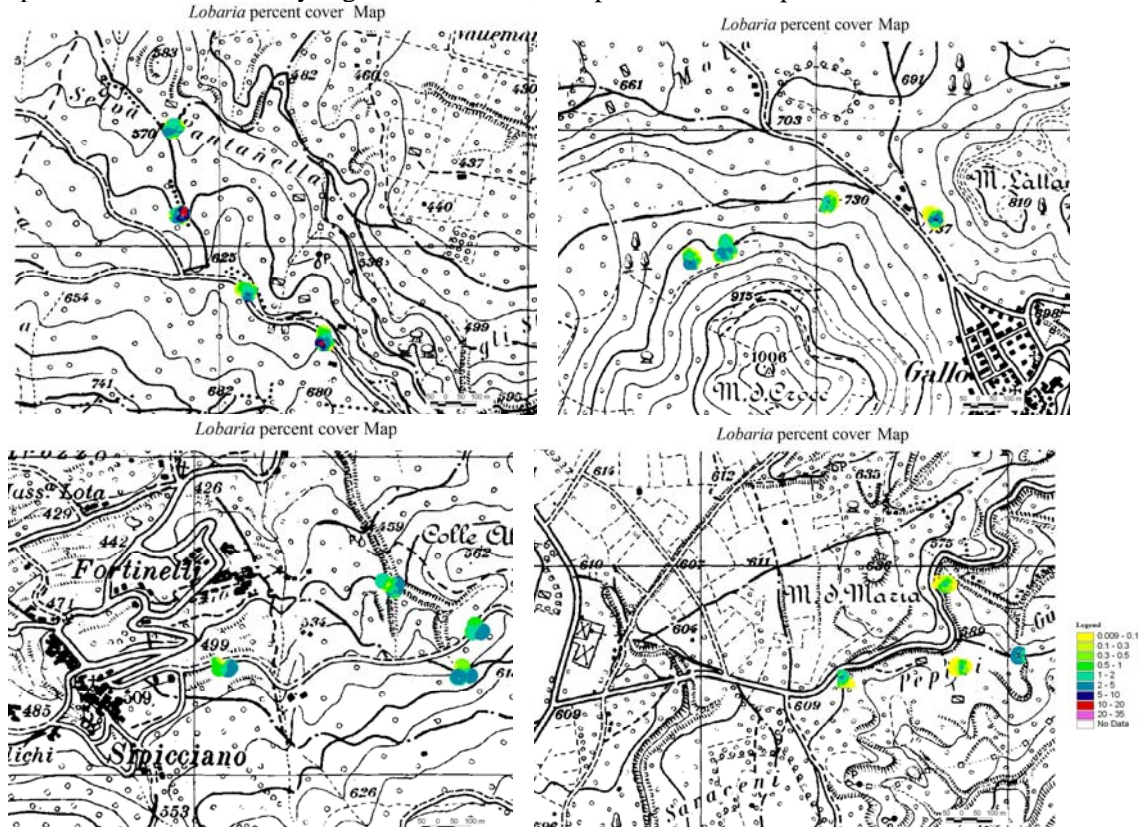
Figure 3: *Lobaria* sp Cover map elaborated from the surveyed data

4. Discussion

Lichen biodiversity resulted relatively high in the sampled areas, both for the numerical representation of taxa and for their floristic quality, though rich of generalist species adapted to disturbed areas. *Lobaria* cover, however, presented relatively low cover values on the studied area, as it resulted from cartographic analysis. Also the other species of the *Lobarion pulmonariae* alliance were not very diffuse on the area. Ecological indices showed that many of the sampled species are typical of natural or semi-natural habitats, with a hygro-mesophylous behaviour, preferring high availability of diffuse light, but escaping direct sun radiation. Though the list of sampled species represents only a small portion of the lichen flora in the studied area, the marked presence of temperate and sub-oceanic species is well correlated with the sub-mountain character of the area.

A limited number of species characterized by low tolerance to air pollutants prevailed in cluster A, whereas a greater number of species was found in cluster B, most of which typical of undisturbed areas or small mountain urban sites. The most frequent species belonging to the alliance of *Lobarion pulmonariae* are *Lobaria amplissima* and *Lobaria pulmonaria*; other species, such as *Lobarina scrobiculata* e *Peltigera collina*, resulted to be rare and sporadic,

mainly in the northern side of the park, inside the ancient volcanic caldera. These species are good indicators of wood stability over time. They were mainly found in chestnut forests, rather than in coppiced oak mixed wood areas (*Quercus pubescens*, *Olea europaea*, etc.), more represented in the western side of the park. Despite landscape fragmentation, the results could suggest that the agroforestry management carried out over many decades in the north-east of the park allowed wide forest corridors to get established, which could be an important factor of ecological continuity. This ensured the conservation of biodiversity due to the local presence of a large number of vegetative propagules, inducing several colonization events of rare lichen species over surrounding areas. So a fruit chestnut wood, subjected to a good agronomic and forestry management, would give better results in terms of biodiversity than an oak mixed forest, characterized by a more natural floristic composition but strongly disturbed by frequent coppice.

The method used to estimate the actual coverage of the monitored species associated with the cartographic approach, allowed to quantify the species areal extent as monitored on individual trees, and to propose an estimation of the visible cover of the species in the studied area. This kind of study represents a good starting point for further investigations, specifically designed to monitoring possible deviations from current conditions and focused to assess the effectiveness of environmental policy actions taken at municipal and regional level.

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Extent and characteristics of mire habitats in Galicia (NW Iberian Peninsula): implications for their conservation and management

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Abstract

NW Iberian Peninsula hosts a variety of mire habitats linked to wet environments that contrast with surrounding regional vegetation. These wetlands are confined to locations meeting certain azonal conditions, due to local topographies that prevent or delay drainage, to the occurrence of significant rainfall, or to a combination of both. Despite of their international relevance and their designation as habitats of interest for biodiversity conservation by the EU habitats Directive, they are threatened mainly by changes in land use, particularly by agriculture intensification/abandonment and the development of wind farms.

In the present work we address the mapping, description and analysis of these habitats in a spatial explicit way in the region of Galicia (NW Iberian Peninsula), in order to support the development of strategies of planning and management. Results showed differences in the extent, distribution and characteristics of the different types of mire habitats with important implications in their conservation.

Keywords: Mire habitats; NW Iberian Peninsula; spatial distribution; habitat environmental controls; CHAID

1. Introduction

Mire habitats are azonal wetland ecosystems confined to areas with particular environmental conditions defined by a positive water balance, a low organic mater decomposition rate and where the vegetation remains composition has the potential to form peat (Goodwillie 1980; Raeymaekers 2000; Rydin and Jeglum 2008). Their conservation value has been recognized internationally by different institutions and treaties, as the Ramsar Convention. In the EU context, most of mire types were included as interest of priority habitats in the Annex II of the European Directive 92/43/CEE for their inclusion in the European network of protected areas Natura 2000 (European Commission, 2003). They also host a great amount of species of bacteriae, protozoans, fungi, algae, lichens, bryophytes, vascular plants, invertebrates and vertebrates of interest for biodiversity conservation. Most of them have they optimal or even exclusive habitats in these environments (Rydin and Jeglum 2008). In relation with plant communities, mire habitats frequently include endemic taxa and usually show particular floristic compositions along geographical and altitudinal gradients because of their azonal and fragmented distribution.

A key issue in the planning and conservation of these habitats is the assessment and modelling of their spatial distribution in relation with key environmental factors as this information might be used for the optimization of conservation efforts (Wainwright and Mulligan 2004). There are a number of factors that determine the occurrence and the type of mire habitats, being the most important climate, topography and nutrient supply (Graniero and Price 1999). In this work we aimed at the exploration of the relationship and dependence between different environmental controls and the occurrence of different mire habitats in a sector of the NW of Spain. More

specifically, we carried out a data mining procedure to determinate the influence of topography, climate, lithology and distance to sea in the occurrence of four types of mire habitats.

2. Methodology

We conducted our analyses in the region of Galicia, located in the NW of Spain (code NUTS ES11 of the European Union) and covering an area of 29 574 Km2 (cf. fig. 1). Altitudes range from sea level to about 2000 m a.s.l. showing a contrasted relief. Biogeographically most of the area is included in the Atlantic Region, but a sector of the SE quadrant of the scene corresponds with Mediterranean region, being a matter of discussion the exact extent of the Mediterranean domain in the area (European Environment Agency 2008, Rodríguez Guitián and Ramil Rego 2008; Rivas-Martinez and Rivas-Saenz 2009). Natural vegetation comprises different deciduous forest, mostly dominated by *Quercus robur*, but most of the present day land cover shows an important degree of human intervention, being frequent afforestations with non native species, scrubs and heatlands along with mosaics of traditional and modern agrarian landscapes.

Mire habitats maps were done using different data sources, from national habitat inventories (http://www.mma.es/portal/secciones/biodiversidad/banco_datos/info_disponible/index_atlas_m anual_habitats.htm) and wetland catalogs (Galician Wetland Inventory, http://medioambiente.xunta.es/espazosNaturais/humidais/index.htm) to monographic works (Izco Sevillano et al. 2001) and regional maps for protected areas planning (Ramil-Rego and Crecente Maseda 2005). All this information was processed in a Geographic Information System software (ArcGisTM V9.2) and converted to different raster layers (one for mire type) with a cell size of 90 m. Mire classification legend was based on the typology of the Annex I of the European Habitat Directive (consolided version of the 92/43/CEE Directive) and included four types of mire habitats: Blanket bogs, *Cladium mariscus* fens, Calcareous fens and Tufa formations, and was a compromise between the available input information and the categories of the Directive. Other mire habitats of the Annex I of the directive (i.e. Raised bogs, Depressions on peat substrates of the *Rhynchosporion* and Transition mires and quaking bogs) were not considered in this analysis as are often included in mosaics of other habitat complexes (frequently wet heathland or moorland) in the existing cartography.

We considered four groups of explanatory variables (climate, topography, geology and distance to sea) as potential environmental controls for mire habitats (cf. table 1). Climate variables were obtained from regional climate maps available in literature (Martínez Cortizas and Pérez Alberti 1999), where the variables are expressed in intervals of different amplitude labelled as a numeric scale (cf. table 2). Topographic variables were computed from a Digital Elevation Model using the ArcGisTM V9.2 software package. Geology map were done by reclassifying the original classes of geological charts from the Spanish Geological Institute in five classes, namely sedimentary (sd), granitic (gr), ultrabasic (ub), siliceous metamorphic (mt) and calcareous (ca) materials. We also computed the minimum distance to sea as an indicator of the degree of continentality. All the information layers were converted to raster format with the same spatial reference and resolution as the mire habitat maps. We extracted the explanatory variables data by means of the spatial overlay of the masks corresponding with each mire type. The final output for the subsequent analyses was a table with mire type as dependent / grouping variable and several explanatory or independent variables.

In order to asses the effect or explanatory power of these variables, we performed a classification using the tree based segmentation technique CHAID, acronym of Chi-Squared Automatic Interaction Detection (Biggs et al. 1991; Kass 1980). CHAID is an exploratory analysis based in the recursive partitioning of a feature space of several independent or potential predictors, that themselves might interact, in relation to a dependent or response variable. Both predictors and response variables may be continuous, ordinal or categorical. Since CHAID is a non-parametric technique, no normalization of original variables is needed (Van Diepen and

Franses 2006). CHAID technique was applied using mire classes as response variables against the abovementioned collection of potential predictors. For the validation of the model, we randomly split the original data in a training and validation with 50 % of the cases assigned to each subset. We finally generated a contingency matrix for the contrast of the observed and predicted classes for the validation set, and subsequently we computed the KAPPA statistic (Bishop et al. 1975) as a measure of model accuracy.

3. Results and Discussion

Results of the CHAID classification are presented in figure 2. According the diagram, the most powerful discriminant variable was distance to sea. In the second level nodes other variables related to geology, topography and climate were taking into account for the discrimination of mire types. Finally, water balance was considered for the discrimination in the third level between some blanket bogs and *Cladium* fens with similar values regarding their distance to sea and slope. Overall accuracy reached more than 96 % (table 3) while the estimation of KAPPA index, regarded as a more reliable indication of the overall accuracy due to its compensation of chance agreement (Congalton 1991), achieved a value of 0.93, indicating an almost perfect agreement between the classification and reference values (Landis and Koch 1977). Per class accuracies reached particularly high values for blanket bogs and tufa, while fen and *Cladium* mires accuracies were lowered because the confusions with each other and also with tufa mires.

According these results, blanket bogs occur on sub-coastal areas at different exposures, more frequently facing north and under high annual rainfall or water balance, as previously stated by biogeographic studies of this habitat in NW Iberian Peninsula (Rodríguez Guitián et al. 2007). *Cladium* fens are located close to the coastline, on sedimentary deposits (corresponding in most cases with the inland border of coastal salt marshes). They also occur in the inland, on flat surfaces under not particularly high water balances, where some confusion with tufa or fens could happen. Even when some fen localities may occur in the inland, they tend to appear close to the coast, on ultra basic material sharing these environmental conditions with localities of *Cladium* fens and tufa formations. Finally, tufa occurs on the coast, in springs or water table ruptures leaching fossil/raised coastal dunes systems still rich in carbonates on coastal cliffs, or alternatively in the inland, linked to the few ditches of limestone rocks in the region (Ramil Rego et al. 2008).

4. Conclusions

In the present work we explored the role of different environmental controls on the occurrence of four types of mire habitats. We found out that the degree of continentality (using the relief-corrected distance to sea as an indicator) play a potential key role in the differences in spatial distribution of types in the region of Galicia. However mire types occurrence can not be differentiated or explained on the basis of just one kind of environmental control, but rather a combination of different controls (as geology, distance to sea, climate or lithology), being the importance of each one related to the ecology, tolerance and requirements of each particular habitat.

The results corroborate in a quantitative and spatially explicit way the previous knowledge on the ecological differences between the different mire habitats in the region. This information has a potential application in habitat management plans for protected areas in combination to other datasets (e.g. spatial pattern and distribution, vulnerability and resilience, future climatic and land use scenarios) and also constitutes a first step towards a predictive biogeographic modelling of habitat distribution.

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Table 1: Explanatory variables

Variable group	Variable	Acronym	Type	Units
Climate	Annual average temperature	Temp	Ordinal	Adimensional (intervals)
	Annual total rainfall	Rain	Ordinal	Adimensional (intervals)
	Annual total evapotranspiration	ETP	Ordinal	Adimensional (intervals)
	Annual water balance	Waterbal	Ordinal	Adimensional (intervals)
Topography	Transformed aspect	TRASP	Scale	Adimensional
	Curvature	Curv	Scale	Adimensional
	Plan curvature (across slope)	Plancurv	Scale	Adimensional
	Profile curvature (along slope)	Profcurv	Scale	Adimensional
	Slope	Slope	Scale	degrees
	Terrain shape index	Tershp	Scale	Adimensional
	Wetness index	Wenidn	Scale	Adimensional
	Elevation	DEM	Scale	m a.s.l.
Geology	Geologic material	MAT	Nominal	Adimensiona
Distance to sea	Distance to sea	Distosea	Scale	m

Table 2: Intervals for the climate variables

Average year temperature		Total year rainfall		Total year Evapotranspiration		Total year water balance	
Code	Intervals (ºC)	Code	Intervals (mm)	Code	Intervals (mm)	Code	Intervals (mm)
1	<6	1	< 600	1	<500	1	-250/-200
2	6-8	2	600-800	2	500-550	2	-100/-50
3	8-10	3	800-1000	3	550-600	3	0-200
4	10-11	4	1000-1200	4	600-650	4	200-400
5	11-12	5	1200-1400	5	650-700	5	400-600
6	12-13	6	1400-1600	6	700-750	6	600-800
7	13-14	7	1600-1800	7	750-800	7	800-1000
8	14-15	8	1800-2000	8	>800	8	1000-1500
9	>15	9	> 2000	-	-	-	-

Table 3. Accuracy of the CHAID classification

Observed	Predicted				
	Blanket	Cladium	Fen	Tuf	Percent correct
blanket	1767	0	0	1	99,9%
cladium	13	122	4	40	68,2%
fen	11	11	49	0	69,0%
tuf	1	14	10	924	97,4%
Percent correct	60,4%	5,0%	2,1%	32,5%	**96,5%**
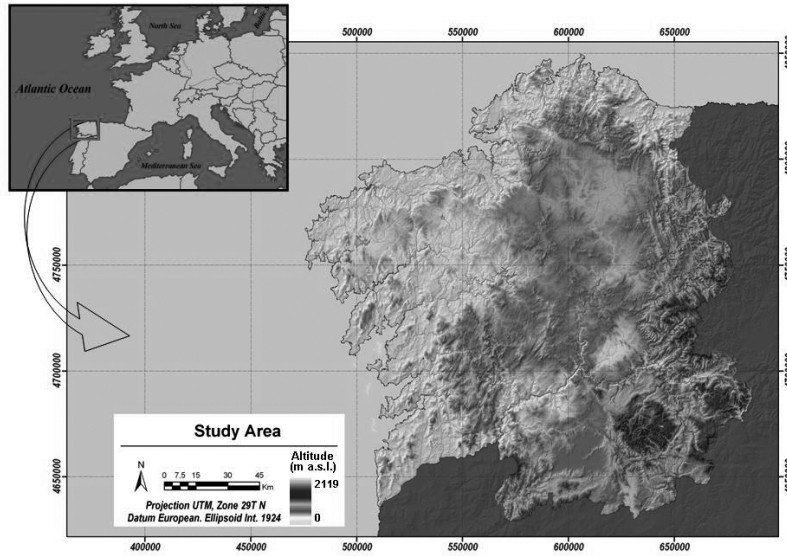
Figure 1: Study area
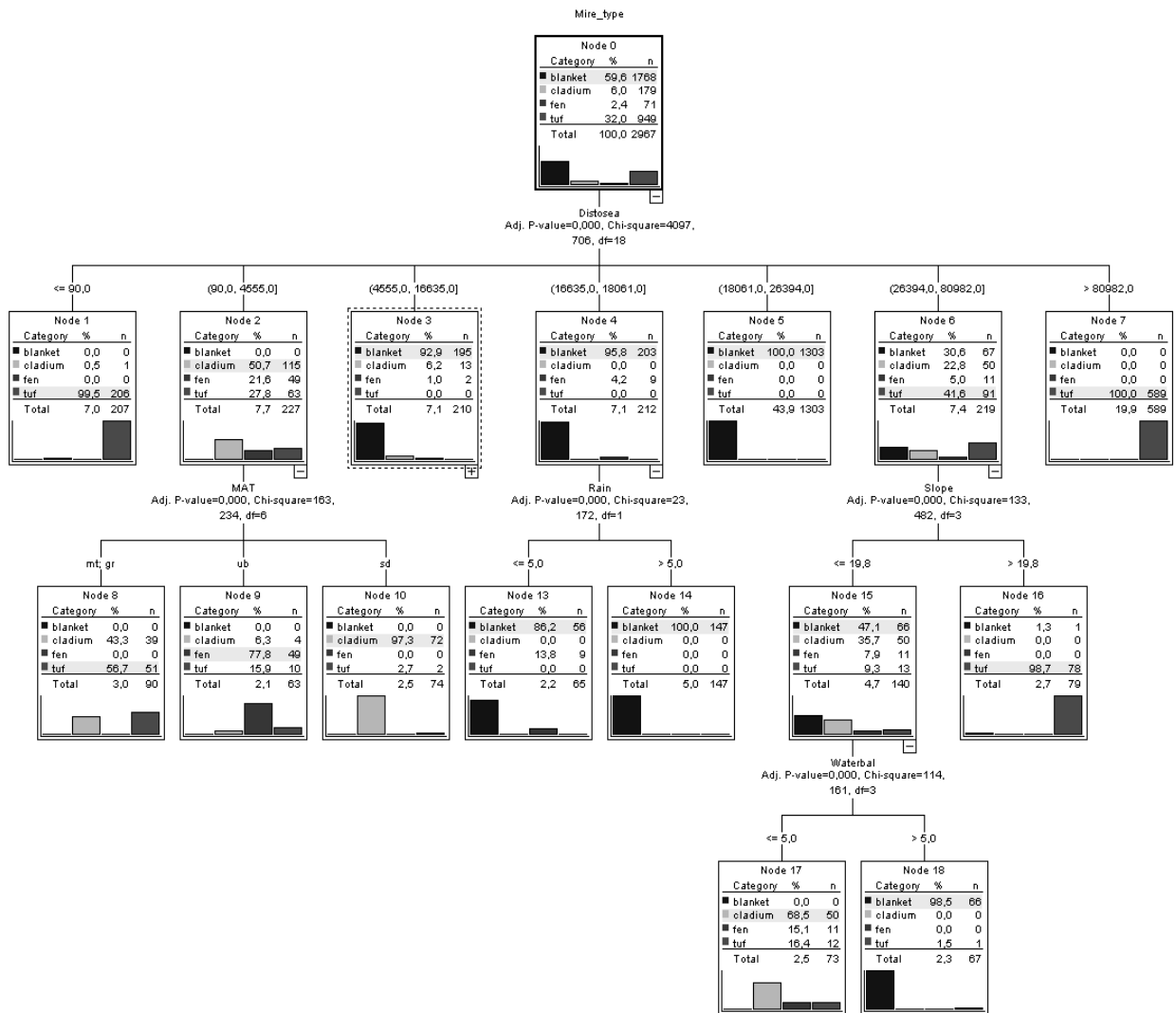
Figure 2: CHAID results

Assessment of conservation status in managed chestnut forest by means of landscape metrics, physiographic parameters and textural features

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Abstract

In this work we aim to model the conservation status of chestnut forests in the NW of Iberian peninsula, assuming the coverage of chestnut and developing state as indicator of forest stands quality. We used as potential predictors features available at wide geographic scales, namely: geographic location, land-cover heterogeneity approached by means of satellite images texture, and landscape metrics. As some of these variables are prone to be influenced by terrain shape, we also introduced topographic parameters derived from Digital Elevation Models in the analyses. Results allowed us to classify chestnut forests in relation to their conservation status and to identify current degradation trends. We expect that the results would serve as a basis for a more indeep research on conservation strategies for Iberian chestnut forests.

Keywords: Chestnut; NW Iberian Peninsula; Landscape metrics; Terrain features; Image texture

1. Introduction

Chestnut forest has been recognised as habitat of interest in the European Natura 2000 network and it was also acknowledged as a characteristic cultural landscape of the Mediterranean and Atlantic regions in Europe. Despite of its environmental and cultural interest it is threatened by pathogen fungi, traditional management abandonment and recent rural landscape change both in the Atlantic and Mediterranean Europe (Cevasco, 2009; Díaz Varela et al. 2009). In fact, its conservation status is regarded as "not favourable" either in the Alpine, Continental and Mediterranean regions, while information is lacking in the Atlantic region, according to the European Topic Centre on Biological Diversity (2008). One of the main threats for the long term conservation of this habitat is the natural evolution of the chestnut stands towards some kind of native forest due to natural succession dynamics or its invasion by alien woodland species.

Taking these threats into account, it is necessary to design simple, repeatable and precise methods for the monitoring and assessment of chestnut forest conservation status at large scale in the European Union in general and in the Atlantic region in particular. In this work we explore the possibilities of automatic and spatially exhaustive assessment of chestnut woodlands conservation status using datasets easily available like remote sensed imagery, forest inventory maps and digital terrain models. We hypothesized that some simple stand variables are reliable

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indicators of the conservation status of chestnut woodlands. Then using statistic methods, we explored the predictor value of several datasets potentially related to forest structure and composition, like patch morphology metrics (Saura and Carballal 2004) or satellite image texture (Kayitakire et al. 2006). As these potential predictor features are prone to be influenced by topography, we also considered terrain attributes in the analysis.

We conducted the study in a sector of NW Iberian Peninsula, an area where good examples of chestnut forest stands with different conservation status occur. In order to provide a dataset with an adequate size to assemble variability in forest stand conditions, we considered an area of approximately 24 448 km^2 corresponding with the land extent of the Landsat TM scene 204-30 (Fig. 1). Altitudes range from sea level to about 2000 m a.s.l. showing a contrasted relief. Biogeographically most of the area is included in the Atlantic Region, but a sector of the SE quadrant of the scene belongs to the Mediterranean region, (European Environmental Agency 2008; Rivas-Martinez and Rivas-Saenz, 2009). Natural vegetation is dominated by different deciduous forest, mostly dominated by *Quercus robur* and *Quercus petraea*, coexisting toward the west with *Betula alba* and *Fagus sylvatica* and interspersed with mixed mesophytic woodland at lower altitudes. Transition to Continental and Mediterranean environments are characterised by *Quercus pyrenaica* forests, while some evergreen or sclerophyllous forest are restricted to the dryer and warmer locations (Rivas-Martínez, 2007). Chestnut forests appear as pure stands or interspersed with different deciduous forests or alien species in the area, being more frequent towards the East.

2. Methodology

Chestnut forest variables were extracted from the Digital Forest Map of Spain at a scale 1:50 000 (Ministerio de Medio Ambiente, 2002). This map is based on digitalisation of forests from satellite images or aerial orthophotographs and supported by fieldwork and ancillary data. Minimum mapable area is 2.5 has for forested area and 6.25 has for other land cover types. The map provides information on tree species composition, overall (in percentage) and per-species (in 10% intervals) canopy coverage, along with other stand variables. We queried the map to extract the chestnut forest patches for the study area. At the effects of the present work and as we are focused on dense forest with a significant share of chestnut in the canopy, we considered patches with minimum crown coverage of tree species of 60 %, a minimum of 20 % of chestnut coverage, and the interval 2 to 4 of stage of stand development for chestnut out of a scale from 1 to 4, resulting a total of 1585 chestnut patches. For each patch we retrieved chestnut canopy coverage in intervals of 10%, coded as a scale variable from 1 (0-10% to 10 (90-100%) along with the stage of stand development. Then we set three classes of chestnut stand quality based on the combination of these two variables (cf. table 1), being class 1 the worst and 3 the best quality. As some of the analysis inputs must be in raster format, we also generated 30 m resolution raster mask of chestnut patches.

A collection of morphometric parameters were extracted from the selected forest patches by means of two different approaches (table 2). The first approach was based on the use six different landscape metrics: patch area (MPS), patch edge (TE), shape index (MSI), perimeter area ratio (MPAR), fractal dimension (MFRACT), and number of shape characteristic points (NSCP). All were calculated using the software V-Late (Lang and Tiede 2003), except for NSCP (Moser et al. 2002). Calculation was made at patch level. We also used the GUIDOS software (Graphical User Interface for the Description of image Objects and their Shapes) initially designed for morphological spatial pattern analysis (MSPA) of forest functional connectivity (Vogt et al., 2009) as an alternative morphometic approach. The output of the MSPA is a raster layer where patch cells are assigned to seven morphological spatial pattern classes: edge, core, perforated, islets, bridge, loop and branch. We ran the software using the default parameters for the computation of MSPA, considering one pixel edge (30 m).

Considering that terrain relief might play a key role in the landscape structure and in vegetation pattern in general (Hoechstetter, et al. 2008) we selected several terrain features that showed their potential as predictors for forest distribution in previous works (Lindenmayer et al. 1999). Terrain features were derived from a raster digital elevation model with a spatial resolution of 30 m. We selected a number of first and second order terrain features widely used in hydrological, geomorphological, and ecological studies (Wilson and Gallant 2000) along with other addressing more specifically vegetation and forest assessment (Mcnab 1989; Roberts and Cooper 1989) as detailed in table 2.

Image texture has shown its potential as predictor for forest stand characteristics (see p.e. Franklin et al., 2001). In order to assess its value as predictor of chestnut stand quality at patch level, we computed eight texture features based on kernel grey level co-occurrence matrices as proposed by Haralick et al., (1973) on a NDVI (greenness index) image, using the software package PCI^{TM} 9.1 (cf. table 2) setting a direction 45°, displacement of one pixel and a window size of 5x5. We used a relatively small size for the kernel as some small or narrow patches are foreseen and to avoid influence from the neighbouring patches.

As terrain relief and texture information are refered at pixel level, we computed mean (MN) and standard deviation (SD) of these features for each patch in order to obtain information at patch level. The final dataset comprises 16 texture variables (MN and SD for the eight texture features), 14 terrain variables (MN and SD for the seven terrain features) and 13 patch morphology variables (six patch landscape metrics along with the percentages of each of the seven typologies of the MPSA analysis for a given forest patch). These 43 variables were analysed by means of a Classification and Regression Tree (CaRT) procedure using the statistical package SPSS^{TM} 16.0. CaRT is a data mining technique pursuing the recursive binary partition of a multivariate space of independent or predictor variables into regions for which the values of the dependent or response (in this case stand quality) variable are approximately equal. In this application, we use the method for exploring the internal structure of the dataset in order to assess the potential of the different variables as chestnut patch quality predictors.

3. Results

Figure 2 shows the results of the CaRT application on the 43 potential predictors, pruned to 3 branch levels. The first significant classification variable was mean terrain slope, with a value of 15° that splits a terminal node corresponding with patches of gently slope assigned mainly (72 %) to the worst class of chestnut stands quality. The second significant classification variable was the mean patch value of GLCM mean (Mean_MN), a variable sensitive to the image tone and texture, that could be interpreted in this case as an indicator of the degree of texture complexity and greenness inside a patch. Values lower that 48 for this variable led to a third level defined by terrain elevation, spitting at a value of approximately 600 m in two branches, one dominated by the lower quality classes corresponding to low altitudes and other dominated by high quality stands, located at higher altitudes. Values of Mean_MN higher that 48 led to another splitting level, where the criterion was patch size. In this case low area patches correspond with good quality stands, while larger patches correspond to stands containing lower chestnut canopy coverage and development (qualities 2 and 3).

4. Conclusions

We assessed the potential discrimination power of different kind of variables and chestnut forest conservation status by means of CaRT data mining. Despite of the relative high degree of impurity in some of the nodes, the method allowed us to recognise some mayor trends of

behaviour of predictors and chestnut forest quality classes. Focusing on high quality stands, they occur mainly on quite steep slopes and also tend to occur at altitudes higher than 600 m showing a relative low textured and low greenness value. This is consistent with the theoretical confinement of the chestnut traditional forest to mountain or marginal areas, where agricultural activity is constrained by the environment, and also indicates that a relative low degree of heterogeneity in the patches might be used as an indicator of well preserved stands. Good quality stands can also occur on more textured (heterogeneous) patches, but in this case corresponding to small plots, fact that could be interpreted as the separation between large heterogeneous forest patches with lower relative chestnut coverage and small plots dominated by chestnut but with some heterogeneity in the stand characteristics.

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Table 1: Criteria for stand quality index. Grey tone indicates canopy coverage and stage of stand development corresponding to each of the chestnut forest quality classes: light grey quality 1; medium grey quality 2 and dark grey quality 3. Cell values indicates number of patches.

		Chestnut canopy coverage								
		2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stage of stand development	**2**	-	5	2	1	1	1	-	-	-
	3	1	56	33	31	40	17	36	5	1
	4	1	345	202	174	149	152	131	151	50

Table 2: Predictors

Variable group	Variable	Acronym	Reference
Landscape pattern	patch area (m^2)	MPS	Lang and Tiede 2003
	patch edge (m)	TE	Lang and Tiede 2003
	shape index	MSI	Lang and Tiede 2003
	perimeter area ratio	MPAR	Lang and Tiede 2003
	fractal dimension	MFRACT	Lang and Tiede 2003
	number of shape characteristic points	NSCP	Moser et al. 2002
	Fraction of Edge	Edge	Vogt et al., 2007, 2009
	Fraction of Core	Core	Vogt et al., 2007, 2009
	Fraction of Perforated	Perforated	Vogt et al., 2007, 2009
	Fraction of Islets	Islets	Vogt et al., 2007, 2009
	Fraction of Bridge	Bridge	Vogt et al., 2007, 2009
	Fraction of Loop	Loop	Vogt et al., 2007, 2009
	Fraction of Branch	Branch	Vogt et al., 2007, 2009
Terrain	Elevation (m a.s.l.)	DEM	Wilson and Gallant 2000
	Curvature	Curv	Wilson and Gallant 2000
	Plan curvature	Plancurv	Wilson and Gallant 2000
	Profile curvature	Profcurv	Wilson and Gallant 2000
	Slope (degrees)	Slope	Wilson and Gallant 2000
	Transformed aspect	TRASP	Roberts and Cooper 1989
	Terrain shape index	Tershp	McNab 1989
Image texture	Contrast	Contr	Harlick 1973
	Correlation	Corr	Harlick 1973
	Dissimilarity	Dissim	Harlick 1973
	Entropy	Entrop	Harlick 1973
	Homogeneity	Homog	Harlick 1973
	Mean	Mean	Harlick 1973
	Second Moment	Sec_mom	Harlick 1973
	Variance	Stand_de	Harlick 1973
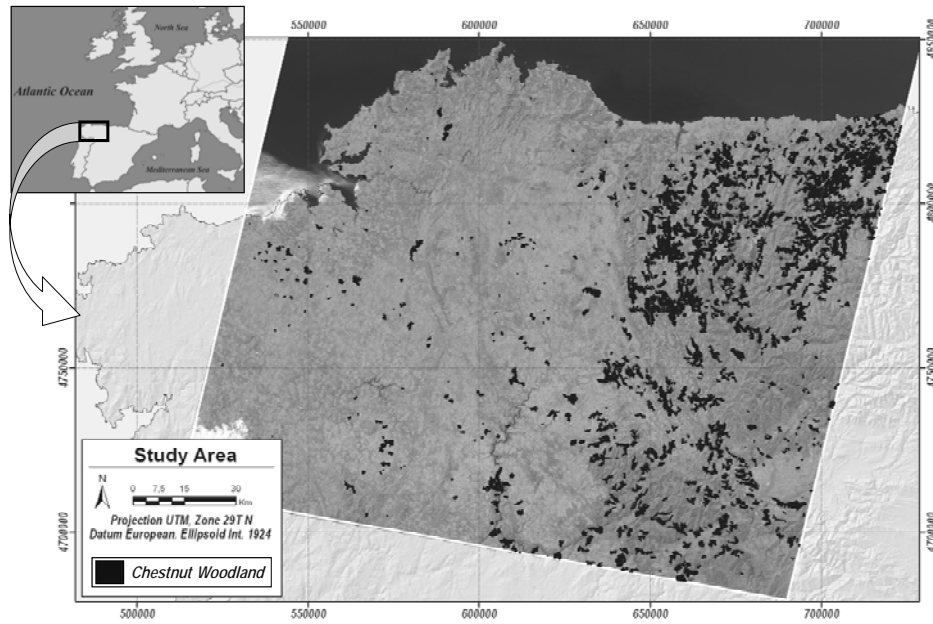
Figure 1: Study area
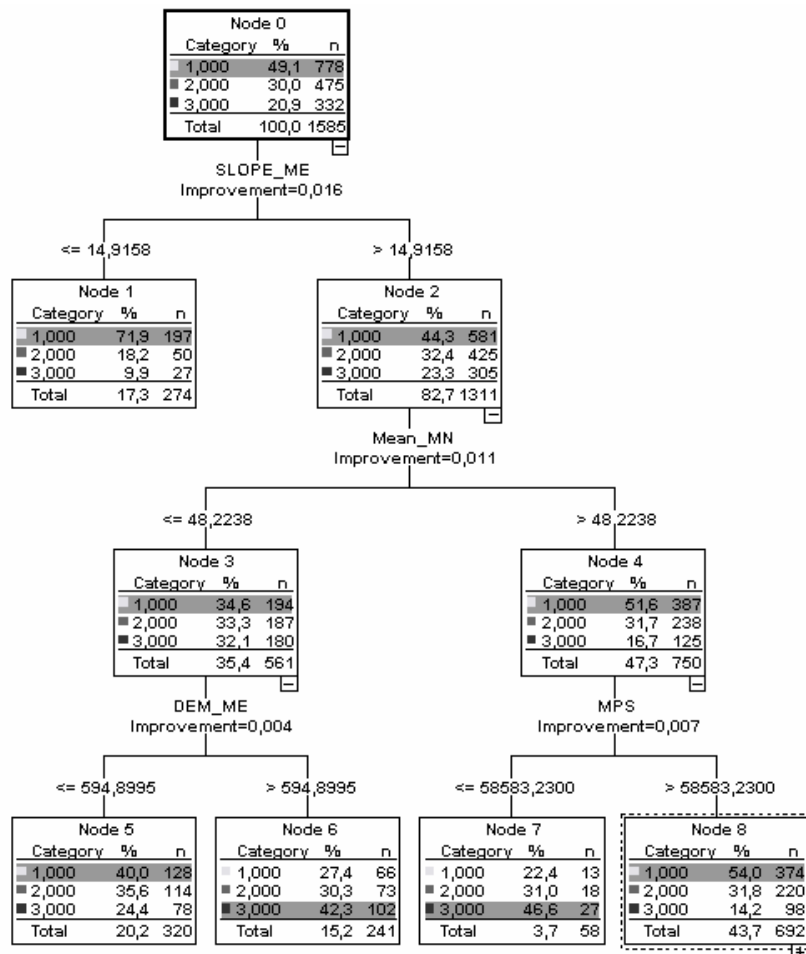
Figure 2: CART results

GIS analysis of the Antidote Programme in Portugal

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Abstract

The aim of this research was to analyse the huge number of animal poisoning occurrences in Portugal and to establish a relationship between poisoning, land use, land cover and human activity.

It was used a large database, belonging to the programme Antidote Portugal in order to create a GIS. This database records all occurrences attributes, such as, the location of dead animals, the number of affected individuals, the species that belong and their location.

Two approaches were made, one based on poisoning occurrences and one base on number of dead animal per occurrence, in order to calculate hazard maps. Both approaches were based on multivariate analysis and geostatistical processes.

According to the results, agro-forested areas are those were the most cases occur. A special reference must be made to the Protected Areas and the Natural Park of Southwest Alentejo and Costa Vicentina, were token place few cases but very deadly.

Keywords: Principal Component Analysis, Geostatistic, Hazard Poisoning, Programme Antidote Portugal, GIS

1. Introduction

The Portuguese Antidote Programme (PAP) was created in January the 12th, 2003 with the aim of evaluating the effects of the use of poisons on wildlife populations and to establish measures to control this problem (Brandão 2003). It is a platform based on the Spanish Antidote Programme (SAP), which began in 1997 due to growing concern about the illegal use of poisons and other toxic substances posing a threat to wildlife conservation (FCQ 2009). The PAP's aims is to establish a cooperation protocol between different organizations, public and private entities, and to developed policies in order to gather all the scattered information and establish mechanisms for its concentration and a complete study (Brandao 2003).

The first use of poison is reported to the nineteenth century, leading some drastic declines or extinction of some wildlife populations, especially the Iberian Wolf (*Canis lupus*) and carrion birds. In agro forested areas and natural areas, poisons area used for various reasons, mainly as an attempt to control predators of game animals and livestock. These actions are carried out by hunters and hunting areas managers, and have as target species and feral dogs, wolves and mammals of small and medium businesses. This is the most accessible and successful method because of the easiness of which it can be applied and the number of individuals that can be eliminated under a low level of effort for anyone who applies. Almost all historical references

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refer the use of strychnine. This poison is often used in horse carcasses, viscera of ruminants and dogs, and chicken gizzards, thus attracting not only species such as wolves, but also carrion birds (Brandão, 2004).

National Association for Nature Conservation (Quercus - Associação Nacional de Conservação da Natureza) is the organisation which supports the project, as been developing a database of all occurrences recorded since 1992 until now. This database records: place where the animal was found, who found it, the species, the cause of death, etc. This important database has hundreds of records, and an enormous potential for a Geographical Information System (GIS) creation (Diogo 2009).

The original aim, of the present research, was to create a GIS, which ultimately aim was to produce maps of the main risk of poisoning for the entire Portuguese country (see Figure 1, Portuguese island not included).

To achieve those aims, it was necessary to stablish a relationship between the poisoning episodes, environmental characteristics and the human activity. Thus, they were used GIS techniques, such as 3D Analyst, Spatial Analyst and Geostatistical Analysis were used in ity (Morrison, 1991; Reis, 1997; Hoef et al, 2001; Clemente *et al.* 2002; Blanquer *et al.* 2005; Soares 2006; Abdi & Nandipati 2009).
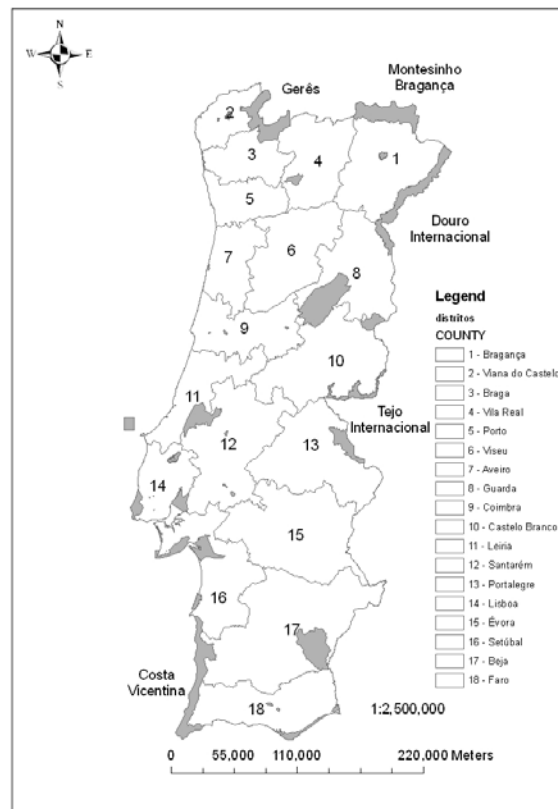
Figure 1: Study area location [Adapted from Portuguese Environment Atlas 2009]

2. Methodology

Using the Quercus database for Portuguese Antidote Programme (PAP), all recorded information was used in order to create a geographic information system (GIS).

In a second stage, the GIS was updated with information concerning:

- Land use and land cover map
- Settlements Location
- Portuguese Roads network
- Digital Elevation Model

In the third stage, 3D Analyst and Spatial Analyst Tools, were used in order to process information and to calculate:

- Land slope and aspect
- Distances to water bodies
- Distance to road network
- Distance to settlements

Then, Principal Components Analysis, Cluster Analisys and Geostatistical Analysis were used in order to stablish a relationship between the poisoning episodes, environmental characteristics and the human activity (Morrison, 1991; Reis, 1997; Hoef et al, 2001; Soares 2006).

In a fourth stage, previous present data were submited to geostatistical calculation, in order to create poisoning hazard maps for the entire Portuguese country (islands not included).

3. Results

The results showed a greater number of episodes (274) and poisoned individuals (781) were located in Agriculture Areas, which corresponds to an average of 2.85 dead animals per poisoning episode. The Artificial Territories (e.g. industrial areas) and Forested and Semi-natural Areas presented similar values for the number of dead animals (331 and 371 respectively), but significant differences for the number of episodes, 104 over 79 respectively. Thus, the rate of poisoned individuals per poisoning episode is higher for Forested and Semi-natural Areas (4.70) then for Artificial Territories (3.18). Classes "Wetlands" and "Water Bodies" do not present any type of episode.

These results enable to state that the Agriculture Areas are those with higher probability to observe poisoning episodes but under small ratio of dead animals per episode (2.85). In the opposite, Forested and Semi-natural Areas are those with lower probability to observe a poisoning episode but under high ratio of dead animals per episode (4.70).

4. Discussion

Wild species.
In "Artificialized Areas", the most affected wild species are the *Miliaria calandra* with 6 poisoned animals (16.67%), followed by *Gyps fulvus* and *Streptopelia turtur* both with 5 poisoned animals (13.89% each) and the *Ciconia ciconia* with 4 dead animals (11.11%). The remaining 12 cases were attributed to other 12 species.

In "Agricultural Areas", the *Gyps fulvus* was the species that accounts for a greater number of poisoned animals (69) with nearly 44.52% of the cases, followed by the *Canis lupus* with 17 cases (10.97%) and *Ciconia ciconia* 16 cases. Although the *Milvus milvus* presented a smaller number of poisoned animals (14 - 9.03%), this is quite worrying, especially when considering that Portugal only has 50 to 100 breeding pairs (Cabral et al. 2006).

In class "Forested and Semi-natural Areas", *Canis lupus* was the species most affected, with 29.73% of the deaths, followed by *Aegypius monachus* with 6 poisoned animals (16.22%) and the species *Gyps fulvus* and *Buteo buteo* both with 5 dead animals (13.51% each). The

remaining 4 episodes of poisoning have been attributed to *Aquila chrysaetos*, *Ciconia ciconia*, *Milvus milvus*, and *Milvus migrans*.

Game hunting species.

In the class "Artificial Areas", *Vulpes vulpes* was the species clearly more affected in poisoning episodes, with 14 dead animals (87.50%), followed by *Pica pica* and *Herpestes ichneumon* with 6.25% of the cases each.

In class "Agricultural Areas," the *Vulpes vulpes* was, again, the species with the highest number of dead animals (71 or 85.54% of total), followed by *Corvus corone* and *Pica pica* with 6 and 4 dead animals, respectively.

In class "Forested and Semi-natural Areas", the *Vulpes vulpes* remains the species most affected (21 to 85.54%) followed by *Herpestes ichneumon* with 1 dead animal.

Home Species.

In "Artificial Areas", the *Canis lupus familiaris* was the species most affected with 234 (83.87%) poisoned animals, followed by *Columba livea* with 9.32% (26 individuals) and by *Felis silvestris catus* with 19 dead animals (6.81%) and

In the "Agricultural Areas" the *Canis lupus familiaris* was, again, the species with the highest number of dead animals (495 - 90%). The *Columba livea* was the second most affected species (25 individuals), followed by the *Felis silvestris catus* with 18 cases. There is also the death of 4 *Ovis aries*, which corresponds to a percentage lower than 1% of the total.

In "Forested and Semi-natural Areas", only *Canis lupus familiaris* (308 to 98.72%) and *Felis silvestris catus* (4) dead animals were noticed.

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Investigation on species diversity by inventory in Caspian Forests (Case study: Gorazbon District- Noshahr, Iran)

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Abstract

Species diversity is an index for forest ecosystems and is an important matter in plant cover ecology. In this study after %100 inventory in Gorazbon district (Kheyrud Forest) and establishment of forest type, biodiversity indexes were applied. The results illustrated that the highest level of the plant species richness, diversity and evenness indexes belonged to *Carpinus-Alnus* type with *Acer sp*. and the least level of the plant species richness belonged to *Fagus* and *Fagus-Carpinus* type. The least level of diversity and evenness belonged to *Fagus* and *Carpinus-Quercus*. The results show that sampling is suitable for biodiversity evaluation too.

Keywords: Kheyrud Forest, diversity, species richness and evenness, Noshahr, Iran

Introduction

Hyrcanus forests with special genetic diversity as number of wooden species and plant communities is very rich and have different forest communities (Asadollahi, 2000). The studies of biodiversity indicators in Hyrcanus forests for investigation on species diversity and exact recognize and function of management plan is very necessary.

Moderate regions forests have the main role in biodiversity conservation. Wooden species are the major matters in the forest ecosystems that have most traces on the other beings life, as decrease of species diversity can lead weakness other beings.

In biodiversity study, many experts work on it and show many formula, such as Sympson biodiversity indicator in 1949, Manhinic richness indicator in 1964.

The purpose of this study is determination of species diversity in North forests of Iran with 100% inventory as sustainable management of stands under utilization. The results can investigate status of wooden species as number and abundance.

Eshagh Nimvari and et al., (2006), for studying of biodiversity in Fagetum community, Carpino-fagetum and Querco-carpinetum in Namkhane and Gorazbon district (Noshahr), richness, species diversity and Evenness indicators were measured. The results show that the most richness, diversity and Evenness were in Querco-carpinetum and the least was in Fagetum community. Species diversity in mixed communities was more than pure communities.

Hauk (2005), richness and species diversity were studied in Austrian forests and the results showed that richness and species diversity in the whole broadleaf communities except Fagetum was more than conifers. Quercus communities had the most richness , Picea and Fagus communities had the least.

Porbabaee (2000), diversity in Fagus habitats in Gilan province is studied and shows that in Fagus communities because of prevailing of Fagus population to another species, species diversity is very low is this community.

Porbabaee (1999), richness, diversity and evenness indicator were studied in forests of Gilan province, and the results show that the least diversity indicator was in Fagus habitats.

Materials and methods

Study area

Kheyrud educational and investigational forest is located in eastern of Noshahr in North of Iran. This forest has 8 districts that located in different latitude.

We selected Gorazbon district as 100% inventory was done in this district in the past.

Study method

Sampling

For the first time in autumn of 2007, 100% inventory as execution of selection method of silviculture in Gorazbon district was suggested and done. In this inventory method the whole of trees (up than 7.5 cm in diameter) were measured. In this method the number of trees and shrubs in each diameter class and in each parsel was numbered. With the number of trees in parsels, the typology map was applied.

Research method

For investigation of biodiversity indicators, we must know about type and number of wooden species that as taken with 100% inventory forms that was done for the entire of forest.

For investigation of biodiversity, there are many indicators but we use of common indicators for calculation of species diversity. After extraction of data of inventory forms, 8 types in Gorazbon district were defined. In these types with formulas, Shannon Wiener and Sympson diversity indicators and Sympson Evenness indicators was calculated.

For calculation of these species diversity indicators, Ecological methodology software was used. For drawing of graphs Excel software was used too.

Results

The results show that the most richness is in Carpinus- fagus with Alnus type and Carpinus- Alnus with Acer. The least of richness is in Fagus and Fagus- Carpinus type (figure 1).

Shanon and sympson species diversity indicators is the most in Carpinus- Alnus with Acer and the least in Fagus type (Figure 2, 3).

Sympson Evenness indicator is the most in Carpinus - Alnus with Acer type, and show that frequency of species in this type is evenness. This indicator in Fagus type and Carpinus – Quercus is the least (Figure 4).

Conclusion

In recent years, biodiversity and climate change are tow subjects that are the major cases in environment circles. The condition of universe biodiversity is very critical that one of the tow environments intricate in the universe is biodiversity (Majnonian, 1996).

In a forest, study of stand structure can has the key role in biodiversity indicator description (Franklin, 1993).

As we saw in this study biodiversity indicators: richness, evenness and species diversity was the most in Carpinus - Alnus with Acer type that it was the same to the Eshagh Nimvari (2006) research.

Statistics results showed that Fagus and Fagus- Carpinus types had the least richness indicators that the same to the results of Hauk (2005) and porbabaee (1999 & 2000).

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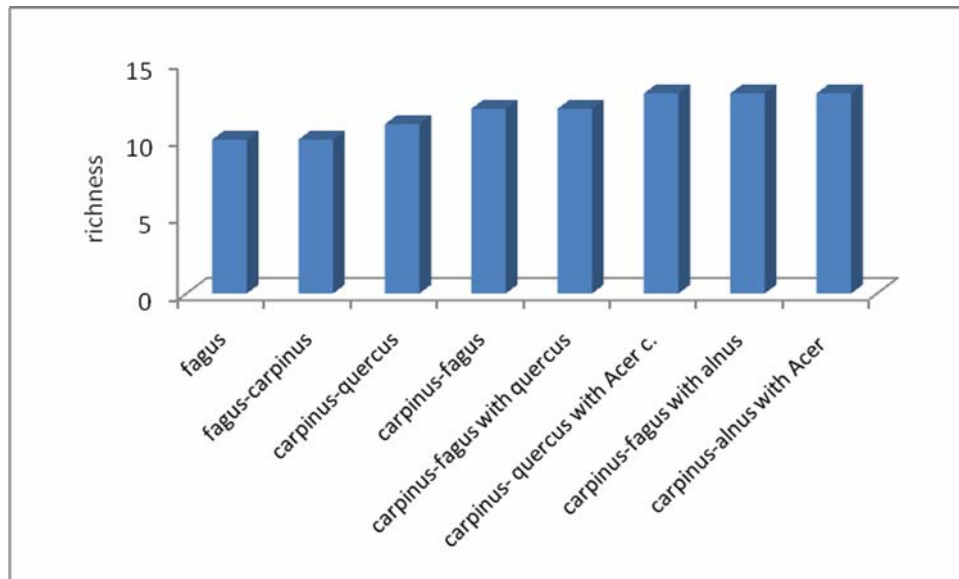
Figure 1: richness indicator in different types
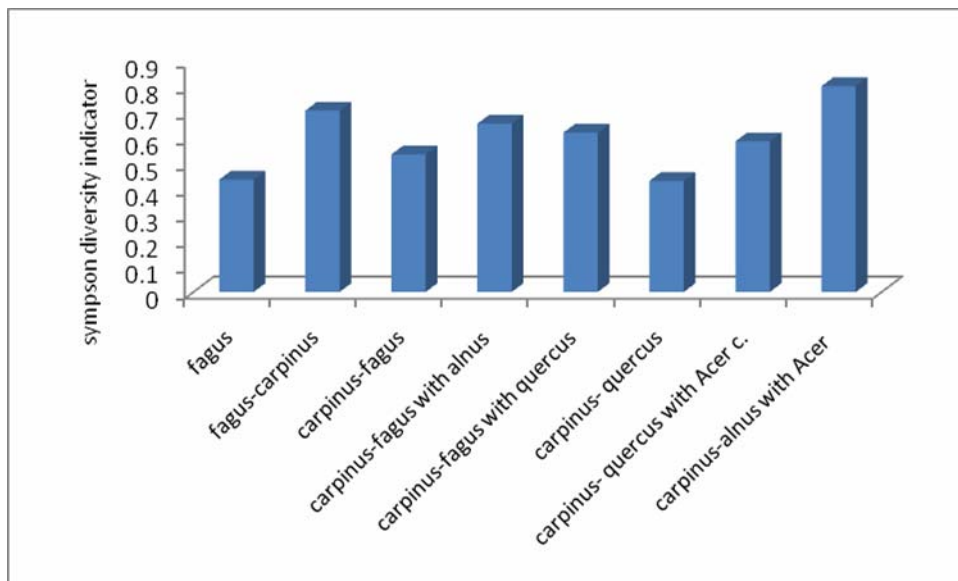
Figure 2: sympson diversity indicator in different types
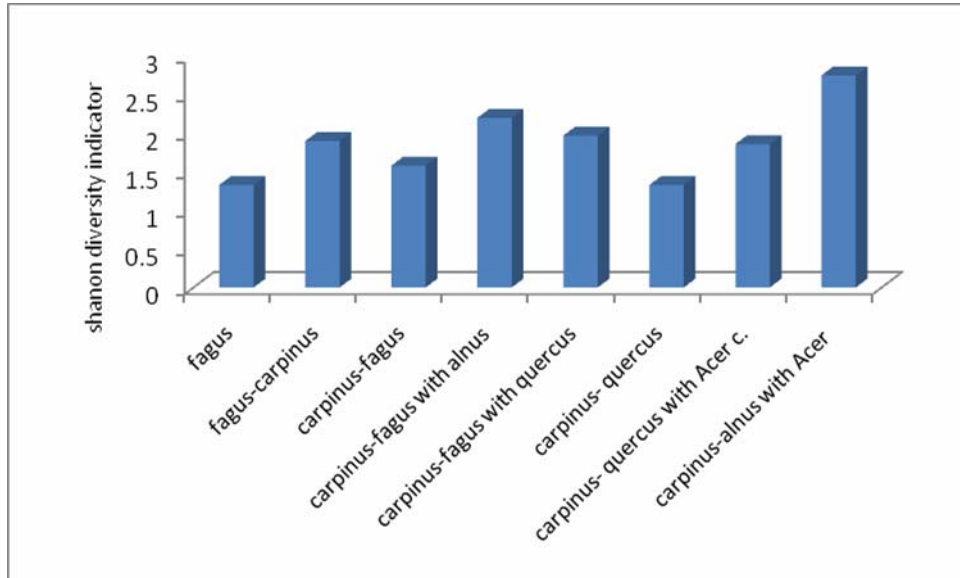
Figure 3: shanon diversity indicator in different types
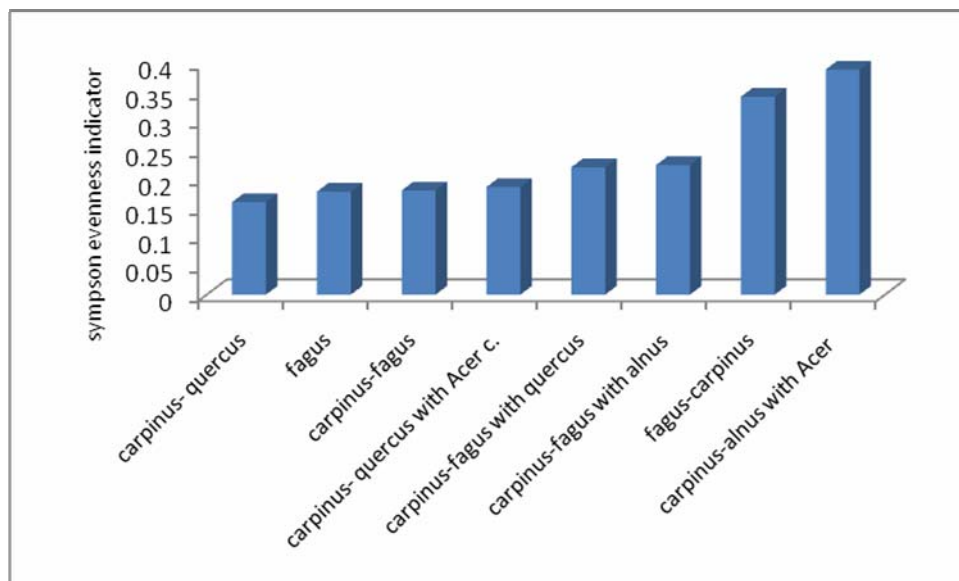
Figure 4: sympson evenness indicator in different types

The impact of the matrix on species movement: systematic review and meta-analysis

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Abstract

An increasing number of studies have demonstrated an impact of matrix structure on species movement. However, the strength of these effects are variable, with no general indications of which kinds of matrix might be more permeable. In this study we test four possible reasons for the variability in outcomes from 19 different studies on a range of animal taxa. In particular, we test whether matrix that is more similar in vertical structure to the 'home' habitat increases individual movement.

Patch emigration rates were extracted from studies where controlled comparisons or 'choice' experiments compared the impact of different matrix types on emigration rates.

Matrix types that have a more similar vertical structure to the 'home' habitat were associated with increased emigration rates. The planning of forests will need to account for ways of achieving permeable matrix for both forest species moving across cleared areas and open ground species passing through forests.

Keywords. matrix structure, emigration, patch, connectivity

1. Introduction

It is now widely established that the matrix, i.e. the intervening land cover between patches of habitat, can have a significant impact on species movement (Debinski, 2006; Franklin & Lindenmayer, 2009; Ricketts, 2001). Ecological network modelling techniques are developing rapidly to meet the challenge of incorporating matrix impacts (Saura & Pascual-Hortal, 2007). Such models are currently a key part in the development of some adaptation strategies to help species move in response to climate change (Hopkins et al., 2007, p.18). What is less clear, however, is how to account for the matrix in multi-species ecological networks. The data are limited by taxonomic coverage and by spatial and temporal scale. To the best of the authors' knowledge, there are two quantitative analyses of how the matrix affects the abundance of different taxa (Prugh et al., 2008; Prevedello & Vieira, 2010) but no analyses of movement.

In this paper we apply systematic review and meta-analysis to this problem. We examine the impacts of matrix structure and experimental designs on the outcomes of the different studies.

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2. Methodology

2.1 Data search

We used a systematic review technique that was originally developed for conservation and environmental management from the medical evidence review model (Pullin & Stewart, 2006). Systematic review strives to minimise error and bias through an exhaustive search of peer-reviewed journal publications, grey literature and unpublished research findings.

Full details of the systematic review methodology and search terms can be found atwww.environmentalevidence.org/SR43.html. In summary, we aimed to select all articles (including grey literature and web-published data) that presented original, empirical data on measured emigration rates from habitat patches where two or more matrix types were directly compared in a controlled experiment or through a single survey. We excluded studies which measured emigration indirectly, for example by distribution patterns, or where the patches were too small to support a single individual (e.g. Castellon & Sieving, 2006). We also were unable to include those papers from which raw emigration rates could not be extracted and the authors of which did not respond to our request for the original data.

2.2 Data synthesis

Matrix types were classified as 'more favourable' or 'less favourable'. This was decided using the classification by the author of each study. In all but one case, the matrix type that was assumed to be more favourable was that most structurally similar to the habitat patch, the exception (Goodwin & Fahrig, 2002) being more ambiguous.

In order to combine the outcomes of different studies, all the data were converted to a single measure that describes the magnitude of the effect of the study treatment. In this case the 'treatment' is the matrix type. We used risk ratios as the measure of the size of the effect. The risk ratio is the multiplication of the risk that occurs in a 'treated' group relative to a control group. In this case, the 'treatment' was the more similar matrix and the 'control' the less similar matrix. If the chance of movement is reduced by a more favourable matrix, the risk ratio will be less than one; if it increases the chance of individual movement, the risk ratio will be greater than one.

'Number needed to treat' (NNT) can more intuitively illustrate the effect of a 'treatment'. NNT is defined as the expected number of individuals who need to receive the experimental 'treatment' (the permeable matrix) rather than the control (the less permeable matrix) in order for one additional individual to either incur (or avoid) an event in a given time frame.

The risk ratio was calculated individually for each homogeneous subgroup in a study, e.g. 'all the tests performed on species x over a distance of 250 m'. Calculated risk ratios were pooled across studies to generate an overall weighted average risk ratio within a random effects model (DerSimonian & Laird, 1986). The estimate of heterogeneity (variation in risk among studies) was taken from the Mantel-Haenszel model.

2.3 Covariate analysis

We looked at the impact of five different factors on the study risk ratio: distance, duration, contrast, choice and taxon. Distance and duration were investigated using meta-regression. Contrast, choice and taxon were investigated using subgroup analysis, where the meta-analysis

is repeated on just one group of data, e.g. all the birds, to see if there is a difference in mean effect size to the complete analysis.

A 'contrast' covariate was generated to define whether the two matrix features being compared were structurally different. Matrix type was split into four different categories: wooded, grass or arable, bare or 'made ground' (e.g. concrete), and water. The 'contrast' was zero if both matrix features were from the same groups and one if they came from different groups.

The 'choice' subgroup analysis was determined by the experimental design. Some data were based on comparisons of emigration from different patches set in different matrix types. 'Choice' was coded zero for these types of experimental design. When the design involved a comparison of emigration rates through two different matrix types adjacent to different parts of the edge of the same patch, 'choice' was coded one.

3. Result

We found 19 studies that met our criteria, all of which were animal species across a range of phyla (birds, fish, insects and rodents). Two of these studies were on forest species – both birds (St. Clair 2003, Desrochers & Hannon 1997). From those 19 studies we extracted 107 data points that met the homogeneous subgroup criteria. The pooled risk ratio over all studies was significantly greater than one and the lower 95% confidence intervals was not less than one (RR = 1.32, 95% CI 1.20 to 1.45, p<0.001; Figure 1). This suggests that, at least for the animal species that were considered, matrix that is structurally more similar to the home habitat will increase emigration rates.

Matrix comparisons with greater contrast in vertical structure had significantly higher effect sizes (meta-regression coefficient 0.61, z = 2.58, n = 107, p < 0.010). Choice experiments showed a greater effect of matrix type on emigration rates than patch comparison experiments (meta-regression coefficient 0.76, z = 4.83, n = 107, p < 0.001). Experiments with a longer duration showed a slightly stronger impact of matrix type on patch emigration rates (meta-regression coefficient 0.006, z = 3.19, n = 107, p < 0.001). The durations ranged from ten minutes to 138 days. Greater distance between source patch and measurement location did not significantly affect the effect of matrix type on patch emigration, despite a wide range of distances from <1 m to 700 m (meta-regression coefficient -0.0006, z = -1.08, n = 107, p < 0.281).

The calculation of NNT indicated that 15 individuals emigrated from patches through structurally similar matrix for every 14 animals that emigrated from habitat patches through less structurally similar matrix.

4. Discussion

This study further strengthens the evidence that matrix structure impacts on species movement. This outcome would seem to lend support to the way in which many ecological networks have been defined. The size of this effect is small, however, as demonstrated by the estimated NNT. It is important to remember that emigration rate is only one of a large number of factors that regulate population persistence and species range boundaries. We have not shown that permeable matrix features increase regional population persistence. Evidence gaps remain particularly for larger spatial and temporal scales and less mobile species. The impact of correlation between covariates should also be further explored.

The analysis suggests that permeability is, for many species, related to the structural complexity of the matrix. It is possible that organisms are adapted to move through structurally similar habitat types. This could be due to locomotive adaptation or for predator avoidance as species may avoid different matrix types because they are more conspicuous. This effect was not wholly consistent across all studies and risk ratios below one were found in a number of cases. Some species may prefer to move through a matrix type structurally dissimilar to their home habitat for a range of reasons, for example features could be used as visual cues or cover from predators.

While the high heterogeneity and correlation of the covariates means further inferences from the results remain speculative. However, the contrast subgroup analysis may suggest that, in order to encourage a greater number of individuals to move out of their habitat patch, the matrix may need to be radically altered to become much more similar to the focal patch habitat structure. The implication of this would be that a large conservation investment may be necessary to have a significant effect on connectivity. The 'choice' subgroup analysis may suggest that adding a permeable route out of a patch is enough to encourage emigration, rather than needing to surround the patch entirely within a permeable matrix. Routes out of a patch would still need to be wide enough to provide the matrix required without edge impacts and also not lead to lethal cul-de-sacs (Simberloff et al., 1998).

This review suggests that planning for ecological networks can be generalised to support groups of species by providing routes through the matrix of similar vegetation structure to their habitat. Not enough studies were on forest species to compare forest to open-habitat species. In the majority of densely inhabited regions, altered for hundreds of years by agricultural activity, fully functional landscapes need to include habitat networks which include permeable elements for both forest and open ground species.
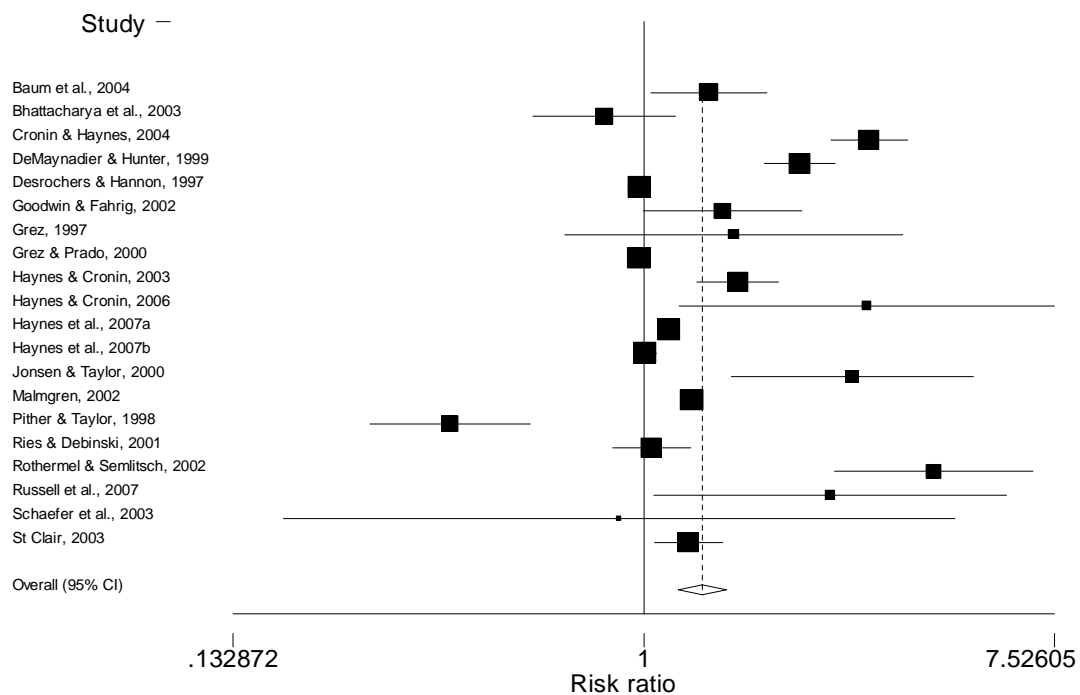
Figure 1: Mean risk ratios from each study. The vertical dashed line represents the mean risk ratio.

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Eight years of development of a silvopastoral system: effects on floristic diversity

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Abstract

Biodiversity is an important issue to promote agricultural sustainability, and usually depends on vegetation management. One of the main reasons to maintain biodiversity is to enhance productivity in extensive systems, due to the best complementarity between different species to use soil resources. The objective of this study was to evaluate the effect of two different tree species, an exotic (*Pinus radiata* D. Don) and a native (*Betula alba* L.) established at two densities (833 and 2500 tree ha^{-1}) and three types of fertilization (no fertilization, dairy sewage sludge fertilization and mineral fertilization) on component, species richness and abundance eight years later. The results showed an important reduction in species richness in the systems established at high density under pine tree compared with birch fertilised with mineral or without fertilisation. Shannon index was reduced when fertilization was applied under birch at high density, mostly with dairy sludge, compared with no fertilisation. No effects on plant diversity was detected when tree density was 833 trees ha^{-1}.

Keywords: pine, birch, species richness, Shannon index, fertilisation

1. Introduction

In the Northern Spain, where the study was carried out, important changes have occurred in rural land use in the last decades. The traditional landscape, a heterogeneous mosaic of pastures and native deciduous forests has been gradually substituted by plantations characterized by the presence of a unique forest tree species (*Eucaliptus* spp and *Pinus* spp.). The lack of subsequent management of these plantations has resulted in excessive FCC and very high tree densities that hamper an adequate forest development. Silvopastoral systems may be a viable means to promote multipurpose forest land use and obtain income from newly afforested. Areas managed for silvopastoralism can reduce fire and erosion risk in forests (Rigueiro-Rodríguez et al. 2005), and can enhance biodiversity and contribute to the preservation of many endangered species that depend on ecotones between woodlands and open landscapes (Rois-Díaz et al. 2006). However, these land use changes can cause important modifications to microclimatic conditions (soil, interior temperature of the system...) and this can affect biodiversity in the short and medium term. On the other hand, studies carried out in NW Spain have shown that fertilisation enhances pasture production as well as tree growth in a silvopastoral systems established in very acidic soils (López-Díaz et al. 2007), but reduces both in neutral soils (Mosquera-Losada et al. 2006) but, it is important to study how this fertilisation affects to vascular plant biodiversity on a short time. This study aims to evaluate the effect of *Pinus radiata* D. Don and *Betula alba* L. established at two density with different soil fertilisation treatments on alpha biodiversity over eight years.

2. Methodology

2.1 Characteristics of the study site

The experiment was established in Lugo (Galicia, NW Spain) at 439 meters above sea level. The zone in which the study was carried out is located in the Atlantic Biogeographic Region of Europe (EEA 2010). The experiment was developed from 1995 to 2003 over a soil classified as Umbrisol (FAO 1998), with a sandy-silty texture (61% sand, 34% silt and 5% clay) that was previously used for agricultural purposes (cultivation of potatoes). The initial water pH (1:2.5) was close to neutrality (6.8), indicating an optimum availability of nutrients for plants (Porta *et al.*, 2003).

2.2. Experimental design

The experimental design was a completely randomized block with three replicates. In 1995, a plantation of *Pinus radiata* D. Don (from container plants) and *Betula alba* L. (from bare root) were established at 2,500 and 833 trees ha^{-1}. Each experimental unit consisted of a rectangle square of 5×5 trees with an area of 64 and 192 m^2, respectively. At the end of the winter of 1995, after ploughing, the plots were sown with a mixture of 25 kg ha^{-1} of *Dactylis glomerata* L. var. Saborto, 4 kg ha^{-1} of *Trifolium repens* L. var. Ladino and 1 kg ha^{-1} of *Trifolium pratense* L. var. Marino. Two types of fertilisation were applied: *mineral fertilisation* (M) every year throughout the experiment following a standard procedure for the region: 500 kg ha^{-1} of 8:24:16 (N:P$_2$O$_5$:K$_2$O) fertiliser complex in March and 40 kg of N (calcium ammonium nitrate 26% N) ha^{-1} in May, and *fertilisation with dairy sludge* (D) in the first year (1995) at 154 m^3 ha^{-1}, i.e. 160 kg of total N, 85.9 kg of total P$_2$O$_5$ and 23.4 kg of total K$_2$O ha^{-1}, with values determined based on total N of sludge. In the two years following (1996 and 1997), the plots to which the sludge was applied were not fertilised, but they were fertilised again from 1998 until the conclusion of the study (2003), using the same fertilisers and doses as for M. One control treatment was also included in the comparison: *no fertilizer* (NF). A low pruning (at 2-m high) was performed on pine at the end of 2001 and the birch was given a formational pruning with the objective of producing quality timber. In this paper, we show the results obtained eight years after establishment (2003).

2.3 Field samplings

Pasture was harvested in July and December under pine at high density and on June, July and December on the other systems. At each harvest in each experimental unit, the entire surface area of the nine trees in the centre of the plot delimited by six trees was cleared, the fresh forage was weighed *in situ*, and a representative subsample was taken to the laboratory. In the laboratory, the species of 100 g subsamples from each plot were hand-separated to determine botanical composition. The different species were separately weighed to determine dry weight (48 h at 60 ºC) and their relative percentage proportion (taking into account the four harvests of the year) was calculated. The relative abundance of each species was obtained and abundance diagrams were produced, ordering the species from most to least abundance (Magurran 2004). Species richness (SR) (Magurran 2004) and Shannon–Wiener index (H´) (Shannon and Weaver 1949) were also determinated.

2.4 Statistical analyses

The results obtained were analysed with ANOVA following the model: $Y_{ijk} = \mu + F_i + Sp_j + B_k + \varepsilon_{ijk}$, where Y_{ijk} is the studied variable; μ the variable mean; F_i: fertilisation; Sp_j: tree species; B_k:

the block; and ε_{ijk} is the error. The LSD test was used for subsequent pairwise comparisons ($P <$ *0.05*; α= *0.05*). The statistical software package SAS (2001) was used for all analyses.

3. Results

26 species were found eight years after establishment, belonging to 9 different families. Eight species belonged to the family Asteraceae (31%), 7 to the Poaceae (27%), 3 to the Leguminosae, 2 to the Geraniaceae, 2 to the Polygonaceae, leaving just one representative for each of the families Caryophyllaceae, Umbelliferae, Plantaginaceae and Rosaceae (see Figure 1). Of these, 54% are perennial species, 42% are annual species and 4% are biannual. The total number of species (SR) under pine was 2, 5 and 1 at 2,500 trees ha^{-1} and 6, 12 and 13 at 833 trees ha^{-1} for the treatments D, M and NF, respectively. Under birch, SR was 5, 10 and 17 and 8, 8 and 14 at high and low density and D, M and NF treatments, respectively. *Dactylis glomerata* was the most abundant species in all treatments evaluated; Dactylis species was above 70% under pine and 50% under birch, independently of density. *Holcus lanatus* L. and *Agrostis capillaris* L. appeared also in all treatments, with the exception of those systems established with pine at high density and fertiliser with dairy sludge (D) and no fertiliser (NF). On the contrary, there were species, all annuals, that were only associated to certain treatments e.g *Erodium moschatum* (L.) L´Hér and *Lolium multiflorum* Lam under pine at low density or *Bromus diandrus* Roth, *Chamaemelum mixtum* L., *Conyza canadensis* L., *Cerastium glomeratum* Thuill and *Sonchus oleraceus* L. that were cited only under birch systems (the first three at high density and the last at low density). Finally, Shannon index (H´) was reduced when fertilization was applied under birch at high density, mostly with dairy sludge (D), compared with control (NF) No effects of tree species or fertilization on plant diversity was detected when tree density was 833 trees ha^{-1}.

4. Discussion

It is generally assumed that even-aged forest plantations are negative from the viewpoint of biodiversity conservation because, they are characterized by loss of horizontal and vertical heterogeneity, fundamental components of forest biodiversity (Marcos et al 2007). Our results show that this is true only, if at the moment of establishment of the system, the choice of tree cover and tree density are not adequate. In the year of establishment (1995), when the development of canopy was small and the understory environmental conditions were quite similar between both tree systems, SR was very similar between them (23 and 20 species under high and lower density, respectively, of which approximately 55% were annuals) (Fernandez-Núñez et al 2010). From the beginning of study (1995), the growth of pine was greater than that of birch (Rigueiro-Rodríguez et al. 2000) and resulted in a faster canopy closure in pine than birch in the systems established at high density five years after establishment (year 2000) (Fernández-Núñez et. al 2010). This canopy closure caused a deep shade, especially in spring, lead to fast reductions of vascular plants when biodiversity is compared among the years 1995 and 2003 (88% *vs* 49% at high density under pine and birch, respectively and 48% *vs* 52% at low density, under pine and birch, respectively). This reduction effect was especially important on annuals species, as they dissapiared under pine at high density and reduced their proportion around 67% in the other systems, which depend on high levels of radiation, that in our case, was mostly intercepted by pine at a high density. Moreover, the higher accumulation of litter and humus under pine at high density (Mosquera-Losada et al. 2006b), that is know to contain plant growth inhibitors (Piggot 1990), contributed to enhance biodiversity losses. On the other hand, a negative relationship between mineral fertilizer (M) and development of pine at hight density (Mosquera-Losada et al. 2006) was found from the begining of study. This effect has been repeated until year 2003 (data not presented), and results in a lower reduction on alpha biodiversity. While, under birch at hight density, alpha biodiversity

was reduced when fertiliser was applicated (D or M). These treatments have favoured the presence of *Dactylis glomerata* (80, 60, 39% under D, M and NF, respectively). This gramineae is characterised by strong growth in height that limit the presence of other species (Rodríguez et al. 2001). At low density, SR was reduced by D treatment around 50% when compared with M y NF treatments in pine stands. *Dactylis glomerata* and *Rumex obtusifolius* L. were the most abundant species in D. Some Polygonaceae plants including *Rumex* spp. have been described as allelopathic and reduced the germination of *Lolium* spp (Lutts et al. 1987) and inhibited some grasses and controlled their spatial distribution (Carballeria et al. 1988). Regarding birch established at low density, D and M treatments had lower biodiversity than NF in spite of being birch smaller in those treatments compared with NF. Both D and M had an important proportion of *Dactylis glomerata*, *Agrostis capillaris* L. and *Holcus lanatus* L. Tree canopy develop also caused a reduction on evenness and therefore an increase of the dominance of perennial species (*Dactylis glomerata*, *Holcus lanatus* and *Agrostis capillaris*), irrespective of the overstorey tree species and density.

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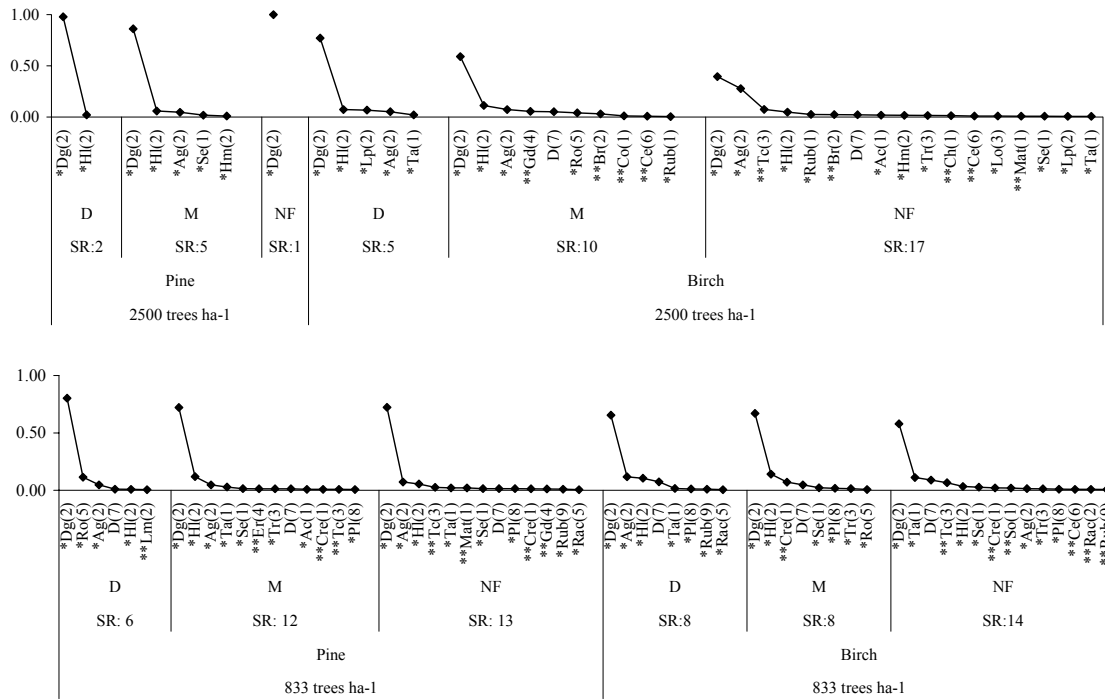
Figure 1: Abundance diagrams in the plots established under *Pinus radiata* D. Don (Pine) and *Betula alba* L. (Birch) at two densities (2500 and 833 trees ha^{-1}). Note: SR: species richness, D: fertilised with sludge, M: mineral fertiliser, NF: not fertilised, Ac: *Achillea millefolium* L.; Ag: *Agrostis capillaris* L.; Br: *Bromus diandrus* Roth; Ce: *Cerastium glomeratum* Thuill; Ch: *Chamaemelum mixtum* L.; Co: *Conyza canadensis* L.; Cre: *Crepis capillaris* (L.) Wallr; D: *Daucus carota* L.; Dg: *Dactylis glomerata* L.; Er: *Erodium moschatum* (L.) L´Hér; Gd: *Geranium dissectum* L.; Hl: *Holcus lanatus* L.; Hm: *Holcus mollis* L.; Lo: *Lotus corniculatus* L.; Lm: *Lolium multiflorum* Lam; Lp: *Lolium perenne* L.; Mat: *Chamomilla recutita* L.; Pl: *Plantago lanceolata* L.; Rac: *Rumex acetosella* L.; Ro: *Rumex obtusifolius* L.; Rub: Rubus sp.; Se: *Senecio jacobaea* L.; So: *Sonchus oleraceus* L.; Ta: *Taraxacum officinale* Weber; Tc: *Trifolium campestre* Schreber and Tr: *Trifolium repens* L.; families: (1) Asteraceae, (2) Poaceae, (3) Leguminosae, (4) Geraniaceae, (5) Polygonaceae, (6) Caryophyllaceae, (7) Umbelliferae, (8) Plantaginaceae and (9) Rosaceae, (*): perennial species, (**): annual species and ( ): biannual species.
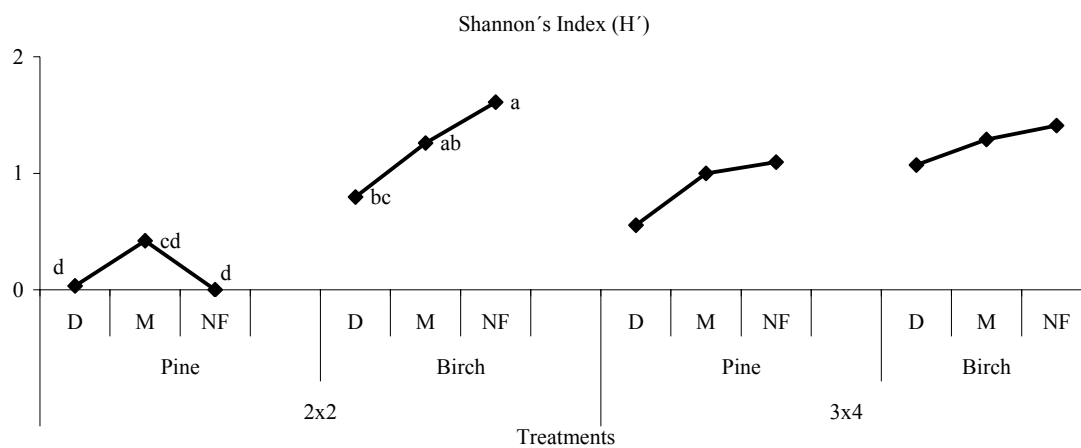
Figure 2: Shannon-Wiener index (H´) determined for each of the fertiliser treatments applied under the two types of trees and densities. Note: D: fertilised with sludge, M: mineral fertiliser and NF: not fertilised. Different letters indicate significant differences between treatments in the same density.

Participatory action research concerning the landscape use by a native cervid in a wetland of the Plata Basin, Argentina

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Abstract

The marsh deer is one of the few deer species restricted to wetland habitats. It is considered "threatened" at both national and international levels. In the Delta of the Paraná River part of the natural vegetation has been converted to industrial forest after to drain the land. Thus, the persistence of the species at the landscape level may depend on its adaptation and the attitude of the local people towards the deer. From 26 stakeholders' interviews, we evaluate how the cervid uses the landscape and what threats this species is facing. The deers were registered mostly in adult and young poplar afforestations followed by adult willow afforestations, but interviewees agreed that afforestations that maintain understory foliage function as refuges for deers. In turn, interviewees agreed that the deer population declined in the last 10 years and current level of hunting is the biggest problem for the regional marsh deer population.

Keywords: marsh deer, wetland, afforestations, stakeholders, landscape, threats

1. Introduction

The marsh deer (*Blastocerus dichotomus*, Illiger, 1811) is the largest and probably the most endangered cervid in South America (Thornback and Jenkins 1982; Fonseca *et al.* 1994). The species is distributed from mid-western and southern Brazil, Paraguay, eastern Bolivia and a small portion of south-eastern Peru to northern Argentina (Pinder and Grosse 1991; Tomás *et al.* 1997; Wemmer 1998; D´Alessio *et al.* 2001). It is considered "threatened" at both national (Díaz and Ojeda 2000) and international (IUCN, 2002) levels, and it is one of the few deer species known to be restricted to wetlands such as seasonal streams, swamps, and flooded savannas (Schaller and Hamer 1978). In Argentina, the Delta of the Paraná River (provinces of Buenos Aires and Entre Rios) constitutes the austral distribution boundary of the species and it holds one of the three main populations of this cervid in the country (Chébez 1994, D'Alessio *et al.* 2001).

The Lower Delta of the Paraná River is a wide costal freshwater wetland characterized by a vegetation mosaic crossed by an intricate network of rivers. Native forests develop on levees and relatively elevated sites, whereas lowlands are colonised by marshes or rush communities (Kandus *et al.* 2003). A part of the terminal portion of this wetland has been altered in the last 80 years mainly due to the replacement of natural vegetation by forestry plantations after the drainage of the land. Three different population nuclei of marsh deer have been proposed to occur in this wetland, one in an undisturbed area covered with native vegetation and the two

remaining in areas mostly dominated by forestry plantations (D´Alessio *et al.* 2002). The recently created Delta of the Paraná River Biosphere Reserve (MAB-UNESCO) currently protects the nuclei inhabiting the undisturbed area. The two remaining nuclei, on the other hand, are established in non-protected human-dominated areas where productive activities with low sustainable management appear to be threatening the long-term persistence of the species. The population status of the marsh deer in this wetland under current conditions is unknown (Dellafiore and Maceira 1998). So, an evaluation of the main threats that affect this population and the detection of how individuals use the various components of the altered landscape are necessary. In turn, conservation strategy generated for the marsh deer can also bring conservation benefits to other wild species and the whole Delta as well.

As the persistence of the species at the landscape level may depend on its adaptation to the altered habitats and the attitude of the local people towards the deer, the aim of this study was to evaluate the local people perception about how this cervid uses the landscape and which threats are affecting the species.

2. Methodology

The study area covers around 500km^2 and is centred in the downstream area of the Lower Delta of the Paraná River region (Buenos Aires province, Argentina). It includes the accretion portion of the delta between Paraná de las Palmas and Paraná Guazú rivers. The Lower Delta region (2,700km^2) has a temperate climate with a mean annual temperature of 289.96K, and an annual rainfall of 1,073 mm. The hydrological regime is the result of the combined effects of the Paraná river flow and the tidal pattern of the Del Plata estuary (Mujica 1979; Minotti *et al.* 1988). About 50% of the region is affected by human activities, mainly by the development of Salicaceae plantations (*Salix spp.* –willow- and *Populus spp.* –poplar-) and tourist and recreation activities (Kandus 1997).

This Delta holds the largest Salicaceae plantations in the country (Petray 2000) and this activity constitutes the economically most significant in the region (SAGPyA 1999; Casaubón *et al.* 2001) with 75% of willow and 25% of poplar afforestations (Borodowski 2006). Before planting, systematic work is carried out through the construction of canals and drainage ditches of different sizes and / or construction of embankments along the coast (locally known as "diques" and "atajarrepuntes"), which prevent entry of water from flooding (Casaubón *et al.* 2001). In the study area the poplar plantations are made for sawing wood, with large planting spacing ranging from 6x2 m to 6x6 m (Poplar Commission 1985). The willow, on the other hand, is used mainly for paper and particle board industries and plantations vary in spacing on 3x3 and 3x2 m. In the case of poplar, the understory foliage management implies keeping the soil free of weeds.

The methodology was based on the interview to stakeholders (local people, producers, and land managers). Six questions were included in the interview: 1) Area occupied by each habitat type in the area of influence (e.g. ranch) of the interviewer; 2) Which habitat types are used by deers to transit and feed?; 3) Which habitats appear to be used by deers as refuges?; 4) Did the population decline in the last 10 years?; 5) Which are the main threats for the deer population?; and 6) How can we contribute to the protection of the marsh deer?.

Habitat types were divided into: 1) adult willow afforestations; 2) young willow afforestations; 3) adult poplar afforestations; 4) young poplar afforestations; 5) marshes; 6) Cattle pastures; 7) afforestations without management or abandoned; 8) riparian native forests; 9) roads; and 10) others. A habitat was considered as a refuge for deers when it was used by individuals to rest or to escape from humans.

3. Results

During 2009, 26 stakeholders (with an area of influence of 250.6 km2) were interviewed. The habitat types included in this area of influence are shown in Figure 1. The most representative habitats were the young and adult willow (49.7%) and poplar (28.3%) afforestations, whereas the rest of the habitats occupied a smaller area.

Most of the records were reported in almost all habitats but mainly in adult poplar afforestations (24.7%) (see Figure 2). On the other hand, interviewees reported that abandoned afforestations or afforestations without understory management were the habitat most used as refuge by deers, followed by poplar and willow afforestations (see Figure 3). In turn, interviewees reported that a half of the poplar afforestations used as refuge by deers corresponds to afforestations without understory management or with presence of herbaceous and shrubs.

Regarding the population status, almost 60% of interviewees reported that there are fewer deers in the population than 10 years ago, while the remaining responded that the number of deer is equal or higher (19% and 23%, respectively) than 10 years ago (see Figure 4). Hunting was reported as the principal threat that affects the species in the area, whereas habitat modification (ej. embankments construction and drainage of lands) and the interaction with cattle (ej. competition and transmission of diseases) were considered secondary threats (see Table 1). Interviewees suggested that the effective control of hunting (by their own or by control agents) could be the most appropriate action contributing to the conservation of the deer (see Table 2). In turn, they also considered as an important conservation measure to leave unmanaged afforestations within their own fields as a refuge for deer. Finally, they agreed that education in schools and awareness within the general public and decision makers would help minimize the risk level of the deer population in the Lower Delta.

4. Discussion

According to interviewees, despite the low representation of natural habitats in the study area (marshes and riparian forests) marsh deer are present and uses the new habitats generated by forest industries as transit and feeding sites. However, the greater visibility inside poplar plantations due to the planting distance and the lack of understory foliage could improve the detection of deers in those areas in comparison with other more closed habitats. Considering the use of different habitats as refuge, the interviewed agreed that the marsh deer uses the denser poplar afforestations with presence of understory proportionally more often than the rest of the poplar because this habitat provides greater protection and resting sites. On the other hand, both cattle pastures and roads would be less optimal habitat due to the lower presence of refuges.

In spite of the possibility that the species may have adapted to the habitat transformation, the current level of hunting continues threatening the deer population in the region. The possibility of diseases transmission from cattle to deers and the increase of suboptimal habitats due to the mishandling of understory foliage and water in the afforestations are also threats for this population. In relation to water management, people perception agreed with Varela (2003), who determined that the land use type associated with hydrological management is a key factor in the distribution patterns of marsh deer in afforestations. Periodic openings of the dams floodgates (or diques) would allow the coexistence of forest plantations with high-rich patches of forage resources for the deer. Thus, an analysis of the effects of water management inside afforestations and hunting on the population is urgently needed. In addition, the analysis of the distribution, size, and connectivity of optimal and suboptimal habitat patches at different landscape levels could allow an assessment of the regional population viability.

At the afforestations level, is essential to delineate a scheme of plantation planning and forest management that considers relevant aspects such as (1) understory management (at least in poplar plantations), (2) management of patches in abandoned afforestations, (3) the inclusion of high density willow plantations in some areas as an alternative to generate favorable refuge patches for the deer, and (4) landscape management of forestry establishments. Therefore, the detection and design of corridors connecting feeding zones with refuge areas in the

afforestations and others productive lands would contribute to the persistence of the deer regional population.

It would be also relevant to evaluate the effects of the cattle production system on the deer population as well, because the regional increase in cattle numbers related to the expansion of silvopastoral systems (Arano, 2006) may constitute a new potential threat. This analysis should include both sanitary and competence aspects. Finally, it is essential to organize and perform environmental awareness campaigns focusing on stakeholders and decision makers. Based on the appropriate application of laws and the increased knowledge of the ecology and demography of marsh deers, is possible to implement more effective conservation programs. In this context, the participatory action research approach considered in this study can provide a suitable platform to build these conservation programs, generating the commitment of the local people since the beginning of the program execution.

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Table 1. Principal threats for marsh deer in the Delta of the Paraná River according to interviewees.

Threats	Number of interviewees that listed this threat as the principal threat	Number of interviewees that listed this threat as a secondary threat
Hunting	16	3
Habitat modification	8	4
Interaction whit cattle	2	6

Table 2. Perception of interviewees regarding the main actions contributing to the marsh deer conservation in the Delta of the Paraná River.

Action	Importance degree (%)
Effective control of hunting	39.4
Education & Awareness	27.3
Maintenance patches of unmanaged understory afforestations	21.1
Improve livestock good management practices	6.0
Research on marsh deer ecology	3.1
Hydrological management into afforestations	3.1
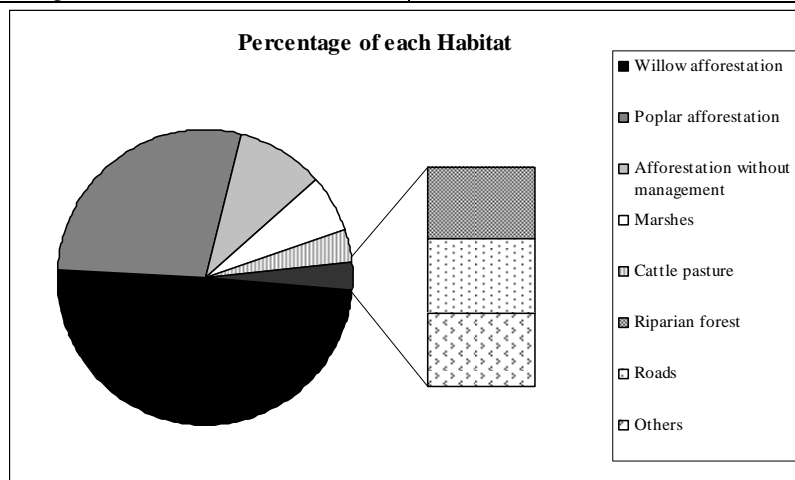
Figure 1. Percentage of each habitat in the influence area of stakeholders.
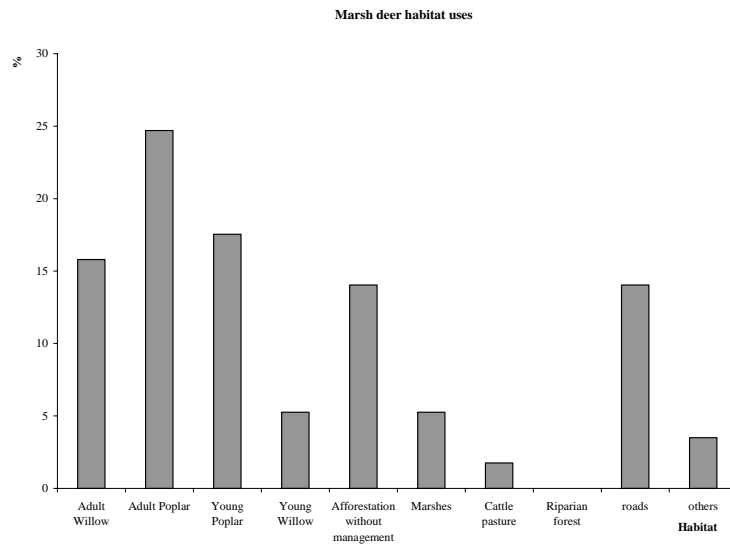
Figure 2. Percent of marsh deer records in each habitat typeas reported by interviewees
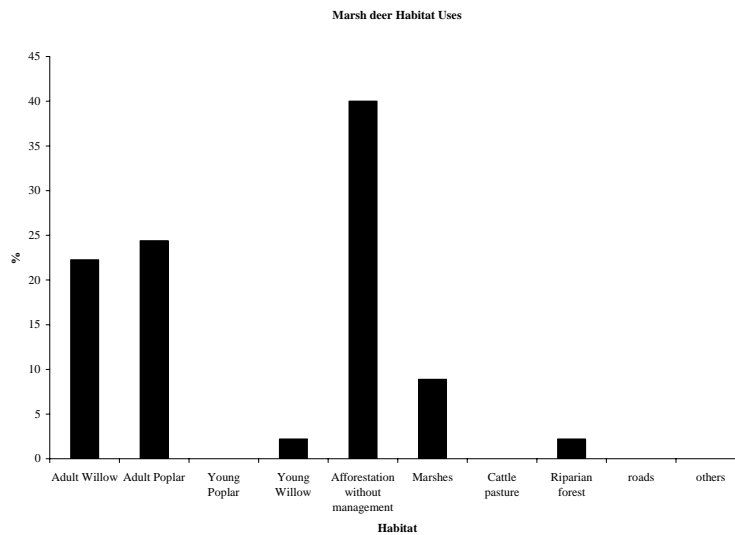
Figure 3. Percent of interviewees that reported each habitat type as a refuge for the Marsh deer.
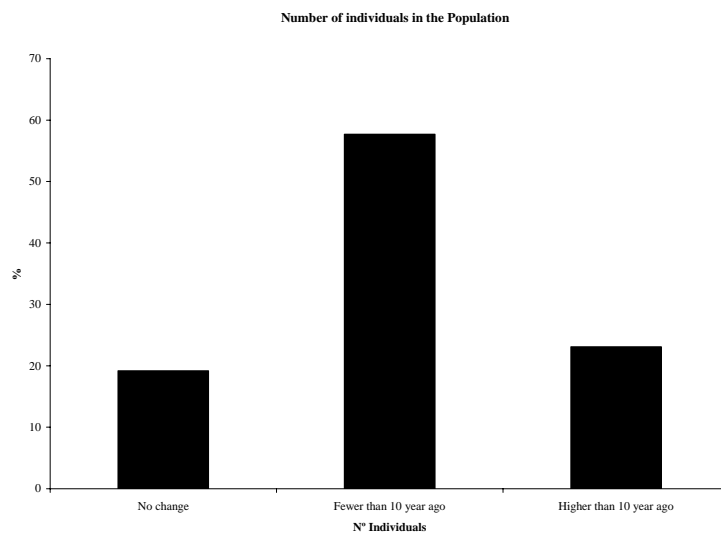
Figure 4. Perception of interviewees regarding the current number of marsh deers in the Delta population.

Fortresses and fragments: impacts of fragmentation in a forest park landscape

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Abstract

Our research addresses patterns of land cover and forest fragmentation in and around Kibale National Park in equatorial East Africa, and how park presence affects local livelihoods. Combining discrete and continuous data analyses of satellite imagery with a geographically random sample of two agricultural areas neighboring Kibale, we examine multi-scalar landscape change and diminishing resources in the context of population increase, potential climate change, and fortress conservation. While park boundaries have remained relatively intact since 1984, the domesticated landscape has become increasingly fragmented, with forests and wetlands shrinking, becoming more isolated, and suffering decreased productivity. Remnant wetland and forests are of particular interest because they supply ecological goods and services, but also provide habitat for primates and elephants from which to raid crops, not only posing a risk to food security, but may also lead to zoonotic disease emergence through spillover and spillback events.

1. Introduction

Recently, there has been a call for an integrated methodology that crosses temporal and spatial scales to promote understanding of the social, ecological, and climatological dynamics within park landscapes and to identify global trends, focus conservation priorities, and enable innovative and effective policy and resource management at multiple levels (DeFries et al. 2007). This paper details our data acquisition methodology that is designed to anticipate the consequences of a dynamic social and ecological system faced with anthropogenic pressures and climate change at multiple scales to inform appropriate management or legislative interventions for the mechanisms using Kibale National Park as a "natural laboratory".

Establishing parks is the primary mechanism used to protect tropical forest biodiversity, particularly in regions with high human densities. Parks (protected areas of

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all sorts) protect and maintain endemic, threatened or endangered, flora and fauna, geological features, and cultural heritage sites. In addition, they can generate income for the local and national economies, and provide important benefits associated with enhanced tourism sectors. However, many parks are also associated with negative social and ecological impacts. Human populations neighboring parks are often excluded from settlement, access, resource extraction, and most forms of consumptive land use in the park, which in turn affects farmers' land use and livelihood options.

The processes that drive land cover change are complex and cannot be understood without addressing underlying cause and effect relationships. Changes in climate, population, and land use occur and interact simultaneously at different temporal and spatial scales, having major implications for both livelihoods and biodiversity. Forest loss and fragmentation are regarded as the greatest threat to global biological diversity (Turner and Corlett 1996). Fragmentation negatively impacts species composition due to a reduction in forest area and isolation of remaining fragments. Between 1990 and 2005, forest cover in Africa decreased by 21 million ha (Chapman et al. 2006). Since most parks are already ecosystem remnants of a limited size, it is important to consider each as a component of a larger landscape.

The presence and use of forest fragments outside parks illustrate the interconnected nature of the park-domestic landscape. Within the greater continuous landscape, remnant fragments of larger forests can be important to neighboring human communities, providing subsistence-based resources. These forests represent reservoirs of land, resources, and economic opportunity for people, while at the same time are often viewed as buffers for parks by managers, as wildlife corridors and habitat that extends the effective size of the park.

Unfortunately, these forest fragments are also hazards for local farmers, as sources of crop raids by primates, elephants, and birds. There has been extensive conversion of fragments, both to claim more land and to destroy the habitat of would-be crop raiders. Health concerns have also arisen as pest animals move pathogens across landscapes, leading to spillover of disease (potential zoonotic emergence), and spillback (pathogens transferred back into parks).

The decline of remaining fragments in the human-dominated landscape may be an inevitable process, exacerbated by the impacts of current and future changing climate. The impacts that fragmentation has on both wildlife and vegetation within a fragment and perhaps more importantly, the impact of loss of intact habitat and wildlife on the people relying on the remaining fragments, are important to understanding and slowing or preventing future decline. As fragments decrease and become more degraded, encroachment into the park and the number and severity of human-wildlife incidences may increase.

There is growing interest in the academic community and by policy makers as to the extent of climate change impact on ecological communities (Walther et al. 2002). Climate variability and change are affecting wildlife populations, posing serious risk to poverty reduction and threatening rural livelihoods. Local climate variability directly impacts crop yields, resource quality and abundance, vegetation productivity, and wildlife habitat and food sources. Climate change can also adversely affect the availability of resources for human populations outside of parks, who depend on the land for their livelihoods. In addition, changes in food abundance within parks may force wildlife to seek food in agricultural areas near the park boundary, increasing the vulnerability of farms to crop damage and predation.
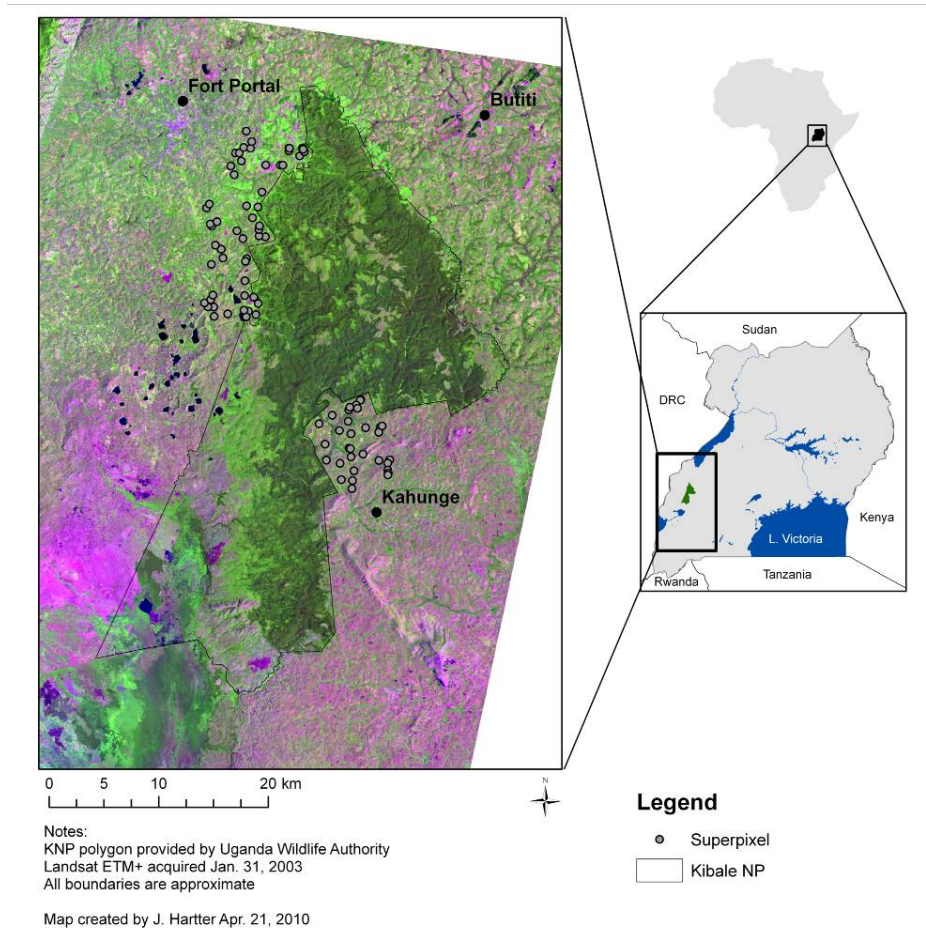
Figure 1. Kibale National Park in western Uganda.

2. Study Site

Kibale National Park (795km^2, Figure 1), medium altitude tropical moist forest in western Uganda represents one of the best-studied forest sites in forested Africa, having been the site for multiple field projects for 40 years. The human population surrounding Kibale has increased seven-fold since 1920 and exceeds 270 people/km^2 at the western edge. Annual population growth rates range between 3 and 4% per year. The landscape is a mosaic of small farms (most <5ha), large tea estates (>200ha), and interspersed forest fragments and wetlands (0.5-200ha or more), effectively isolating the park (Hartter and Southworth 2009). Forest fragments and wetlands extending from Kibale's boundaries and isolated within the agricultural matrix vary in size, shape, and resource types and amount. The Kibale landscape is an extremely valuable setting because the biophysical and social response to social and ecological change may be emblematic of forest park landscapes across the entire Albertine Rift and likely elsewhere. Parks in the Albertine Rift have been identified as areas of extremely high endemic biodiversity and have been classed as a conservation priority (Plumptre et al. 2007).

3. Methodology

Integrating landscape level change detection with household level processes and ecological sampling requires a sampling scheme that links household surveys and ecological sampling to remotely sensed data. Social and ecological surveys provide valuable fine-scale, ground-data. Household-level decision making is critical to understanding the changes in land-use and land-cover and their effects on livelihoods. Ecological sampling provides means of understanding the consequences of household decisions to biodiversity and allows the generation of future scenarios for change. Linking classifications of land cover to socio-economic and ecological surveys can provide a more comprehensive understanding of land use and land cover change over time. Instead of asserting that deforestation happened, we can now describe the effects of this change (i.e., loss of biodiversity), and pinpoint key social drivers for this change.
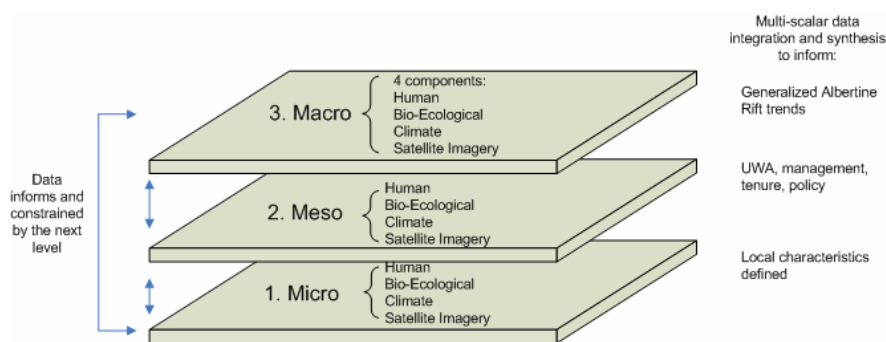
Figure 2. Hierarchical framework that is embedded with multiple datasets at multiple spatial resolutions to examine four elements of the park landscape and their temporal and spatial changes. Within this hierarchical framework, the higher level provides a context and imposes top-down constraints on the lower level, and the lower level provides mechanisms and imposes bottom-up constraints.

3.1 Data Acquisition

To provide the link between landscape and household/ecological data, appropriate areas had to be defined that permitted the integration of research tool and intellectual questions. These areas had to be large enough to include the scales of satellite-evaluated land cover change, and small enough to permit assessment of biodiversity and human activities.

Household Interviews – To link micro-scale land use decisions with meso-scale land cover change area, we used the superpixel methodology (Hartter and Southworth 2009) to define a 5-km perimeter around park boundaries as the meso-scale research area. Interview respondents were selected from among landholders in each of the 95 9-ha circular superpixels for which there were landholders. The number of respondents selected per superpixel was proportional to the number of landholders controlling land within the study area, and at least one interview was conducted in each superpixel. Therefore, superpixels with more landholders (and correspondingly smaller individual landholdings) had a higher sampling intensity than those with fewer landholders. GPS points were also taken at access points for the nearest forest fragment and wetland for each house and were used to calculate the straight-line distance from the house to the nearest wetland and/or forest fragment and park boundary. Thus social and ecological units of interest can be mapped together.

Time Series Analysis of Land Cover, Productivity, & Landscape Fragmentation – To quantify landscape change outside Kibale, Landsat TM and ETM+ imagery was chosen because it offers the best combination of spatial, spectral, temporal and radiometric resolutions. Six dry season images were acquired: (August 4, 1986, August 20, 1989, January 17, 1995, January 9, 2001, January 31, 2003, and September 1, 2008) (path 162, row 60). An additional image (May 26, 1984) was acquired near the end of the rainy season and was the only available cloud-free image within this time period. Our analysis accounts for the phonological difference. Images were geometrically registered to 1:50,000 scale survey topographic maps of the region within an RMS of <0.5 (below 15m accuracy), followed by radiometric calibration and atmospheric correction.

Three images (1984, 1995, 2003) were used to construct a landscape classification. The 1984 image provided baseline data prior to park establishment at the time the area was a forest reserve, the second captures conditions at park establishment, and the third represents 10 years after park establishment. In 2004 and 2005, 180 training samples were collected and used to construct a supervised classification using the eight-band layer stack and the normalized difference vegetation index (NDVI) layer. Five classes were used in the classification: 1) forest, 2) wetland (mainly of papyrus (*Cyperus papyrus* L.) and grassland (elephant grass (*Pennisetum purpureum*), 3) bare soil, crops, short grasses, 4) tea, and 5) water; and overall accuracy was 89% (Hartter & Southworth 2009).

Vegetation indices are important to help us address changes within land cover classes across dates. Derived composites of NDVI from satellite images provide an indication of photosynthetic activity and a proxy of net primary productivity. NDVI composites from each date will be used to measure the change in forest productivity (e.g., higher NDVI values indicate more photosynthetic activity).

Landscape pattern recognition software (e.g., FRAGSTATS); and spatial ModelMaker in Imagine) was used to conduct spatial analyses with classified and continuous data. The classified data descriptive metrics of land cover pattern (patch area, shape, core area, diversity, effective mesh size) were compared across dates and locations. These techniques reveal patterns of spatial regimes of land cover that may be related to land-use patterns. Examining autocorrelation statistics using continuous variables (e.g., NDVI) provide detail on variations *within* patterns of spatial dependence.

Climate Analyses – Precipitation in and around Kibale exhibits a high degree of spatial and temporal variability. Therefore we investigated the temporal and spatial variation in intra-annual precipitation patterns (Stampone et al. *submitted*) and will quantify its contribution to land-cover change. Total seasonal and annual rainfall data were analyzed using the Global Historic Climate Network (GHCN) 5° gridded dataset and from long-term research at Kibale from T. Struhsaker and C. and L. Chapman (1970-). Trends in total seasonal and annual rainfall over the period of record were identified at each station and tested for statistical significance at the 95% confidence level. Significant trends were identified using Mann-Kendall test, a non-parametric test for data interdependence over time. The direction and magnitude of significant trends were then calculated using Sen's slope estimator. Temporal autocorrelation functions associated with each station time series will indicate whether or not there are long-term trends or periodicities in temperature and the amount and variability of precipitation

over the period of record. Periodicities in autocorrelation functions are indicative of a cyclical response in seasonal and annual climate variables and may be attributed to fluctuations in large-scale atmospheric circulation patterns (e.g., ENSO). Spatial autocorrelation will be used to assess the spatial variability in temperature and precipitation at sub-regional scales. High spatial autocorrelations between stations may be indicative of strong regional influences on local climate, whereas strong local influences, such as land use, may result in lower spatial autocorrelations between stations.

Integration of data – A series of logistic models will be incorporated into a model selection algorithm, assessed using an information theoretic framework, such as AIC (Akaike's Information Criterion) based estimators. These models will be constructed by overlaying the information gathered and constructing process based models predicting fragment loss as a result of covariates such as ownership, fragment type, isolation and distance metrics, ecological factors, climate in preceding years, neighborly crop types and perceptions of use. We will derive suites of models at different spatial scales, wherein processes will likely differ.

4. Conclusion

While it is well established that models of the park-landscape interface are necessary to the conservation discourse and to the persistence and sustainability of parks and the human populations that surround them, the necessary data to understand the multifarious processes at play are hard to acquire. We have addressed issues of socio-ecological boundaries, climate and both spatial and temporal scale within our data acquisition. We will thus not only document a park-landscape dynamic process, but identify drivers which are relevant to management and policy.

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Landscape structure of a conservation area and its surroundings in Minas Gerais State, Brazil

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Abstract

This study examined the suitability of a conservation area establishment through the landscape structure investigation inside and outside the area. The land cover mapping was performed using CBERS image, supervised and unsupervised classification. Landscape metrics were calculated utilizing Fragstats 3.3. The presence of a large forest patch inside the conservation area revealed the preservation of a rare patch in the landscape. Shape index varied from 1,68 to 2,02. Core index was higher for the forest patches (92,73%). Percentages of 50,00% of forest patches and 57,14% of grasslands presented distances lower than 100m. The pastures showed high juxtaposition index (95,41%). The overall pattern denoted low influence of edge effect and reasonable connectivity among patches. Conservation planning for the area has to take into consideration that grazing can be an impact source. Measures for the surrounding areas maintenance as a buffer zone can enhance flux among patches inside and outside the area.

Keywords: Landscaspe structure, landscape metrics, nature conservation

1. Introduction

Nature conservation in Brazil has been a challenge since the demand for economic growth has contributed to environmental degradation, fragmentation and deforestation. The country presents a great importance for global biodiversity comprising a large percent of the remaining tropical forest stock. Although a large amount of land is under protection these do not represent Brazil's biodiversity. (Lele et al 2000).

Biodiversity and ecological infrastructure maintenance are fundamental for nature conservation (Bridgewater 1993). The conservation value of a specific area in terms of ecological infrastructure can be examined through the measurement of the landscape features (Haines-Young and Chopping 1996). In the case of biodiversity, the role of landscape structure characterization is well known. Some landscape components such as patch size, heterogeneity, perimeter-area ratio and connectivity can be major controls for species composition and abundance (Noss and Harris 1986).

As a part of the landscape, the structure comprises the patches connected by corridors and surrounded by a matrix (Forman and Godron 1986). The landscape structure patterns include two aspects: composition and configuration (Turner 1989; Griffith et al 2000). Landscape composition refers to the patch or land cover types without being spatially explicit. Landscape configuration has to do with the spatial distribution of patches or cover types within the

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landscape and includes measures relatives to the placement of patch types relative to others (Mac Garigall and Marks 1995).

A large number of landscape indices that provide quantitative measurement of the landscape structure are found in the literature (Forman and Godron 1986; Turner and Gardner 1990; Mac Garigall and Marks 1995; Haines-Young and Chopping 1996). According to Haines-Young and Chopping (1996), for practical purposes, those indices can be grouped in the following categories: area, edge, shape, core area, nearest-neighbor, diversity, contagion and interspersion.

The present study aimed to verify the landscape structure concerning area, shape, core area, nearest-neighbor, contagion and interspersion inside and outside an area to be preserved. The conservation area is located in the Iron Quadrangle (Quadrilátero Ferrífero) region, Minas Gerais state, where besides the agricultural land use pressure, the mineral resources exploitation has led to the reduction of rocky shrublands formations, grasslands and forest. The responsibility for the conservation area creation belongs to the Vale Mining Company, as a demand from the state forest government agency to compensate impacts on environmental resources, due to mining exploitation.

2. Methodology

2.1 Study area and land cover mapping

The conservation site Mata do Limoeiro is located in Itabira county, Minas Gerais state, in the west extreme distribution of the Brazilian Atlantic Forest, setting bounds with the Savannah dominion (Rizzini 1979). The climate is tropical showing mean annual temperature of $21,3^0$C. The relief is characterized by the presence of quartzite escarpments, gneiss hills and alluvial lowlands (Radambrasil 1987).

The land cover mapping was performed for the conservation area and its surroundings (10 km round) using CBERS-2 CCD image 2008, 20m resolution. The software package Spring 5.1.5/INPE was used for image processing. In a previous phase was carried out a contrast correction. Segmentation and classification techniques were applied during the processing phase. For the segmentation, a region growing method was used and for the classification, supervised (pixel based) and unsupervised (region based) procedures were undertaken. Adjustments in the classification were made after data collection in the field.

2.2. Landscape pattern metrics

The landscape metrics were calculated utilizing the public domain software package Fragstats 3.3. (Mac Garigal and Marks 1995). The land cover map (raster format) was used as input data. The set of indices utilyzed for the landscape structure characterization are listed in Table 1. Calculations of the relative percentage of the cover, number, size and isolation of the patches were also undertaken. The whole landscape area was given by the sum of the area inside and outside the conservation area.

3. Results

The land cover map of the conservation area Mata do Limoeiro and its surroundings derived from the classification of the image CBERS-2 CCD 2008 is showed in the Figure 1. The land cover classes found were generalized into four: forest (semi-deciduous seasonal forest in advanced, intermediate and initial succession stages); grasslands (savannah grasslands, rocky shrublands, scrub); pasture (pasture, agricultural areas) and urban areas (villages, cities).

The landscape metrics resulted for the conservation site are presented in Table 1. The whole study area inside the conservation site is 2.097,04 ha. The forest class covers the largest area

(1.559,20ha), followed by the grasslands (515,08ha) and pasture (31,76ha). When comparing the number of patches one can see that the majority belonged to the grasslands comprising 35 pieces, followed by 8 pasture and 6 forest pieces. The mean patch area was higher for forest class (258,36ha) that presented a continuous and large patch inside the conservation area of 1.529,20ha. Patch density was 1,66 for grasslands, 0,38 for pasture and 0,28 for forest.

Table 1: Landscape metrics used for the landscape structure characterization inside and outside the conservation area*

Acronym	Metric Name (units)
Area Metrics	
TA	Total Area (hectares)
CA	Total Class Area (hectares)
PD	Patch density (no./100 ha)
NP	Number of patches
AREA MN	Mean Patch Area (hectares)
AREA	Patch Size (patch size selected minimum and maximum)
Shape Metrics	
SHAPE MN	Mean shape index
Core Metrics	
TCA	Total Core Area (ha) – specified edge depth (20 m)
CAI	Core Area Index (percent)
Isolation/Proximity Metrics	
ENN MN	Mean euclidean nearest neighbor distance distribution (meters)
Contagion/Interspersion Metrics	
IJI	Interspersion and Juxtaposition Index (percent)

* Full description of landscape metrics equations is provided in Mac Garigal and Marks (1995)

The mean shape index varied from 1,68 (grasslands) to 2,02 (forest). The core area index was higher for forests. The mean distance among patches was lower for the grasslands (109,82m), followed by pastures (164,83m) and forests (224,93m). The pastures showed high interspersion and juxtaposition index (95,41%). This index was 63,82% for grasslands and 49,38% for the forest class.

The results for the surrounding area are presented in Table 2. The total surrounding landscape comprises an area of 52.674,92ha. The pastures cover the largest area (28.561,80ha), followed by forest (16.833,28 ha) and grasslands (31,76ha). Two small urban areas are located inside the surrounding area occupying 35,56ha. The forest cover presented the highest number of patches (334), followed by pastures (224) and grasslands (102). The mean patch area was higher for pastures (119,00ha). For the grasslands and forest covers the value of this variable was respectively 71,02ha and 50,39ha. Patch density was 0,63 for forest, 0,45 for pasture and 0,19 for forest.

Mean shape index in the surrounding area varied from 1,69 (forest) to 2,10 (grasslands). Core area index was similar for forest (86,58%) and grasslands (85,91%). Mean distance among patches was lower for urban area (72,11m), followed by pasture (139,73m), forest (191,37m) and grasslands (312,11m). The highest interspersion juxtaposition index was found for grasslands (63,82%).

Considering the whole landscape area, the forest to be preserved inside the conservation area represents 8,43% and the grasslands 6,63%. The 6 forest and 35 grasslands patches were equivalent to 1,76% and 25,54% of the total patches. The largest forest patch inside the conservation area (> 1.000ha) represented 0,29% and the largest grasslands one (> 100 ha) 5,83%. Regarding isolation, 50,00% of forest patches and 57,14% of grasslands presented distances lower than 100m.
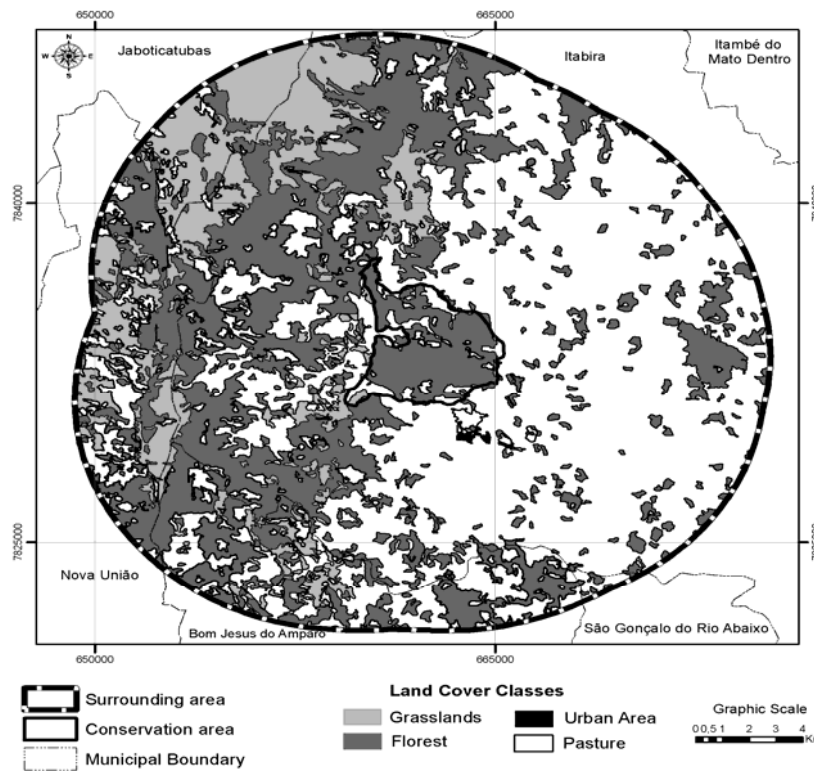
Figure 1: Land cover map of the conservation area Mata do Limoeiro and surroundings.

Table 2: Landscape metrics results for the conservation area

Metrics	Classes			Landscape
	Forest	Grasslands	Pasture	
TA (ha)	1.550,20	515,08	31,76	2.097,04
PD (no./100 ha)	0,28	1,66	0,38	2,33
NP	6	35	8	49
AREA MN (ha)	258,36	14,71	3,97	42,79
AREA (minimum – ha)	0,60	0,04	0,04	0,04
AREA (maximum – ha)	1.529,20	121,00	26,68	1.529,20
SHAPE MN	2,02	1,68	1,73	1,73
TCA (ha)	1.437,60	393,76	21,45	1.852,84
CAI (%)	92,73	78,44	67,53	93,12
ENN MN (m)	224,93	109,82	164,83	132,90
IJI (%)	49,38	63,82	95,41	64,04

Table 3: Landscape metrics results for the surrounding area

Metrics	Classes				Landscape
	Forest	Grasslands	Pasture	Urban Areas	
TA (ha)	16.833,28	7.244,28	28.561,80	35,56	52.674,92
PD (no./100 ha)	0,63	0,19	0,45	0,00	1,28
NP	334	102	240	2	678
AREA MN (ha)	50,39	71,02	119,00	17,78	77,69
AREA (min. – ha)	0,04	0,04	0,04	9,60	0,04
AREA (max. – ha)	11.190,24	3.540,96	22.580,76	25,96	22.580,76
SHAPE MN	1,69	2,10	1,78	1,88	1,77
TCA (ha)	14.573,72	6.223,76	23.356,88	26,20	47.180,56
CAI (%)	86,58	85,91	92,28	73,68	89,57
ENN MN (m)	191,37	312,11	139,73	72,11	190,55
IJI (%)	51,47	62,50	49,20	16,13	52,53

4. Discussion

The landscape structure results for the conservation site showed that the area to be preserved comprises a large amount of forest and grasslands. These findings increase the site importance for nature conservation purposes especially considering that the area is set in the Brazil's Atlantic Forest Dominion, a highly threatened tropical ecosystem (Conservational International 2000), where conservation recommendations includes large areas, with elevate forest cover to favor species maintenance (Metzger 2009).

Inside the conservation site the results of low patch number and high average area for the forest cover indicated the preservation of more continuous areas whereas in the surroundings the findings suggested concerns regarding fragmentation, especially for those areas located at the east side, closer to Itabira county. Valente (2001) found as more fragmented, in a landscape structure study of river basins, the sites with lower mean patch area and higher patch density. As pointed out by Ji at al (2008), patch number and average area can reflect the fragmentation of a certain landscape in some degree. Landscapes comprising lower mean patch area tend to be more fragmented (Mac Garigal and Marks 1995).

The mean shape index results inside and outside the conservation area for the various land cover classes indicated a prevalence of irregular patches. Valente (2001) and Jorge and Garcia (1997) found similar results for the mean shape index in forest and savannah environments. Patches characterized by larger areas tends to present more irregular shapes (Mac Garigal and Marks 1995) and irregular patches with lower areas interact in a higher degree with the surrounding matrix being more susceptible to the edge effect (Valente 2001). In the present study, the characteristics of the core area might be compensating the shape. The land cover majority inside and outside the conservation area presented high proportion of core area suggesting a larger proportion of natural vegetation with low influence of the edge effect. This is the case of the largest forest patch found inside the area to be preserved (1.529,20ha). Regarding conservation purposes, the forest patch exceeds the 250ha core area criterion suggested by Jongman (1995), for nature conservation planning in Europe.

The mean distance among patches of the same land cover inside the conservation area was highest for forests and in the surroundings for grasslands. Considering that approximately half of the patches of natural vegetation inside the conservation area presented low mean distances, a relative aggregation and low isolation among patches is occurring. Low isolation enables a better influx of animals, seeds and pollen improving dispersion and biological diversity (Forman & Godron 1986).

The highest interspersion and juxtaposition index inside the conservation area was found for the pastures. This land cover type showed consequently a higher adjacency to the other patch types indicating a potential impact risk, since inappropriate fencing system coupled with free grazing, may favor invasive species colonization and damages to the seed bank.

The surrounding area may work well as a buffer zone and enhance the flux among patches, given the richness in patches found. Nevertheless, the fragmentation trend especially on the east side and the large amount of pastures has to be considered. As pointed out by Jongman (1995) nature conservation sustainability must be supported by policies on buffering external influences and integrating functions, where possible.

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Ecological factors influencing beta diversity at two spatial scales in a tropical dry forest of the Yucatán Peninsula

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Abstract

Understanding the ecological factors determining beta diversity at different spatial scales is relevant for ecological theory and for conservation and management. We analyzed the relationship of beta-diversity and environmental and spatial variables at two spatial scales. We identified vegetation classes based on a supervised classification, determined species composition, and obtained soil samples from a total of 276 sites in 23 sampling landscapes. Using vegetation classes and FRAGSTAT, we calculated patch-type metrics in each landscape. Spatial dependence was included in the models using PCNM. Partial CCA and RDA were performed to partition variation. Soil properties, stand-age, landscape metrics and site PCNMs were used at the local level, while landscape metrics and landscape PCNMs were used at the landscape level. At the local level, space was the most important variable related to variation in species composition (48.87%), whereas at the landscape-level, landscape-metrics explained most (50%) of the variation in species composition.

Keywords: Beta diversity; CCA; forest succession; *landscape patterns; RDA; spatial dependence*

1. Introduction

Beta diversity refers to variation in species composition among sites within a geographic area (Legendre et al. 2005). It could be determined by different habitats along an environmental gradient, or by geographic distance within seemingly uniform habitats. In the latter case, beta diversity reflects spatial isolation among species (Halfter 1998). Beta diversity allows us to understand how species habitats are distributed, it is also an important component in biodiversity conservation planning and management (Halfter 1998).

Factors affecting species turnover and the scale at which they operate have been debated for a long time in ecology. Two of the main causal factors of beta diversity are: 1) limitation in the dispersal capacity of species that are demographically and competitively equal (neutral theory, Hubbell 2001). 2) Environmental conditions as a determinant of species presence and/or abundance (niche theory, Grubb 1977).On the other hand, it is important to note that factors affecting species turnover may vary among spatial scales (Garcia 2006).

The aim of this study was to analyze the relative importance of environmental heterogeneity, stand age, landscape structure and spatial dependence on species turnover of a tropical dry forest at two different spatial scales.

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2. Methods

2.1 Study Area

The study was conducted in a landscape of 22 x 16 km^2 located in the Yucatán Peninsula, México (-89.60 W, 20.01 N and -89.39 W, 20.16 N). The climate is warm subhumid, with summer rain (May-October) and a marked dry season (November-April). Mean annual temperature is ± 26°C, and mean annual precipitation ranges from 1000 to 1200 mm. Topography consists of flat areas alternating with low hills. Elevation ranges between 60 and 160 m.a.s.l (Flores and Espejel, 1994). The landscape is dominated by tropical semideciduous forest of different successional ages derived from traditional agriculture (Figure 1).

2.2 Remotely sensed data, imagery processing and calculation of landscape metrics

A Spot 5 satellite imagery acquired in January 2005 was geo-referenced to Universal Transverse Mercator Projection (WGS 84) and radiometrically corrected to minimize the effect of atmospheric scattering. A false color composite image was created from bands 2 (red), 3 (near infrared), and 4 (mid infrared). Training sites were selected from this image to perform the classification. The land-cover classes consdiered were: 1) 3-8 y-old secondary forest; 2) 9-15 y-old secondary forest; 3) >15 y-old secondary forest on flat areas; 4) >15 y-old secondary forest on hills; 5) agricultural fields; 6) urban areas and roads. We used the maximum likelihood algorithm in Idrisi Kilimanjaro (Eastman, 2004), and two accuracy measures were applied to the map: the overall accuracy, and Cohen's Kappa statistic (Campbell, 1987).

We selected three landscape metrics that can be considered as fragmentation indices: TECI (Total Edge Contrast Index), SIEI (Simpson´s Evenness Index) and LPI (Large Patch Index). The definition of these metrics is given in McGarigal et al (2002). Finally, the weighted edge contrast between vegetation cover classes required to compute total edge contrast index were calculated as the inverse values of the Morisita-Horn measures between each pair of vegetation cover classes.

2.3 Species composition and environmental data.

Survey sampling was performed in the summer of 2008 and 2009 during the rainy season. First, we selected 23 1 km^2 landscapes along a fragmentation gradient. Second, we selected 12 sites using a stratified random sampling design using the four vegetation classes. Each site consisted of two concentric circular plots: all woody plants > 5 cm in DBH (diameter at breast (1.3 m) height), hereafter referred to as adults, were sampled in a 200 m^2 plot; whereas 1-5 cm DBH woody plants, hereafter referred to as juveniles, were sampled in a nested 50 m^2 subplot. In each site, we identified each individual and calculated the Importance Value Index (IVI) for each species. To characterize soil conditions at each site, we estimated percent stoniness and collected soil samples for physical-chemical analyses: pH in water, electric conductivity (EC), soil organic matter (SOM, combustion or Walkley-Black), total nitrogen (N, Kjeldahl), available phosphorous (P, Bray), and interchangeable potassium (K).

2.4 Statistical Analysis

To explore general patterns of species composition, we used detrended correspondence analysis (DCA) ordination of the IVI of each species in each site or landscape in CANOCO (4.52).

Principal coordinate of neighbor matrices (PCNM) was used to account for spatial dependence (Borcard and Legendre 2002). The PCNM vectors were calculated from the location of each sampling site for local-level analyses and from the centroid of each landscape unit for landscape-level analyses.

Variation in community composition among sites was partitioned using the method of Borcard et al (1992). Four sets of explanatory variables were considered at the local level: environmental variables (soil attributes, % stoniness), landscape structure (TECI, SIEI, LPI), spatial dependence (PCNMs), and stand age; whereas only two sets of variables were used at the landscape level: landscape structure and spatial dependence. To determine the amount of variation explained independently by each set of predictor variables, we performed partial constrained ordination separately for each set of variables at both levels. Due to the length of gradients, CCA was used at the local level (3.99 SD), while RDA was used at the landscape scale (2 SD).

3. Results

The land cover thematic map of the study area is shown in Figure 1. The total area occupied by this landscape was 37,243 ha, 94.8% corresponded to tropical sub-deciduous forest in any of the four vegetation classes, whereas 5.2% corresponded to agriculture and urban areas. We obtained an overall accuracy in the supervised classification of 73.3% and the Kappa index was of 0.7.
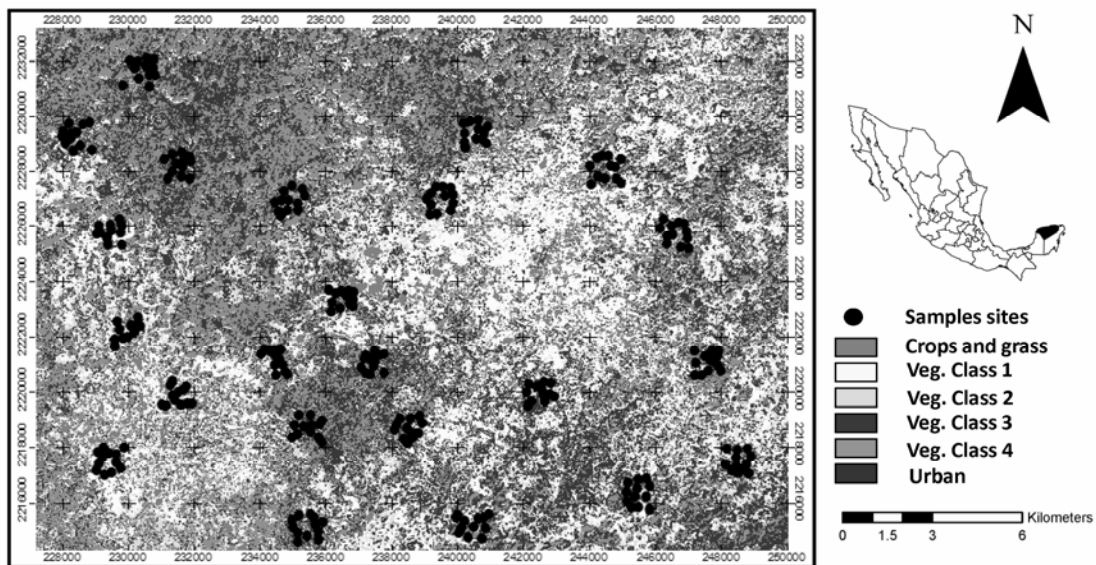
Figure 1: Location and land cover map of the study area obtained from a supervised classification.

A total of 22,262 woody individuals belonging to 204 species and 52 families were recorded in 276 sites in 23 landscapes. Of total of sites sampled, 51 belonged at class 1, 77 to class 2, 83 to class 3 and 62 to class 4. The most abundance species was *Neomillspaughia emarginata* with 3,421 individuals, whereas 29 species were represented only by a single individual.

3.1 Local scale.

Detrended correspondence analysis at the local scale showed a large length gradient of species composition (3.99 sd; Fig. 2a). Vegetation class 4 differed significantly from the other classes. Canonical correlation analysis showed that total variation explained was 13.79%. Variation partitioning showed that space is the most important variable explaining 5.95% of species composition, followed of the soil variables with 5.83% (Table 1). Vegetation class 1 was negatively associated with organic matter (SOM), stoniness, stand age and TECI whereas vegetation class 4 showed the opposite pattern (Fig. 2b).
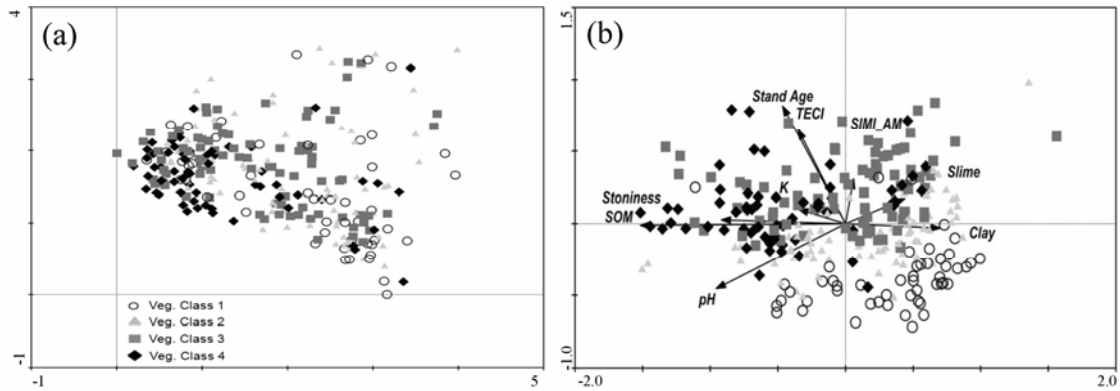
Figure 2. Ordination analysis at the local scale. (a) Detrended correspondence analysis (DCA) of the IVI of each species at each site. (b) Canonical correspondence analysis biplot for the first and second axes showing stand age, space, environmental, and landscape structure variables.

Table 1. Variation partitioning of woody plant species composition at the local scale.

PREDICTOR VARIABLE	MARGINAL VARIATION EXPLAINED	PERCENT VARIATION EXPLAINED
Soil Variables	0.49	41.56
Stand age	0.07	6.34
Structure Metrics	0.08	6.94
Space	0.50	43.10
Share	0.02	2.06
Total inertia explained	1.17	100
Unknowledge	7.23	
Total Inertia	8.40	

3.2 Landscape scale.

Detrended correspondence analysis showed a short length gradient (2 sd) of species composition. We found no clear pattern of species composition in relation to fragmentation class (Fig. 3a) (. Redundancy analysis showed that landscape structure variables explained a greater amount of variation in species composition than space (16.5% and 13.8%, respectively; Table 2). Fragmentation class 4 was positively associated with SHEI and negatively associated with LPI, whereas fragmentation class 1 showed the opposite pattern (Fig. 3b).
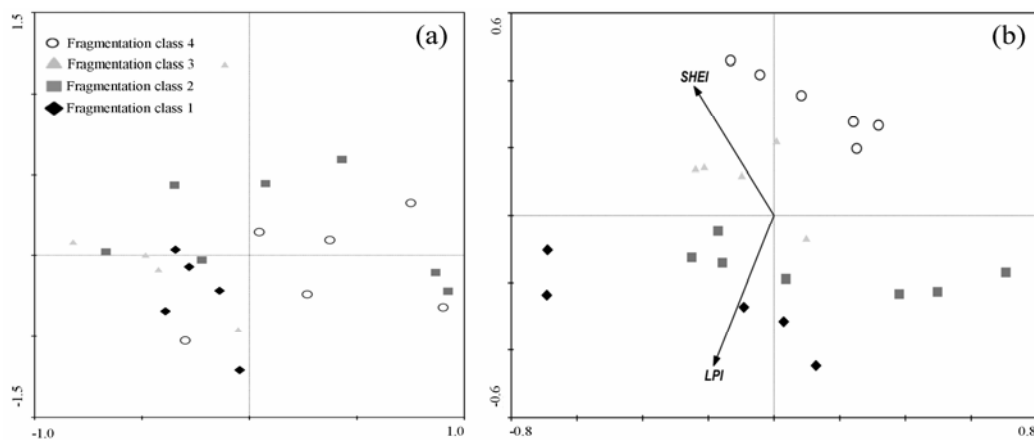
Figure 3. Ordination analysis at the local scale. (a) Principal components analysis (PCA) ordination of the IVI of each species in each site or landscape. (b) Redundancy analysis biplot for the first and third axes showing Shannon´s Evenness Index (SHEI) and Large Patch Index variables.

Table 2. Variation partitioning of woody plant species composition at the landscape scale.

PREDICTOR VARIABLE	MARGINAL VARIATION EXPLAINED	PERCENT VARIATION EXPLAINED
Landscape structure	0.17	16.5
Space	0.14	13.8
Shared	0.01	1.4
Total inertia explained	0.32	31.7
Unknown	0.68	68.3
Total Inertia	1.00	

4. Discussion

The amount of variation in species composition (beta diversity) was higher at the landscape scale (32%), than at the local scale (13.89%). This indicates that differences in species composition are greater among landscape units with varying degrees of fragmentation, compared to differences among vegetation cover classes (Figures 2a, 3a).

Arroyo-Mora et al. (2005) also found differences in species composition among successional classes in neotropical dry forests.

At both spatial scales, environmental factors and spatial dependence explained a similar amount of variation in species composition (Tables 1. 2). This lends support to both niche theory (environmental drivers, Grubb, 1977) and the neutral theory (based on dispersal limitation, Hubbell 2001, Chust et al. 2006). This is consistent with the recently proposed continuum hypothesis of Gravel et al. (2006), which states that both niche theory and dispersal limitation play an important role in beta diversity.

Variation partition at the local scale showed that soil attributes had a higher contribution to explaining beta diversity than stand age or landscape structure (Table 1). In particular, soil organic matter and pH were the variables most strongly associated with change in species composition (Figure 2b). At the landscape scale, landscape structure was the most important contributor to beta diversity (Table 2). The large patch index (LPI), which was the variable most strongly associated with beta diversity, was also positively associated with the least disturbed landscape units (Figure 3b). These results concur with other studies indicating that species composition is affected by several factors and process operating at different spatial scales (Leibold, 2006, Hubbell, 2001, Parker, 2004).

Although there were fewer environmental and space variables explaining species composition at the landscape scale than at the local scale, the variation explained by these variables was more than double at the landscape scale compared to the local scale (31.7% versus 13.8%). This may suggest that disturbance has a greater influence on woody species composition than vegetation cover.

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Impact of roads on ungulate species: a preliminary approach in Portugal

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Abstract

The impact of linear infrastructures, particularly the roads on wildlife, has been one of the highlight themes of a new field of knowledge that combine Conservation Biology and modern Engineering Sciences. The impacts of roads in the ecological landscape include habitat loss, fragmentation and degradation, barrier effect, wildlife vehicle-collisions, among others long-term effects. Wildlife vehicle-collisions represent an additive source of mortality to wildlife populations in addiction to natural mortality, such as predation and disease. This preliminary approach reveals the importance of variables involved in vehicle collisions with ungulate species in northern and central Portugal, such as road type, time of the day and season of the year. In this study the majority of accidents occured with wild boar at national roads (EN), during the night and principally in winter and August. These studies are very important in order to prevent and mitigate effects of vehicle-collisions on large animal populations.

Keywords: ungulate vehicle-collisions; wild boar; red deer; roe deer; central and northern Portugal

1. Introduction

The references of wildlife vehicle-collisions began on the 1920' and 30' by some researchers, and very few of these early studies found ungulate causalities (Gagnon *et al.* 2007). From 1970' big game species, such as ungulates, became a concern as traffic levels and vehicle speeds increased, leading to higher rates of ungulate vehicle-collisions. Research of potential direct and indirect effects of roads and traffic on ungulates populations start on that time. There are many studies about this subject (Christie & Nason 2003, Seiler 2004, Huijser *et al.* 2009, Apollonio *et al.* 2010). Actually we know that roads and traffic associated have many primary effects on wild ungulates populations and ecological landscape, as mortality caused by ungulate-vehicle collisions, habitat loss, fragmentation, and degradation, decreased movement across roadways leading to habitat fragmentation and potentially genetic isolation, recognized as barrier effect, among others long-term effects (Gagnon *et al.* 2007; Huijser *et al.* 2009).
Roads, in general, are a great linear feature within the landscape directly impacting wildlife populations through vehicle collisions. The ungulate vehicle-collisions often result in injuries or

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fatalities to vehicle occupants, significant property damage, and animal deaths that represent an additive source of mortality to wildlife populations, in addition to other mortality, such as predation and disease (Christie and Nason 2004, Seiler 2004). Road mortality affects the individual animals and also some species at the population level which may create a serious reduction in population survival probability, affecting the entire ecosystem (Bruinderink and Hazebroek 1996; Huijser 2009). Further, these collisions are a considerable threat to traffic safety, socio-economics, animal welfare, and wildlife management and conservation (Christie and Nason 2004; Seiler 2004; Huijser 2009).

Some researchers state that the increasing traffic levels are the primary reason for number grow of ungulate vehicle-collisions but many recognize traffic level as a component of this increase, along others factors such as wildlife population fluctuations, wildlife behavior, driver behavior and temporal and spatial environmental factors (Gagnon *et al.* 2007).

In Portugal there is a lack of information about this subject but we know that the wild ungulate populations, as wild boar (*Sus scrofa*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) tend to increase in a generalized way (Vingada *et al.* 2010). Some populations have been dispersing into historical areas like coastal and urban areas. It's just at this range, where human presence is more intense, causing impacts on these species.

This study aimed to put in evidence some variables involved in car accidents with ungulates in central and northern Portugal, and the conclusions obtained may be important to help the mitigation of ungulate-vehicle collisions and ungulate habitat fragmentation because it could potentially be used by roads designers and planners to avoid potentially hazardous areas in future roads development or new roadway design or to identify appropriate preventive measures. The findings could also potentially be used to identify "black points" on existing routes that are involved in many ungulate-vehicle accidents and should be the focus of mitigate procedures.

2. Methodology

Ungulate vehicle-collisions data was acquired from the National Forestry Authority (AFN) of the Portuguese Ministry of Agriculture, particularly the services at central and northern Portugal (Central Regional Direction of Forests (DRFC) and Northern Regional Direction of Forests (DRFN)). Many of this data belong to the National Policy whose reports wildlife vehicle-collisions cases to AFN.

Data used for this work include the districts of Aveiro, Braga, Bragança, Castelo Branco, Coimbra, Guarda, Leiria, Portalegre, Porto, Viana do Castelo, Vila Real and Viseu. The information was collected during 10 years, from 1999 to 2009. However data from 1999 and 2000 are unreliable, as well as in 2008 and 2009. During these two last years, the lack of information can be explain by the few number of cases that arrives to AFN. Probably some of them will be received soon.

A database with important information as the species involved in the accident, local, the road type, date, particularly the month and year, and time of day was created. This study involves three ungulate species, wild boar (*Sus scrofa*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) and are considered six different road types namely national roads (EN), municipal roads (EM), high speed roads (A), complementary roads (IC), main roads (IP) and forestry ways (CF). The times of day (dawn, day, evening and night) was defined according to the seasons with specific hour range.

The information contained in database was subjected of a basic statistical analysis as the collisions' percentage with wild boar, roe deer and roe deer, to understand which the ungulate's species are more affected by the vehicle accidents; collisions' percentage in the different types of roads, to evidence the importance of the selected landscape variables to make the area more or less susceptible to these types of accidents; collisions' percentage at different time of the day and months of year (date), to understand the relation of road type to ungulate movements and behaviour.

3. Results

According to our data, the majority of the ungulate vehicle-collisions with tractable information occurred with wild boar (86%), followed by roe deer (9%) and lastly the red deer with 5% of the cases (Figure 1).
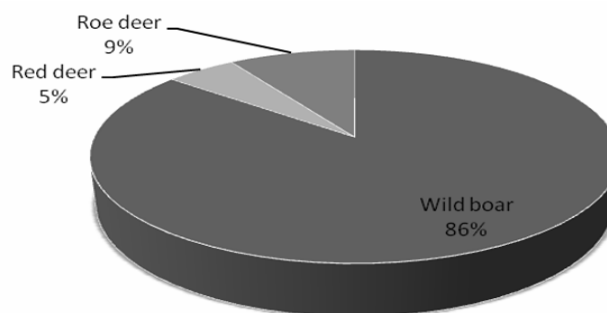
Figure 1: Percentage of ungulate vehicle-collisions per species in central and northern Portugal.

Taking into account the road type (Figure 2) it is evident that the majority of ungulate vehicle-collisions occurred at national roads (EN), with 131 cases among 186, which corresponds to 70,4% of the cases, followed by municipal roads (EM) (12,9%), high speed roads (A) (9,1%), main road (IP) (5,4%) and complementary roads (IC) and forestry way (CF) with 2 accidents each one (1,1%).
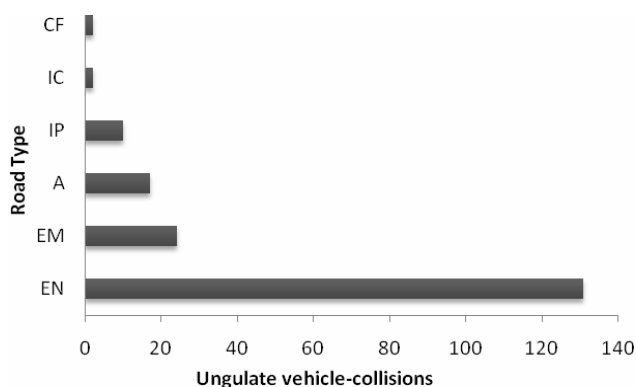
Figure 2: Ungulate vehicle-collisions in different road types (EN; EM; A; IP; IC; CF) in central and northern Portugal

The distribution of ungulate vehicle-collisions throughout the months of the year showed that the majority of accidents occurred in winter, particularly in the months of November (19,5%), December (13,3%) and January (13,8%) and in summer its visible a peak in August (10,8) (Figure 3).
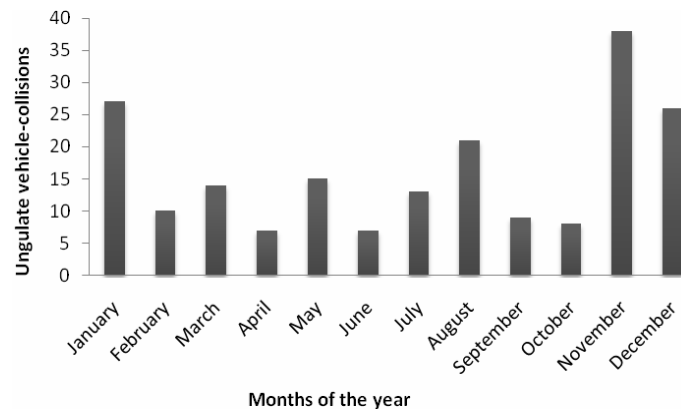
Figure 3: Distribution of ungulate vehicle-collisions over the months of the year (1999 to 2009) in central and northern Portugal.

Day time analysis highlights the nigh period that concentrate the biggest ungulate vehicle-collisions number with 129 cases (70,9%). The accidents involving ungulates occurred in the evening showed a smaller but still relevant peak with 27 cases of the 182 (14,8%) (Figure 4).

The number of accidents during the dawn and day are the less expressive, corresponding both to 14,3% of the total ungulate vehicle-collisions in central and northern Portugal.
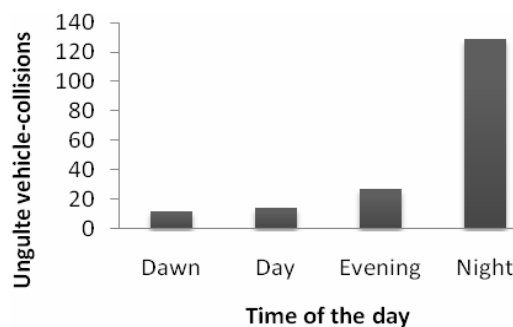
Figure 4: Ungulate vehicle-collisions at different time of day (dawn; day; evening; night) in central and northern Portugal (1999-2009 years interval).

4. Discussion

Linear infrastructures like roads and the traffic associated have impacts on wildlife and particularly in this case, in ungulate species. To understand the size of the problem it's imperative to monitor roads kills, on a national scale, and comprehend the various parameters involved in the accidents.

Our data support that in Portugal the wild boar was the most affected wild ungulate in central and northern Portugal with 86% of the vehicle-collisions, and in all districts of the study area this ungulate species was the most affected target because it's the ungulate more widely distributed in Continental Portugal, occupying almost the entire national territory except for large urban settlements and some coastal areas (Vingada *et al.* 2010).

Roe deer's collisions correspond to a 9% of amount cases, which support the reduced number of animals killed by cars. Population estimates show that current populations of roe deer in Portugal include between 3000 and 5000 animals (Vingada *et al.* 2010), with the highest densities concentrated in the northern region of the country where the roe deer collisions were higher (districts of Braga, Viana do Castelo and Bragança).

The red deer vehicle-collisions correspond to a 5% of the cases which proof the reduced and scattered distribution of this animal at Portugal (Vingada *et al.* 2010). The data of red deer collisions were mostly in the districts of Coimbra, Viseu, Bragança, Viana do Castelo and Castelo Branco which is according to dispersed Portuguese northern and central populations (Tejo Internationa, Lousã and Montesinho).

According to the analysis of road type the majority of ungulate vehicle-collisions occurred at National Roads (EN), with overwhelming percentage of 70,4%, probably due to the high traffic volume and bad road conditions. The lower number of accidents with ungulate in main roads (IP), complementary roads (IC) and high speed road (A) could be explained by the existence of lateral road protections (fences) in both sides of the road which avoid the invasion of wild animals. Only two cases of wildlife vehicle-collisions were recorded in forestry ways (CF) because this type of road has not regularly traffic, although of the bad conditions.

The majority of ungulate vehicle-collisions occurred in winter, particularly in November, December and January. This can be explained by the fact that the big game hunting period is mainly from October to February and it's precisely in this time of the year that the animals are more restless (Fonseca and Correia 2008). The August ungulate-vehicle collisions' peak can be derived from the holiday's traffic growth in Portugal.

As expected the overwhelming percentage of accidents occurred at night (70,9%) because it's precisely the time of the day that the ungulates are more active (Apollonio *et al.* 2010). During the dawn, day and evening the number of accidents involving ungulates are smaller.

This study indicates that there are some variables that can contribute to the ungulate vehicle-collisions increase such as the road type, time of the day and month of the year. The first variable can be amended by man in the sense of prevent and mitigate the accidents with wildlife, particularly involving large animals, such as ungulates, but the second concerns to the biology and behaviour of animals.

Gradually there is a growing concern in the road planning and implementation, according to the measures to prevent and mitigate the impacts on wildlife. The design of infrastructures in the landscape has an enormous relevance to wildlife because it causes mainly the fragmentation of available ungulate habitat and resulting in a diminished habitat connectivity and permeability. Mitigations measures that include wildlife crossing structures not only substantially reduce road mortality, but also allow movements of animals across the road (Huijser *et al.* 2009). Properly designed wildlife crossing structures may help to reduce the barrier effect of roads while decrease ungulate vehicle-collisions (Gagnon *et al.* 2007). This connectivity is essential to survival probability of the fragmented populations of some species, in determinate regions. As referred by Seiler (2004) if these measures will be combined with traffic adjustments, such as reduced speed limits, rerouting of traffic flow or improvement of features roads, traffic safety may further be improved and the collisions with wildlife will reduce.

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Electrical network hazard assessment for the avifauna in Portugal

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Abstract

The suspended electrical network represents a danger to the birds' wildlife conservation, both because of the possibility of collision and electrocution. Land use type is strictly related to birds' presence, eating habits and nesting. This way they are factors that are directly related to collision and electrocution hazards.

This work was based on the occurrences geographical position and the location of suspended electrical network. The available data were used to create a GIS in order to calculate hazard maps, by means of geostatistical processes and multivariate analysis.

The final results indicate that approximately 46% of the total (km) electrical network analysed are classified with the two higher hazard classes in the case of electrocution, and about 40% in the case of collision. The classification maps show that the danger of electrocution is greatest in the central and southern Portugal, and the danger of collision is higher in the central region.

Keywords: Avifauna; Collision, Electrocution; Hazard Assessment, GIS

1. Introduction

In the year of 2003, four Portuguese entities: the Portuguese enterprise for electrical energy (EDP – Electricidade De Portugal), the Portuguese Institute for Nature Conservation (ICN – Instituto da Conservação da Natureza), the National Association for Nature Conservation (Quercus - Associação Nacional de Conservação da Natureza) and the Portuguese Society for Birds Survey (SPEA - Sociedade Portuguesa para o Estudo das Aves), signed up a protocol, in order to analyse the relationship between the Portuguese electrical network (high and middle power) and the birds' wildlife conservation.

This research project was derived for entire continental Portugal, with special attention to areas under special protection areas (SPA's) for birds nesting and migration (ZPE - Zonas de Protecção Especial) and areas classified *Important Bird Areas* (IBA's), whish represent 1372966 ha.

The study sought to characterize, in general, the impacts of the electrical power network on the avifauna, in the identification and classification of power lines and their wire supports, in order to create a hazard index (Brandão *et al*. 2005; Martins 2009).

The results from a research project derived in Spain showed that the use of orange PVC spirals along electrical power wire network leaded to a decrease in 60% of birds' collision to electrical wire. The results also showed that the use of these orange PVC spirals reduced the number of birds flying between suspended electrical wire leading birds to fly over or under electrical power wire network (Ferrer & Janss, 1999).

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Results from a 25 year research in USA, showed that the use of non conductive materials for isolate the ground wire from the phase conductor wire or the distance enlargement between these two electrical wire, leaded to a significant decrease in birds of prey dead, such as eagles and hawk, by electrocution. Another important result is related to birds' propensity to nest on the suspension towers of electric network. This way, the researchers proposed the use of landing and/or nesting platforms erected over towers ends (James & Haak 1979).

The aim of this paper is to present the results from a Geographical Information System created to analyse the relationship between the Portuguese electrical network (high and middle power) and the birds' wildlife conservation (Scott et al. 1972; Meyer 1978; James & Haak 1979; Beaulaurier 1981; Burrough 1987; Janns & Ferrer 1998; Bernhardsen 1999; Janss 2000).

The study was conducted for entire continental Portugal and was developed in protected areas, IBAs and SPAs (see Figure 1), in a total area of, approximately, 1 409 365ha (Brandão et al. 2005). They are, in this territory, the most important sites for wild birds, bringing together more than 90% of the national population of at least 21 species of Annex I of Birds Directive. In order to improve the management of fieldwork, the study area was divided into 4 sampling zones and data were collected along 61 senses performed on sections selected for the study of hazard rates, the frequency estimates for birds and species diversity (Brandão et al. 2005).
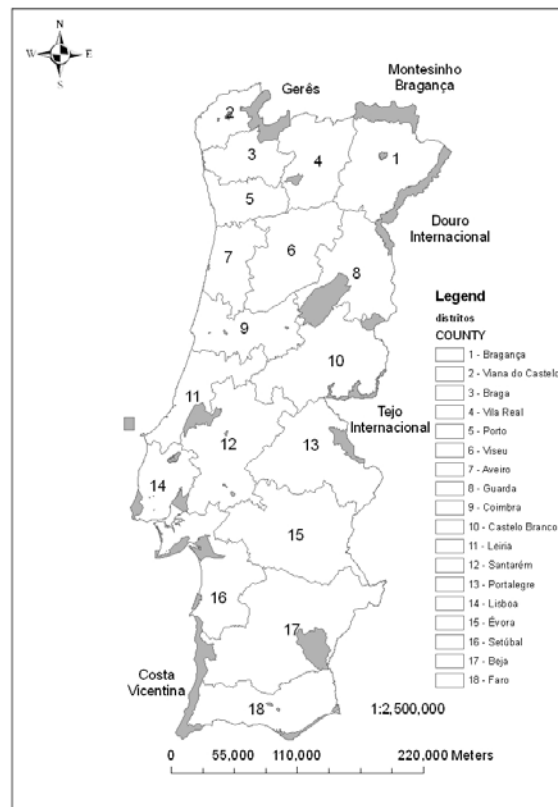
Figure 1: Study area location [Adapted from Portuguese Environment Atlas 2009]

2. Methodology

For a year, all incidents relating to birds killed or injured by the electric network, within protected areas, natural parks and national parks, have been reported, recorded its position with a GPS and recorded the nature of death or injury. The information collected was recorded in a database, which was used to create a geographic information system.

In a second stage, the GIS was updated with information concerning:
- Portuguese electrical network
- Portuguese Roads network
- Settlements Location
- Land use and land cover map
- Digital Elevation Model

In the third stage, using 3D Analyst and Spatial Analyst Tools, the recorded information was processed in order to calculate:
- Land slope and aspect
- Distances to water bodies
- Distance to road network

The fourd stage was dedicated to geodata analysis and multivariate statistics calculation. They were used Principal Components Analysis, Cluster Analisys and Geostatistical Analysis, in order to stablish a relationship between the Portuguese electrical network (high and middle power), environmental characteristics and the birds' wildlife conservation (Morrison, 1991; Reis, 1997; Hoef et al, 2001; Soares 2006).

Results from previous present stages were, then, used to create collition and electrocution hazard maps for IBAs and SPAs

3. Result

Results from data management shown that the frequency of deaths is higher in Steppe land and Agroforestry areas. Tables 1 and 2 summarizes all deaths by type of habitat and electrical power line hazard level.

Table 1: Deaths by type of habitat

Habitat (class code)	Total (n)	%
Steppe (1)	110	28.06
Shrub land (2)	32	8.16
Forested land (3)	51	13.01
Inland wetlands (4)	16	4.08
Coastal wetlands (5)	5	1.28
Agroforestry mosaic (6)	174	44.39
Other (e.g. bare soil) (7)	4	1.02
Total	392	100.00

Results from Principal Components Analysis revealed a positive correlation between the number of deaths and the number of power line network planes and a negative correlation to distance to roads. This could indicate that the "mortality rate" increases as "distance to roads," decreases because power line network is often parallel to road network and birds need to cross roads for feeding in around land.

Table 2: Electrical power line classification, according to hazard level

	Class	Death_class	Number of lines	Length (km)	Length (%)
Electrocution	1	[0 ; 0,83]	6447	1597,375	9,21
	2	[0,83 ; 1,66]	4386	1698,577	9,79
	3	[1,66 ; 2,49]	14926	6024,488	34,72
	4	[2,49 ; 3,33]	11267	4899,044	28,24
	5	[3,33 ; 4,16]	8223	3130,009	18,04
Collision	1	[0 ; 1,32]	6248	2649,333	17,28
	2	[1,32 ; 2,65]	9360	3439,777	22,46
	3	[2,65 ; 3,97]	10557	3761,530	24,53
	4	[3,97 ; 5,30]	6365	2356,527	15,37
	5	[5,30 ; 6,63]	7685	3128,657	20,40

Final results enable to state that Portuguese country areas with lower degree of birds' electric shock danger are: the north and part of the center, as well as the southwestern district of Lisbon, and the coastline of the districts of Setúbal and Beja.
In the districts of Guarda, Castelo Branco; Bragança, Braga, Porto, Portalegre, Santarém (North), Setubal and Viana do Castelo dominates the middle class of danger (see Figure 1 for location).
The regions under high hazard level are: the districts of Évora, Santarém (South), Lisboa (northeast) Beja (central and northern) and Faro.
According to the power line network characteristics and location, the south of Portugal is the results most concern as well the central coast.

4. Discussion

The objectives of this study were successfully achieved. The entire power line net work was classified and analysed, for the entire country, the relationship between power network and environmental characteristics, with special relevance for Natural Regions and Protected Areas. We would like to highlight the following results:
the worst case scenario, related to collision hazard, indicates that the high and very high hazard classes of collision are present in more than 36% of the total analysed kilometres,
for electrocution hazard, the worst forecast indicates the prevalence of high and very high hazard classes in approximately 50% of the total analysed kilometres.
These results are worrying in terms of ecology, and should wherever possible, be eliminated or minimised in order to reduce negative effects on avifauna,
for Natural Regions and Protected Areas, the results indicate that the high and very high hazard classes of collision are present in more than 43% of the total analysed kilometres, the high and very high hazard classes of electrocution are present in more than 34% of the total analysed kilometres and 43% classified as middle class.

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Acknowledgement

Modeling land use/cover change and biodiversity conservation in Mexico

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Abstract

A nationwide multidate GIS database was generated in order to carry out the quantification and spatial characterization of land use/cover changes (LUCC) in Mexico during the last decades. Digital maps from three different dates (1993, 2002 and 2007) were revised and integrated into a GIS database along with ancillary data (Road network, settlements, slope and socio-economical parameters at the municipality level). Land cover maps were overlaid in order to generate LUCC maps and calculate two indices de LUCC: 1) a simple rate of deforestation and 2) a rate of degradation which takes into account the degradation and recovery processes. An analysis of causes and drivers of LUCC was conducted, at the municipality level, computing the Spearman coefficient between these two rates and biophysical and socio-economic factors. Change trends were also compared with biodiversity distribution. Preliminary results show that although rates of deforestation have decreased during the most recent period, LUCC still represents a serious threat to biodiversity conservation in Mexico.

Keywords:land use/cover change, modeling, drivers, biodiversity

1. Introduction

Mexico is a megadiverse country, but biodiversity is threatened by the loss of native vegetation due to the high rates of deforestation (FAO, 2001). Various studies have attempted to assess land use/ cover change (LUCC) over the last decades (Mas et al., 2004). Fuller et al. (2007) examined the effect of LUCC on the distributions of 86 endemic mammal species in 1970, 1976, 1993, and 2000 in Mexico. They showed that this fauna could have been protected considerably more economically if a conservation plan had been implemented in 1970 than is possible today due to extensive conversion of primary habitats. At each time step, optimal conservation area networks were selected to represent all species. These authors found that 90% more land must be protected after 2000 to protect adequate mammal habitat than would have been required in 1970. The goals of this study are to 1) delineate maps of LUCC in Mexico for different periods, 2) identify variables and drivers that influence the LUCC rates and 3) compare LUCC trends with a biodiversity map to evaluate the possible effects of LUCC on biodiversity conservation. In this paper, we present the preliminary results.

2. Methodology

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2.1. Material

The following data were used:

- Maps of land use/cover (LUC) at 1:250,000 scale from the National Institute of Geography, Statistics and Informatics (INEGI) for 1993, 2002 and 2007. These maps are compatible with regards to scale and classification scheme. The classification scheme distinguishes primary covers and 3 categories of secondary land covers (with herbaceous, scrub and tree secondary vegetation respectively). According to INEGI, primary vegetation is defined as relatively undisturbed vegetation that preserves, in large part, its condition of density, coverage, and species composition from its original, primary, ecosystem. Secondary vegetation is defined as the vegetation which substitutes totally or partially the original (primary) vegetation as a result of secondary succession.

- Map of species richness: To generate this map, Sánchez-Cordero et al. (2005) modeled ecological niches for the 459 continental mammal species of Mexico using point occurrence distribution from national and international scientific collections and environmental data layers, including potential vegetation type, elevation, topography and climatic parameters using the Genetic Algorithm for Rule-set Prediction (Stockwell et al. 1999; Anderson et al. 2003). Then maps of each species were overlain in order to calculate the species richness.

- Maps of ancillary data (digital elevation model, roads maps, human settlements, municipal boundaries).

- Socio-economic data from the INEGI organized by municipality (Population census for 2000 and 2005).

GIS operations were carried out with the program ArcGIS (ESRI, Redlands, CA) and statistical analysis and graphs were created using R (R Development Core Team 2009).

2.2. LUCC Monitoring

Mapping of LUCC was done by overlaying the LUC maps of different dates. Based upon LUCC maps, areas of change were tabulated and rates of change, including the rate of deforestation, were computed. As the rate of deforestation is sensitive to the change from forest areas (primary and secondary covers altogether) to non forest area only, we also applied an "index of conservation" which takes into account forest degradation and recovery (e.g. transitions between secondary categories). Land cover categories were associated to a weight value ranging from 0 to 4 for anthropogenic, herbaceous secondary, scrub secondary, tree secondary and primary forest forest respectively. Mean values of this index was calculated for 2004 and 2007 for each municipality.

3.2. Relationship between LUCC and socioeconomic features

To determine which socioeconomic factors are most likely to be indirect drivers of deforestation we calculated the rate of deforestation and the variation of the conservation index for each municipality for 2004-2007 and compared them with various indices describing population density, education, poverty and accessibility to resources. These indices were: a) Population density in 2000 and 2005 (people per km^2) and the variation of density between these two dates; b) settlements density (number of settlements per km^2); c) proportion of the population older

than 12 years without primary education; d) proportion of the population speaking an indigenous language; e) proportion of the population living in small settlements (with less than 100 and 2500 inhabitants); f) proportion of population between 20 and 39 years (%), which is expected to be inversely correlated with migration; g) proportion of houses with a cement roof as an index of social welfare; h) the Gini index which measures inequality and ranges theoretically from 0 to 100, where 0 is perfect equality and 100 perfect inequality; i) the mean salary (expressed as the number of minimum wage salaries) and the proportion of the population with less than one and two minimum wage salaries; j) the natural cover area (ha) and the proportion of total area covered by natural cover; k) the mean slope (degrees); and l) the road density (km of road per km^2).

3. Result

3.1. LUCC Monitoring

Figure 1 and table 1 shows a significant decrease of forest area (except secondary temperate forest) and an increase of crop and pasture lands during both periods. However, rates of change are lower during the more recent period.
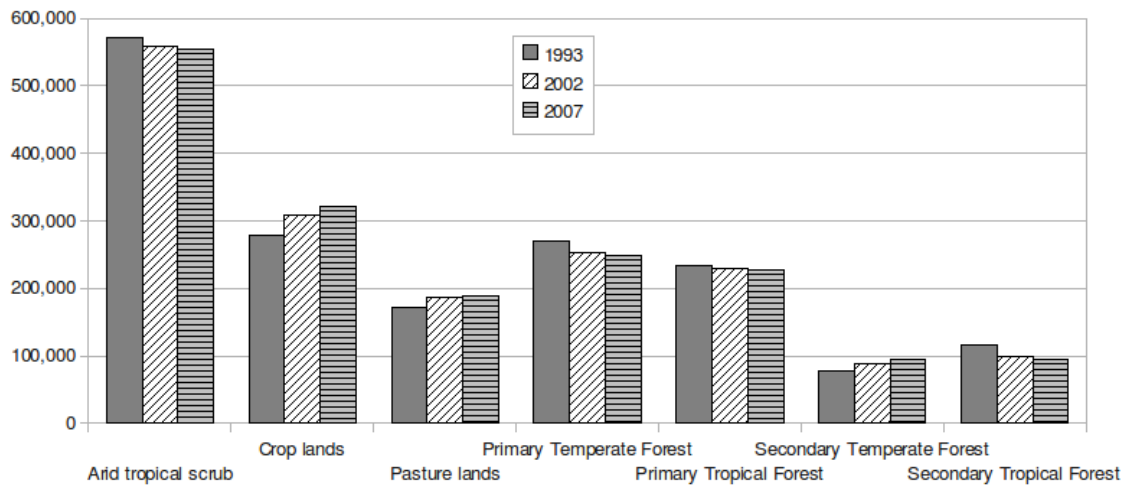
Figure 1: Areas of the main land cover types in 1993, 2002 and 2007 (km^2)

Table 1: Rates of changes for the main land cover types

Land cover category	Area (km^2)			Change (km^2/yr)		Rate of change (%/yr)	
	1993	2002	2007	1993-2002	2002-07	1993-2002	2002-07
Arid tropical scrub	571383	558297	554661	-1454	-727	-0.26	-0.13
Crop lands	278424	308592	321597	3352	2601	1.15	0.83
Pasture lands	172278	187587	188964	1701	275	0.95	0.15
Primary Temperate Forest	270432	252891	247707	-1949	-1037	-0.74	-0.41
Primary Tropical Forest	233388	229815	227205	-397	-522	-0.17	-0.23
Secondary Temperate Forest	78021	89028	93987	1223	992	1.48	1.09
Secondary Tropical Forest	116316	99333	93726	-1887	-1121	-1.74	-1.16

3.2. Analysis of drivers

For the statistical analysis we use only the municipalities with a scrublands or forest area covering at least 500 ha and 30% of the municipality. 2314 municipalities (of a total of 2443) fulfilled this condition and represent more than 96% of the forest and scrub area of the country. Figure 2 shows the rate of deforestation per municipality.

Table 2 shows that rate of deforestation and the variation of the conservation index are strongly associated ($R = 0.77$, $p < 0.01$) and that both indices are weakly, but significantly, related to some of the indices describing the socio-economic and environmental characteristics of the municipalities. Unexpectedly, population density is negatively correlated with degradation and deforestation during 2002-2007 although the increase of density is related with an increase of deforestation. Indices related with poverty present a positive correlation with deforestation and degradation. No significant correlation was found with the Gini index. Higher slopes and unexpectedly road density tend to reduce the deforestation/degradation.

Table 2: Spearman correlation between change and municipality characteristics

Index	Rate of deforestation*		Degradation (Variation of conservation index) *	
	R	p	R	p
Population density 2000 (people per km^2)	-0.04	0.14	-0.05	0.03
Population density 2005 (people per km^2)	-0.02	0.34	-0.05	0.06
Population density variation 2000-2005	0.11	0.00	0.05	0.05
Settlements density (settlements per km^2)	-0.07	0.01	-0.06	0.02
Population older than 12 years without primary education (%)	-0.10	0.00	-0.05	0.06
Population speaking an indigenous language (%)	-0.04	0.07	-0.06	0.02
Population living in settlement of less than 100 inhabitants (%)	-0.02	0.37	0.00	0.97
Population living in settlement of less than 2500 inhabitants (%)	-0.09	0.00	-0.05	0.03
Population between 20 and 39 years (%)	0.17	0.00	0.06	0.02
Houses with cement roof (%)	0.06	0.01	0.03	0.21
Gini index	0.00	0.95	0.00	1.00
Mean salary (number of minimum salary)	0.13	0.00	0.13	0.00
Population with less than one minimum salary (%)	-0.11	0.00	-0.12	0.00
Population with less than 2 minimum salary (%)	-0.13	0.00	-0.13	0.00
Natural cover area (ha)	0.23	0.00	0.23	0.00
Natural cover area (%)	0.09	0.00	0.11	0.00
Mean slope (degrees)	-0.24	0.00	-0.15	0.00
Road density (km/km^2)	-0.13	0.00	-0.11	0.00
Rate of deforestation	-	-	0.77	0.00

* A negative value for the rate of deforestation and degradation indicates recovery
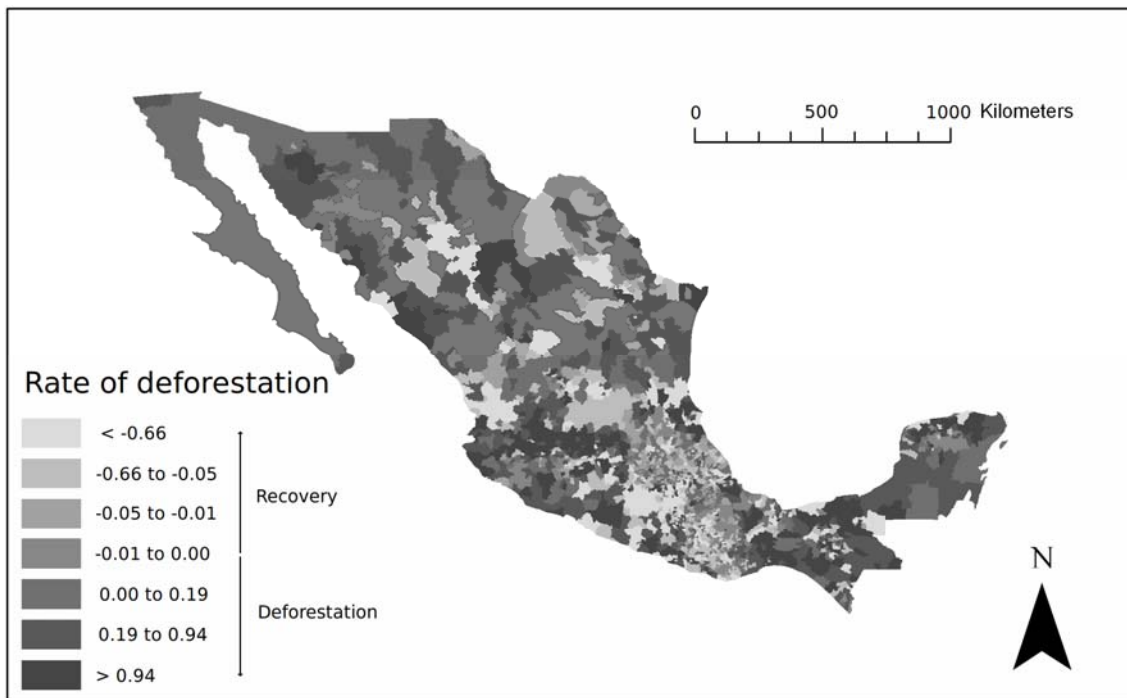
Figure 2: Rates of deforestation by municipality (2002-2007)

Spearman's coefficient of rank correlation between the rate of deforestation and the average species richness per municipality is 0.06 (p < 0.01). The coefficient between the rate of degradation and the average species richness is 0.11 (p < 0.01) which indicates that most threatened areas tend to present more biodiversity.

4. Discussion

According to INEGI maps, the patterns of change observed during 1993-2002 remain similar in 2002-2007: Crop and pasture area is increasing and forest area, expect secondary temperate forest, is decreasing. However, the rates of deforestation are lower during the second period except for primary tropical forest, which presented an increase of the rate of deforestation. Rates of deforestation and degradation tend to be higher in biodiverse areas and, therefore, LUCC still represents a serious threat to biodiversity conservation in Mexico.

The results of the analysis of the drivers must be taken with caution for various reasons: 1) Analysis was based upon average characteristics of the municipality, yet their size is very variable (125 to more than 5,000,000 ha) and they are often heterogeneous; 2) the causes of LUCC in a given municipality are not necessarily reflected in the characteristics of this municipality (spatial lag); 3) LUCC are likely due to different processes over the entire territory, which can obscure meaningful explanatory variables in a nationwide study; 4) only recent LUCC are observed, in many settled regions, with high population and road density, rates of deforestation are low because few forests remain. Moreover, due to multicollinearity, a variable correlated with rates of LUCC may actually have no influence and be correlated with the true causal variables. In further research, method such as hierarchical partitioning will be used in order to deal with these limitations (MacNally 2000; 2002).

However, the results obtained which indicate that marginal poor areas present lower rates of deforestation and degradation are not surprising. Many previous studies reported that most conserved natural areas in Mexico are often located in poor rural areas and/or community lands where people have demonstrated for centuries that they have the ingenuity to cope with major

environmental and social threats to their live-hoods (Klooster 2000; Alix-Garcia et al. 2005; Merino 2007, Figueroa et al. 2009, García-Barrios et al. 2009).

5. Acknowledgements

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Evaluating an old sustainable national forest in south Brazil to decide their conservation status

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Abstract

National Forests were settled in the past in order to increase forestry surveys in Brazil. After their transformation in units of conservation of sustainable use, old abandoned sets becoming important remainders of the endangered Atlantic Forest. The recent government intention to exploit their timber has caused discussions regarding this legallity. To elucidate their appliance, reforestation in the Açunguí National Forest were evaluated. Studies showed 61 species and 30 families, which the most representative were Flacourtiaceae, Lauraceae and Myrtaceae. Frequent species were *Araucaria angustifolia, Cordyline dracaenoides*, *Cyathea corcovadensis*, *Casearia sylvestris, Allophyllus edulis, Clethra scabra, Dalbergia brasiliensis*, and *Matayba elaeagnoides*. The IVI varied between 14.3 and 7.5. Diversity of species was high for secondary forested areas - Shannon's index (H'= 3.15); evenness (J'= 0,77). There were endangered species and bioindicators that enhance the ecological importance of this National Forest. Thus, this one should not be exploited despite their original purpose.

Keywords: Araucaria forest – Atlantic Forest – planted forests

1. Introduction

Remnants of Ombrophylous Mixed Forest is one of the most endangerous at the Atlantic Forest Biome (Castella and Britez 2004). Native species reforestation was a federal politics in Brazil in the decades of 1940-60, settling National Forests all over the country. After the project's dismounting and their transformation in units of conservation of sustainable use (SNUC 2000), old sets presenting vigorous sub-forests becoming important remainders of the endangered Atlantic Forest. Nowadays, the government intention to exploit their timber has caused intense internal discussions once they could be protected by law as mature regenerated forests. Intending to elucidate their appliance, we analyze sub-sets under reforestation and under natural regeneration.

2. Methodology

Surveys were carried out in seventeen 0.01-ha plots laid out in a 30-yr-old 400 ha planted *Araucaria* stand and a natural 320 ha *Araucaria* forest (see figure 1) at Açungui National Forest in Campo Largo, State of Paraná, Southern Brazil (25°10'41"S - 25°14'18"W). The dominant soil types in the region are Inceptisol and Ultisol. The climate is classified as Cfb (under Koeppen's climate classification system), at elevations between 640 m and 905 m above sea level. Phytosociological parameters were performed by Fitopac Software (Shepherd 1994) and the samples are in the HUPG herbarium at Universidade Estadual de Ponta Grossa.

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Figure 1: Sampling sites at Açungui National Forest, Campo Largo (Paraná, Brazil).

3. Results

Among the landscape units, the Natural Forest has 38% of natural *Araucaria* forests and 56% of planted *Araucaria* stands. Species composition and several forest structure parameters are summarized in Tables 1 and 2. Both natural and planted *Araucaria* stands showed similar phytosociological parameters. Therefore, there is evidences that abandoned planted *Araucaria* stands are able to restore this type of community in the Atlantic Forest Biome almost like the espontaneous secondary sucession.

More than a half of the species found in both planted and natural *Araucaria* stands were represented by Flacourtiaceae, Lauraceae and Myrtaceae. Sapindaceae and Euphorbiaceae were found only in the natural *Araucaria* stand. The most abundant families found under the canopy were Agavaceae, Flacourtiaceae, Sapindaceae, Cyatheaceae, Myrtaceae, Canellaceae, and Euphorbiaceae. In terms of the Importance Value Index (IVI), the Flacourtiaceae, Agavaceae, Cyatheaceae, Sapindaceae, and Fabaceae were the most important families found under planted *Araucaria* stands while Sapindaceae, Myrtaceae, Flacourtiaceae, and Araucariaceae were the most important families found under the natural forest canopy.

In the planted *Araucaria* stands only *Araucaria angustifolia* stood up from the canopy, otherwise in the natural forest *Matayba elaeagnoides* could emerge to. The more frequent species were *Casearia sylvestris*, *Casearia lasiophylla, Casearia obliqua*, *Casearia inaequilatera, Vitex megapotamica, Guatteria australis*, *Cabralea canjerana, Cedrella fissilis*, *Allophyllus edulis, Cupania vernalis*, *Clethra scabra, Dalbergia brasiliensis, Matayba elaeagnoides, Cordyline dracaenoides*, *Cyathea corcovadensis, Cyathea schanschin*, and *Myrcia rostrata*.

Table 1: Phytosociological parameters of *Araucaria* forests at Açungui National Forest, Campo Largo (Paraná, Brazil).

	Under planted *Araucaria* canopy	Under natural *Araucaria* canopy
Number of tree species	61	54
Number of families	30	21
Total number of plants	400	160
Density (plant/ha)	3.333	1.680
Basal area /ha	54.867	-
Canopy – mean Dbh (cm)	11.18	11.32
Canopy – mean height (m)	7.12	6.82
Shannon-Wienner Index	3.15	3,43
Evenness	0.77	0.86
Simpson Index	0.93	0.95

Table 2: Species list of both planted and natural *Araucaria* stands at Açungui National Forest in Campo Largo (Paraná-Brazil).

Family	Species	Common name	Ecological group*	Density **	Use ***
1 Agavaceae	*Cordyline dracaenoides* Kunth	Uvarana	Pi, Si, St	VC	Fo
2 Anacardiaceae	*Schinus terebinthifolius* Raddi	Aroeira-vermelha	Pi, Si, St	NC	Ti/ Me
3 Annonaceae	*Guatteria australis* A.St. Hill.	Embiú		NC	
4 Aquifoliaceae	*Ilex dumosa* Reiss.	Caúna-miúda	Pi, Si, St		Fo
	Ilex paraguariensis A. St.Hill.	Erveira; erva-mate	Pi, Si, St	C	Fo
	Ilex theezans Mart.	Congonha-graúda	Pi, Si, St		Fo
5 Araucariaceae	*Araucaria angustifolia* (Bert.) Kuntze	Araucária	Pi, Si, St	VC	Fo
6 Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	Jerivá	Pi, Si, St		Fo
7 Asteraceae	*Piptocarpha angustifolia* Dusén ex Malme	Vassourão-branco	Pi, Si, St		Ti
8 Bignoniaceae	*Jacaranda micrantha* Cham.	Carobão	Si		
9 Bombacaceae	*Chorisia speciosa* St. Hill.	Paineira	Si, St	R	Ha
10 Borraginaceae	*Cordia ecalyculata* Vell.	Louro-mole	Si, St		
11 Caesalpinaceae	*Apuleia leiocarpa* (Vogel) J.F. Macbr.	Grápia	Si, St, Cl	R	
12 Canellaceae	*Capsicodendron dinisii* (Schwanke) Occh.	Pimenteira	Pi, Si, St		Me
13 Celastraceae	*Maytenus evonymoides* Reiss.	Coração-de-bugre	Pi, Si, St	VC	
14 Clethraceae	*Clethra scabra* Pers.	Guaperê	Pi, Si, St	VC	Ti
15 Cunoniaceae	*Lamanonia ternata* Vell.	Guaraperê	Si		
16 Cyatheaceae	*Cyathea corcovadensis* Rad.	Xaxim	Si, St	VC	Ha
	Cyathea schanschin Mart.	Xaxim	Si, St	C	Ha
17 Erythroxylaceae	*Erythroxylum deciduum* St. Hill.	Cocão	Pi, Si	R	
18 Euphorbiaceae	*Actinostemon concolor*	Laranjeira-do-	Pi, Si, St	R	

Family	Species	Common name			
	Spr.	mato			
	Sapium glandulatum (Vell.) Pax	Pau-leiteiro	Pi, Si, St		Me
	Sebastiania brasiliensis Spr.	Tajuvinha	Pi, Si, St		Ti
	Sebastiania commersoniana (Baill.) L. B. Sm. et Downs	Branquinho	Pi, Si, St	R	
19 Fabaceae	*Dalbergia brasiliensis* Vog.	Farinha-seca; marmeleiro	Pi, Si	C	
	Machaerium stipitatum Vog.	Sapuva	Pi, Si		Ti
20 Flacourtiaceae	*Banara tomentosa* Clos.	Guaçatunga-branca	Pi, Si, St	R	
	Casearia decandra Jacq.	Guaçatunga-preta; cambroé	Pi, Si, St		Me
	Casearia inaequilatera Camb.	Guaçatunga-miúda	Pi, Si, St		
	Casearia lasiophylla Sleumer	Guaçatunga-graúda	Pi, Si, St	VC	
	Casearia obliqua Spr.	guaçatunga-vermelha	Pi, Si, St		Me
	Casearia sp			R	
	Casearia sylvestris Sw.	Cafezeiro	Pi, Si, St	VC	Me
	Xylosma ciliatifolium (Clos) Eichler	Sucará	Si, St	NC	
21 Lauraceae	*Cinnamomum sellowianum* (Nees) Kostern.	Canela-raposa	Pi, Si, St	NC	
	Cryptocaria aschersoniana Mez	Canela-fogo	St	C	Ti
	Nectandra lanceolata Ness et Mart. ex Ness	Canela-amarela	Pi, Si, St	C	
	Nectandra megapotamica (Spr.) Mez	Canela-preta; canela imbuia	Pi, Si, St		
	Ocotea dyospyrifolia (Meins.) Mez	Canela-goiaba	Si, St		
	Ocotea lancifolia (Nees) Mez	Canela	St, Cl		
	Ocotea puberula (A.Rich) Nees	Canela-sebo	Pi, Si, St		Ti
22 Meliaceae	*Cabralea canjerana* (Vel.) Mart.	Canjerana	Si, St		Ti
	Cedrella fissilis Vell.	Cedro-rosa	Pi, Si, St		TiMe
	Trichilia elegans A. juss.	Catiguá-de-ervilha	St		
	Trichillia catiguá A. Juss.	catiguá	St		
23 Mimosaceae	*Piptadenia gonoacantha* (Mart.) Macbr.	Pau-jacaré	Pi, Si, St	NC	
24 Monnimiaceae	*Mollinedia clavigera* Tull.	capixim	Pi, Si, St	C	
25 Moraceae	*Ficus guaranítica* Schodat	Figueira		R	
	Sorocea bonplandi (Baill.) W. C. Burger	cincho	Si, St, Cl	NC	
26 Myrsinaceae	*Myrsine umbellata* Mart.	capororocão	Pi, Si, St	C	Ti
27 Myrtaceae	*Campomanesia guabiroba* (DC) Kiaersk.	Guabiroba	Pi, Si, St	C	Fo
	Eugenia blastantha				

	Species	Common name	Group*	Abund.**	Use***
	(O.Berg.) Legr.				
	Eugenia uniflora L.	pitangueira	Pi, Si, St	C	Fo
	Gomidesia affinis (Camb.) Legr.	guamirim			
	Mosiera prismatica (D. Legr.) Landrum	Cerninho; cambuí	Pi, Si, St		Fo
	Myrcia hatschbachii Legr.	Caingá	Si		
	Myrcia myrcioides (Camb.) O. Berg.	Guamirim	Si		
	Myrcia obtecta (Berg.) Kiaersk.	Guamirim-branco; cambuí	Si		
	Myrcia rostrata DC	Guamirim-chorão	Pi, Si, St		Ti
	Myrcianthes pungens (O. Berg) D. Legrand	Guabijú	St		
	Myrtaceae 1				
	Myrtaceae 2				
	Myrtaceae 3				
	Pimenta pseudocaryophyllus Blume	Craveiro	Si		Fo
28 Proteaceae	*Roupala brasiliensis* Kl.	Carvalho	Pi, Si, St		
29 Rosaceae	*Prunus brasiliensis* Schott ex Spr.	Pessegueiro-bravo	Si, St		
30 Rubiaceae	*Coussarea contracta* (Walp.) Muell.Arg.	pimenteira	St		
	Psychotria leiocarpa Cham. et S.	Grandiúva	St		
31 Rutaceae	*Citrus lemon* L.	Limoeiro	Ex	R	Fo
	Zanthoxyllum rhoifolium Lam.	Mamica-de-cadela	Pi, Si, St		
32 Sapindaceae	*Allophylus edulis* (A.St.-Hil., Cambess. & A. Juss.) Radlk).	Chal-chal	Pi, Si, St	VC	
	Cupania vernalis Camb.	Cuvantã	Pi, Si, St	VC	
	Matayba elaeagnoides Radlk.	Miguel-pintado	Pi, Si, St	VC	
33 Solanaceae	Solanaceae 1			R	
34 Styracaceae	*Styrax leprosus* Hook. et Arn.	Carne-de-vaca	Si, St	NC	Ti
35 Verbenaceae	*Aegiphila sellowiana* Cham.	Tamanqueiro	Pi, Si, St		Ha
	Vitex megapotamica (Spr.) Moldenke	Tarumã	St, Cl	C	Me

* PI= initial; Si = initial secondary; St = late secondary; Cl= climacic; Ex = non-native; ** VC- very common: DR≥5%; C- common: 1%>DR%<5%; NC- not common: DR<1%; R- rare: 1 plant in the sample; *** Ti = timber; Me= medicinal; Fo = food; Ha = handcraft.

4. Discussion

According to Brazilian Law definiton (CONAMA 1994), the *Araucaria* Forest at Açungui National Forest might be considered as in intermediary regeneration stadium, characterized by: a) open physiognomies with 1 or 2 strata where *Araucaria* is the only species that stood up over the canopy; there are 53 to 60 species, and tree height ranges from 5 to 16m;

b) including *Araucaria*, basal area ranges from 15 to 54m^2/ha and dbh, from 3 to 62cm; c) liana and epiphytes are rare; there are few grasses and litter reaches more than 10 cm in the most part of the sampled sites; d) gaps could be common, sparsely located; e) there is no dominance of a few species over the others in the stands. Typical species of this regeneration stadium are *Casearia sylvestris, Matayba elaeagnoides, Capsicodendron dinisii, Eugenia uniflora, Dalbergia brasiliensis, Clethra scabra, Casearia lasiophylla, Alophyllus edulis*, and *Cupania vernalis.* It was identified several endangered species as *Dicksonia sellowiana* (IBAMA 1992), *Roupala brasiliensis, Apuleia leiocarpa,* and *Nectandra megapotamica* (Res. SEMA/IAP 31/98). There were endangered species and bioindicators that enhance the ecological importance of this National Forest. Thus, this one should not be exploited despite their original purpose and deserves na integral conservation status.

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A methodological proposal for restoration of forests in southern Brazil

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Abstract

In order to comply with the Brazilian Forest Code, landowners except in the Amazon must set aside at least 20% of their land area as Legal Reserves. Regional projects developed a restoration model that is both ecologically and economically viable. By mixing native and exotic (*Eucalyptus*) species, timber production is possible in 20 years. Adding to wood production, other benefits such as carbon offset, soil and water protection, increased biodiversity, and species conservation are ensured through this strategy. To enhance chances for adoption of such strategy on the highlands in Southern Brazil, we propose to use the native conifer *Araucaria* instead of *Eucalyptus* in the system. A 30-year evaluation between reforestation and natural *Araucaria* canopies showed that biodiversity could be reached using planted forest as well setting natural areas aside. The presence of endangered species in both situations indicated the ecological importance of this alternative.

Keywords: Araucaria forest – forest restoration – planted forests

1. Subject

Timber and cellulose production make up an expressive portion of the Brazilian economy. Planted forests are seen as a land use form of nature conservation on the highlands in southern Brazil. They are important sources of timber that would otherwise be exploited from the natural forests. In order to comply with the Brazilian Forest Code, landowners must set aside at least 20% of their land area as Legal Reserves (except in the Amazon, where at least 80% must be preserved) – land properties that are short of natural forest cover to meet the minimum required Legal Reserve areas are required to restore it by either natural or artificial regeneration.

The Paraná Biodiversity Project, with support from the State Government and the World Bank, developed a Legal Reserve restoration model that is both ecologically and economically viable. It is an effort to combine conservation goals with legal requirements and sustainable development. It is based on a forest management strategy on planted stands with native tree species mixed with exotics (*Eucalyptus*). Timber production is planned on a 20-year span. After harvesting *Eucalyptus* species over that period, only native trees are left to start the restoration of the natural ecosystem. In addition to wood production, other benefits are ensured through the adoption of this strategy such as carbon offset, soil and water protection, increased biodiversity, and species conservation. All these factors contribute to increase forest fragment sizes and landscape connectivity. In order to increase the number of adepts to this strategy on the highlands in Southern Brazil, we propose to use only native species, including *Araucaria angustifolia* instead of *Eucalyptus* as the major timber source in the system.

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2. Base for the proposal

Surveys were carried out in 0.01-ha plots laid out in a 30-yr-old 400 ha planted *Araucaria* stand and a natural 320 ha *Araucaria* forest at Açungui National Forest in Campo Largo, State of Paraná, Southern Brazil (25°10'41"S - 25°14'18"W). The dominant soil types in the region are Inceptisol and Ultisol. The climate is classified as Cfb (under Koeppen's climate classification system), at elevations between 640 m and 905 m above sea level. Species composition and several forest structure parameters are summarized in Table 1.

More than a half of the species found in both planted and natural *Araucaria* stands were represented by Flacourtiaceae, Lauraceae and Myrtaceae. Sapindaceae and Euphorbiaceae were found only in the natural *Araucaria* stand. The most abundant species found under the planted *Araucaria* canopy were of Agavaceae, Flacourtiaceae, Sapindaceae, and Cyatheaceae families. Under the natural *Araucaria* canopy, the most abundant families were Sapindaceae, Myrtaceae, Canellaceae, and Euphorbiaceae. In terms of the Importance Value Index (IVI), the Flacourtiaceae, Agavaceae, Cyatheaceae, Sapindaceae, and Fabaceae were the most important families found under planted *Araucaria* stands while Sapindaceae, Myrtaceae, Flacourtiaceae, and Araucariaceae were the most important families found under the natural forest canopy.

Araucaria trees produced similar height and crown width in both planted and natural stands. The species with the highest relative density under the planted *Araucaria* stand were *Casearia sylvestris*, *Allophyllus edulis, Clethra scabra, Dalbergia brasiliensis*, and *Matayba elaeagnoides* (see figure 1). At shrub level, the stand was dominated by species such as *Cordyline dracaenoides*, *Cyathea corcovadensis,* and *Cyathea schanschin*. The most frequent species were *Cordyline dracaenoides*, *Cyathea corcovadensis*, *Matayba elaeagnoides*, *Casearia sylvestris*, *Casearia lasiophylla, Dalbergia brasiliensis*, *Clethra scabra*, *Cupania vernalis*, *Casearia obliqua*, *Cedrella fissilis*, *Allophyllus edulis*, *Cyathea schanschin*, *Guatteria australis*, *Casearia inaequilatera, Vitex megapotamica, Cabralea canjerana*, and *Myrcia rostrata*.

In the natural stand (see figure 2), only *Araucaria angustifolia* and *Matayba elaeagnoides* stood out over the canopy. The main species present in the stand were *Matayba elaeagnoides*, *Casearia sylvestris*, *Allophyllus edulis, Capsicodendron dinisii, Araucaria angustifolia,* and *Eugenia uniflora*. Among shrubs, the most frequent species were *Mollinedia clavigera*, *Sebastiania brasiliensis*, and *Myrcia hatschbachii*.

Natural and planted *Araucaria* stands were similar in regard to both Shannon index and evenness. Simpson index indicated that there is no dominance of a few species over the others in either stand.

3. Benefits

Both natural and planted *Araucaria* stands showed similar phytosociological parameters. Therefore, our suggestion is that planted *Araucaria* stands are suitable to be used in place of *Eucalyptus* for conservation purposes.

Although *Araucaria* is highly site demanding, when planted on good quality sites, it can produce as much as 50 m³/ha.yr. Commercial *Araucaria* timber volume production was higher in the planted stand.

Eighteen-year-old planted *Araucaria* stands have shown high efficiency in conserving soil organic carbon (Guedes 2005). Thus, wood stock was maintained in levels equivalent to those in natural forests on good sites. Soil organic carbon was maintained on the site at rates ranging from 23 to 56 g/kg, mostly as litter. In a 15-yr-old planted *Araucaria* stand, annual dry matter accumulation in the litter varied from 5.0 to 6.4 Mg/ha (Koehler et al. 1987) while, in natural forests, it could reach 5.9 to 8.3 Mg/ha (Fernandes and Backes 1998; Floss et al. 1999; Figueiredo Filho et al. 2003).

The presence of endangered species in both types of *Araucaria* forests indicated the ecological importance of the low density stand as a suitable alternative for the purpose of

combined timber production and natural forest conservation. We propose a management option involving an initial stand density of 750 trees/ha with at least one thinning down to 250 trees/ha at 15 years of age.

Table 1: Tree species and families found under the canopies of both planted and natural *Araucaria angustifolia* stands at Açungui National Forest in Campo Largo (Paraná-Brazil).

	Under planted *Araucaria* canopy	Under natural *Araucaria* canopy
Sampled area (ha)	0.12	-
Number of tree species	61	53
Number of families	30	19
Density (plant/ha)	550	1,680
Richest families (number of species)	Flacourtiaceae (7) Lauraceae (5) Myrtaceae (4)	Myrtaceae (12) Flacourtiaceae (5) Lauraceae (4) Sapindaceae (2) Euphorbiaceae (2)
Abundant families (count)	Araucariaceae (66) Agavaceae (67) Flacourtiaceae (63) Sapindaceae (42) Cyatheaceae (25)	Sapindaceae (26) Myrtaceae (23) Canellaceae (8) Euphorbiaceae (8)
Families with highest IVI (%)	Araucariaceae (29.5) Flacourtiaceae (10.3) Agavaceae (9.2) Cyatheaceae (7.8) Sapindaceae (7.1) dead (4.4) Fabaceae (3.8)	Sapindaceae (21.9) dead (12.5) Myrtaceae (12.4) Flacourtiaceae (10.5) Araucariaceae (9.6)
Araucaria – mean height (m)	15	16
Araucaria - mean Dbh (cm)	25	29
Canopy – mean height (m)	7.1 (single level)	11.0 and 5.0 (two levels)
Canopy – mean Dbh (cm)	11.2	11.0
Shrub height range (m)	3.0-5.3	3.0-5.3
Species with the highest relative density (in decreasing order)	*Araucaria angustifolia* *Casearia sylvestris* *Allophyllus edulis* *Clethra scabra* *Dalbergia brasiliensis* *Matayba elaeagnoides.*	*Matayba elaeagnoides* *Casearia sylvestris* *Allophyllus edulis* *Capsicodendron dinisii* *Araucaria angustifolia* *Eugenia uniflora.*
Shrub species	*Cordyline dracaenoides* *Cyathea corcovadensis,* *Cyathea schanschin*	*Mollinedia clavigera* *Sebastiania brasiliensis* *Myrcia hatschbachii*
Shannon-Wienner Index	3.15	3.43
Evenness	0.77	0.86
Simpson Index	0.93	0.95

Figure 1: Diagramatic profile (5 X 40 m) of 30-year-old planted *Araucaria* stand at Açungui National Forest in Campo Largo (Paraná-Brazil). 1. *Araucaria angustifolia*; 2. *Cordyline dracaenoides*; 3. *Cyathea corcovadensis*; 4. *Casearia sylvestris*; 5. *Allophyllus edulis*; 6. *Clethra scabra*; 7. *Dalbergia brasiliensis*; 8. *Matayba elaeagnoides*; 9. *Casearia lasiophylla*; 10. *Cupania vernalis*. Author: R. F. Moro.
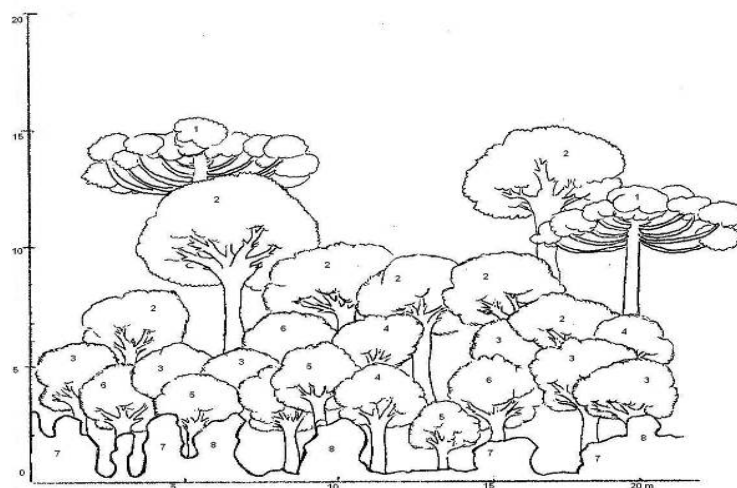
Fig. 2: Diagramatic profile (5 X 20 m) of a 30-year-old natural *Araucaria* stand at Açungui National Forest in Campo Largo (Paraná-Brazil). 1. *Araucaria angustifolia*; 2. *Matayba elaeagnoides*; 3. *Casearia sylvestris*; 4. *Capsicodendron dinisii*; 5. *Allophyllus edulis*; 6. *Eugenia uniflora*; 7. *Mollinedia clavigera*; 8. *Sebastiania brasiliensis*. Author: R. F. Moro.

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Landscape integration of Mediterranean reforestations: identification of best practices in Madrid region

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Abstract

The *European Landscape Convention* was approved in 2000 by The European Council with the aim of protecting, managing and planning landscapes in Europe. In 2008, this Convention entered into force in Spain, so nowadays it is mandatory to develop specific or sectorial strategies.

We propose a methodology to define criteria and identify best practices for landscape integration of reforestations in the Mediterranean region, based on landscape ecology and visual properties. The methodology encompasses the following phases: i) Identification of the main relationships of landscape with biodiversity, connectivity and public preferences; ii) synthesis of principles and criteria for landscape integration of Mediterranean reforestations; iii) Definition of detailed landscape criteria, both qualitative and quantitative, for reforestation design, species selection, soil preparation and protection of the reforestation area.

We applied this methodology to reforestations in Madrid Region. As a result we typified 30 best practices that may be of use for reforestation in the Mediterranean region.

Keywords: Landscape, reforestation, integration, Mediterranean region, best practices

1. Introduction

The importance of landscape in all aspects of forest planning and management has recently become significant due to a number of factors, such as the Rio-Helsinki process, the requirements of certification and an international movement favouring more natural forest management.

Moreover, the *European Landscape Convention* approved in 2000 by The European Council with the aim of protecting, managing and planning landscapes is mandatory nowadays in Spain. So, specific or sectorial strategies must be developed.

All these factors began to change thinking about appropriate silvicultural systems for forests. So comprehensive landscape plans are necessary when new planting is undertaken on a substantial scale.

2. Methodology

We developed a methodology to define criteria and identify best practices for landscape integration of reforestations in the Mediterranean region, based on landscape ecology (Farina 2006) and visual properties. The methodology (Figure 1) encompasses the following phases: i) Identification of the main relationships of landscape with biodiversity, connectivity and public

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preferences; ii) synthesis of principles and criteria for landscape integration of Mediterranean reforestations; iii) Definition of detailed landscape criteria, both qualitative and quantitative, for reforestation design, species selection, soil preparation and protection of the reforestation area.

3. Results

We identified the following list items that must be taken into account for new mediterranean reforestation design. Understanding these factors, the interactions between them, and how they are influenced by stand management is essential in order to provide guidance to reforestation design under visual and landscape ecology criteria.

We applied this methodology to Madrid Region reforestations. Field visits were made throughout the forests and managers were interviewed. As a result we typified 30 best practices that may be of use for reforestation in the Mediterranean region.

3.1.   Main relationships of forest landscape with biodiversity, connectivity and public preferences.

1. Forest landscape and biodiversity
   ✓ Mosaic structure
   ✓ Stand structure
   ✓ Deadwood and large trees
   ✓ Minimum dynamic area (Pickett and Thompson 1978) or independent forest size
2. Forest landscape and connectivity:
   ✓ Size of isolated patches
   ✓ Edges geometry and size
   ✓ Matrix and patches pattern
3. Forest landscape and public preferences
   ✓ Aesthetic preferences
   ✓ Time factor
   ✓ Spatial activities distribution

3.2.   Synthesis of principles and criteria for landscape integration of reforestations in the Mediterranean region

Principles
1. Multiscale approach to reforestation design
2. Try to match up aesthetic and ecological criteria
3. Take into account public preferences
4. Try to simulate nature when designing reforestation
5. Mask inevitable negative landscape impacts

Criteria for *external landscape*: broad-scale approach
1. Avoid fragmentation and improve ecosystem connectivity
2. Increase biodiversity by species introduction
3. Mitigate the visual impacts of reforestation boundary
4. Adapt lineal structures to the terrain
5. Fit reforestation activities to landscape scale

Criteria for *internal landscape*: small-scale approach
1. Protect riversides and shores
2. Design reforestation edges with gradual slope
3. Preserve or create gaps in forest cover
4. Preserve large and dead trees

5. Try to integrate infrastructures and equipment
6. Do not disturb the *genius loci* (spirit of the place)

3.3   Detailed landscape criteria

1. Reforestation pattern
2. Reforestation size
3. Planting density
4. Species selection
5. Soil preparation
6. Protection of the reforestation area
7. Initial pruning and thinning treatments.

We only present here some of the main detailed landscape criteria as they exceed the length of this communication.

3.3.1. Reforestation pattern

We assessed different patterns depending on the reforestation objective (table 1). A mosaic of structures is most proposed because it involves biodiversity increase (Díaz Pineda and Schmidtz 2003; Farina 2006; de Zavala *et al.* 2008), stability improvement (Margaleff 1993), connectivity strength (Pino et al. 2000; De Lucio et al. 2003) and enhanced visual quality (Ammer and Pröbstl 1991).

3.3.2. Reforestation size

Mediterranean landscape reforestations must include forested patches of different size. But, for inside-forest species presence, patches over 100 ha must be part of the mosaic (Dajoz 2002). If pine reforestation is adopted, patches over 70 ha are needed to mature all forest phases development (Korpel 1982).

3.3.3. Planting density

Planting density recommendations depend on reforestation objective: wood production (1000-2000 trees/ha), erosion protection (3000-2000 trees/ha), natural forest reconstruction (<1000 trees/ha) (Serrada et al. 2008). When tree density exceeds 50 trees/ha positive microclimatic effect of trees on soil implicate the whole area (Hernández 1998). This can be considered as the lowest range.

3.3.4. Species selection

Stands of mixed species tend to be more stable against biotic and abiotic damages than monospecific ones (Díaz Pineda and Schmidtz 2003) and are preferred by public (Ammer and Pröbstl 1991). So, when possible, reforestation must include more than one tree species (Serrada 2009).
In case chromatic heterogeneity is of interest: Mix species with different specific form, growth yield, flowers and fruits (Cortina et al. 2006) and promote chromatic heterogeneity among main storey species, with other storeys, and pay attention to seasonal changes (Pemán et al. 2006). Best practices were identified and described in "los Almorchones", "La Marañosa", "Peñalara" Natural Park; and "Sureste" Regional Park.

3.3.5. Soil preparation

The punctual soil-preparation techniques making a hole and constructing small runoff collectors (*minicatchments*) are preferred to linear and surface treatments that prepare the soil in general all over the plantation surface.

Areas that have normally been considered more difficult to restore due to a de-structured profile, to the presence of superficial physical crusts and to a scarce vegetal cover are the ones showing a better response to minicatchments system (Bocio et al. 2004; De Simón 2006). Best practices were identified in "Navas Pinarejo" forest and "Sureste" Regional Park.

3.3.6. Protection of the reforestation area

Individual shelters do not show consistent better results than boundary fences for reforestation survival (Costa 2003; Sharew and Hairston-Strang 2005; Bergez and Dupraz 2009). Visual impact depends on the colour integration and visibility (Ammer and Pröbstl 1991). They cause temporal impact if they are removed. Best practices were described in "Canencia", "Navas y Pinarejo" and "La Morcuera" forests.

4. Conclusion

The proposed array of principles and criteria offers considerable promise to landscape discipline incorporation in reforestation activities and should be view as a push to sustainable forest management and best practices identification.

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Figures and tables
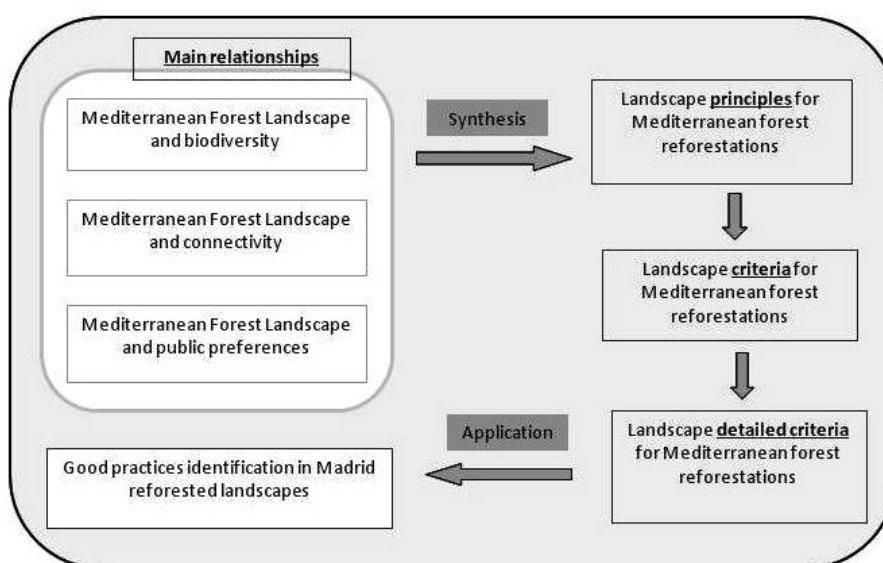
Figure 1: Methodology

Table 1: Reforestation patterns

Land cover class	Main reforestation objective			
	Wood production	Erosion control	Natural Forest	Burned areas restoration
Erosion in grassland, shrubland or scarce tree density forest	---	Plurispecific continuous reforestation, including shrub and tree species	---	---
Grassland, no erosion risk	Preserve grassland gaps to allow fauna movements. Incorporate auxiliary species for soil improvement	---	Plurispecific non continuous reforestation. Wide grassland gaps to preserve biotope. Mosaic pattern	---
Shrub land, no erosion signs, poor soil	Reforestation not recommended	---	Reforestation not recommended	Reforestation not recommended
Shrub land, no erosion signs, deep soil	Preserve shrubland gaps to allow fauna movements. Incorporate auxiliary species for soil improvement	---	Plurispecific non continuous reforestation. Preserve wide shrubland gaps for biotope uses	Plurispecific non continuous reforestation where natural regeneration does not occur. Preserve wide shrubland gaps for biotope uses. Species enrichment where natural regeneration happens
Gaps in forest cover with grassland/shrubland, no erosion	Small gap: reforestation not recommended. Big gap: Plurispecific non continuous reforestation	---	Small gap: reforestation not recommended. Big gap: Plurispecific reforestation of individuals or by small groups to improve biodiversity	---
Forest with scarce canopy cover	Incorporate auxiliary species for soil improvement and future wood production	---	Plurispecific reforestation of individuals or by small groups. Growth must be allowed by existing trees	---
Forest with dense canopy cover	Use felling gaps for plurispecific reforestation of individuals or by small groups. Incorporate auxiliary species for soil improvement and future wood production	---	Use natural cover gaps for plurispecific reforestation of individuals or by small groups.	

Conservation of priority bird species in a protected area of central Greece using geographical location and GIS

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Abstract

The effects of habitat structure and spatial variation on bird community composition were studied in the protected area "Antichasia-Meteora mountains" (GR1440003), 82.635 km^2. The census of bird diversity was conducted from late April until mid June, and in October 2008. In 185 randomly selected sampling plots, the following parameters were recorded: (i) *habitat type*; (ii) *habitat cover variables* and (iii) *spatial variables*. Stepwise regression analysis was used to investigate the relationships between bird species richness and vegetation. Geostatistics were used to examine the spatial distribution of priority species by semivariography followed by kriging interpolation. The results showed that bird species richness is correlated significantly with fallow land (β=0.15, P<0.05), and also the presence of tall shrubs (>50cm tall) (P<0.001). Bird abundance is correlated significantly only with habitat type, specifically with fallow land (β=0.30, P<0.05) and farmland (β=0.24, P<0.05). Geographical location is associated with the presence of priority bird species.

Keywords: Avifauna; Conservation; Geostatistics; Landscape; Richness; Habitat

1. Introduction

The study area is located on a Mediterranean mountainous area, which also includes alluvial planes. This particular configuration allows for the presence of a very rich faunal and floral diversity, including rare or threatened species. The study of species diversity patterns should help understand the mechanisms that result in the observed community structure. Several studies have focused on the relationships between avian diversity and vegetation variables (Santos et al. 2002; Sandström et al. 2006), but only few ones highlighting on the importance of geographic location of occupied plots to bird species diversity patterns in relevance to vegetation structure.

Geostatistical techniques, such as kriging, can be used to improve a sampling strategy that considers spatial autocorrelation (Aubry and Debouzie 2001). Using sample data and geostatistical methods, biologists can make optimal predictions for spatially dependent biological variables, such as species richness, at unsampled sites (Carroll and Pearson 2000). Although many studies have used geostatistical approaches to better understand bird distribution (Fischer et al. 2001; Maes et al. 2003; Couteron and Ollier 2005), few studies have focused specifically on how priority bird species is spatially distributed over a protected area. Specifically, the objectives of this study are: (1) to assess the importance of different habitat types for the conservation of priority bird species, (2) to detect the main vegetation cover

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variables that regulate bird distrubution and (3) to analyse the spatial distribution of bird diversity, referring to richness and abundance.

2. Methodology

The Special Protected Area (SPA) "Mountain Antichasia – Meteora" studied (82.635ha), is extended between 250 to 1,400 m and is considered very important for its wild fauna (Meliadis et al. 2009). There are a few hedgerows among fields, while the main shrub species, *Pyrus amygdaloformis*; *Quercus coccifera*; *Carpinus orientalis*; *Cotinus coggygria*, occupy only 25% of the total area. Trees, mostly *Q. pubescens*, *Q. frainetto* and *Q. cerris*, cover 65% of the area. The rest 10% of the study area is covered by cultivations.

2.1 Vegetation survey

Vegetation measurements were taken within the same circular plots of 50m radius where the birds were sampled. Within each sample unit, five vegetation variables were measured: cover (%) of herbaceous plants, low shrubs, tall shrubs, trees, and cover (%) of bare ground (Table 1). In order to avoid observer-related biases in vegetation sampling (Prodon and Lebreton 1981), all vegetation parameter estimations were conducted by the same observer to control for inter-observer variability (Morrison et al. 1992).

2.2 Bird counts

Bird counts took place in spring and late autumn 2008 on 185 plots using the point count method of 50m radius (0.785ha) (Ralph et al. 1995; Bibby et al. 2000). Each point was separated by at least 250m from all other points to minimize the probability of sampling the same bird more than once. All bird species using a plot were counted. These included all birds recorded on the ground and birds hunting over sample plots such as kestrels. Counts were made with binoculars Nikon 7218 Action 10x50mm by two observers simultaneously (Bibby et al. 1992). The first set of counts were conducted to sample spring migrants that use this area as stopover site during their spring migration, and breeding birds, while the second one aimed at censusing the resident birds.

2.3 Statistical analysis

The overall effect of habitat characteristics (habitat type, habitat cover variables) was assessed by stepwise multiple regression with the variables recorded for each sample plot. In these analyses data were log(x+1) transformed to ensure normality. To explain a significant proportion of variation in field use for each bird species, we used stepwise regression analyses. The role of geographical location was explored by the ordinary kriging geostatistical models (Johnston et al. 2001). The "spatial" data matrix was conducted from x and y geographic coordinates. Non-normal variables were logarithmically transformed (Sokal and Rohlf 1981).

3. Results

The five vegetation variables measured in the 185 studied plots were not highly inter-correlated with the exception of shrubs presence (Table 2). There were two extremely significant variables, the low shrub cover and the tree cover (r= -0.698, P<0.001).
With regard to birds, a total number of 65 species were recorded, including 22 priority bird species based on the EU Bird Directive 79/409 (Table 3). There were recorded 11 species listed in the Annex I and 11 more species listed in the Annex II of the EU Bird Directive (79/409/EC). The four most abundant were *Fringilla coelebs* (N=681, where N means species abundance),

Alauda arvensis (N=119), *Turdus philomelos* (N=106) and *Lullula arborea* (N=95). According to boxplots, bird richness and abundance varies more in farmland and fallowland than the other habitat types (Figures 1 and 2). Specifically, stepwise multiple regression showed that bird richness is correlated significantly with fallow land (β=0.15, P<0.05), and also with the presence of tall shrubs (>50cm tall) (P<0.001). Bird abundance is correlated significantly only with habitat type, specifically with fallow land (β=0.30, P<0.05) and farmland (β=0.24, P<0.05). Map of modeled richness for priority birds concerned by the Bird Directive, using the interpolation models, demonstrated predicted values to unsampled points (Figure 3). Semivariograms show the modeled spatial autocorrelation for bird richness and abundance of the 22 priority species in our study area (Figure 4).

4. Discussion

Our results suggest that in the studied area, fallowland and farmland were the most important predictors of local bird diversity. Similar observations have been reported by other studies (Farina 1997; Cherkaoui et al. 2009). Tucker and Evans (1997) have referred that 81 out of the 278 bird species designated as being Species of European Conservation Concern (SPECs), are recognized as having arable and grassland as a preferred habitat. Conservation strategies should involve decisions on maintaining farmland in protected areas since it favors bird species presence. Our study also highlights that sampled areas with higher cover of tall shrubs support higher numbers of bird species. Shrubs not only promote structural heterogeneity, but also increase food availability (Johnson and Freedman 2002).

Our data show that geographical location of sampled points should also be considered. The model of predicted spatial bird richness suggest that diversity variation is negligible and there is not any spatial autocorrelation. On the other hand, predicted abundances should be used so as to evaluate a protected area network. For conservation purposes, there is a need for understanding the ecological factors affecting bird distribution. Accordingly to Scozzafava and De Sanctis (2006), different areas might show different correlations between habitat features, driving the stepwise procedure to overlook certain factors. However, further investigations of the landscape configuration on the bird occurrence at the protected areas are needed in order to assess more accurately the impact of landscape on birds.

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Table 1: Variables measured to characterise vegetation structure and tree and shrub composition in the sample plots[1].

1. HERBCOVER: % cover of herbaceous plants
2. LSHCOVER: % cover of low shrubs
3. TSHCOVER: % cover of tall shrubs
4. TREECOVER: % cover of trees
5. GRCOVER: % cover of bare ground

[1] Cover variables were recorded as percentages of the sample plot.

Table 2: Pearson correlation coefficients between the five sampled vegetation variables in the studied plots (n=185).

	Herbaceous cover	Low shrub cover	Tall shrub cover	Tree cover	Bare ground cover
Herbaceous cover	1	-0.418**	-0.319**	-0.698**	-0.254**
Low shrub cover		1	0.630**	-0.161**	0.110
Tall shrub cover			1	-0.250**	-0.011
Tree cover				1	-0.138
Bare ground cover					1

P < 0.01, correlation is significant at the 0.01 level
P < 0.001, correlation is significant at the 0.05 level

Table 3: List of the priority bird species in the entire sample area.

Scientific name	Common name	Phenology[1]	SPEC[2] Category (2004)	Birds Directive 79/409
Alauda arvensis	Eurasian Skylark	R	3	II/2
Circaetus gallicus	Short-toed eagle	M	3	I
Corvus corone	Hooded Crow	R		II/2
Corvus monedula	Western Jackdaw	R		II/2
Dendrocopos medius	Middle Spotted Woodpecker	R		I
Dendrocopos syriacus	Syrian Woodpecker	R		I
Garrulus glandarius	Eurasian Jay	R		II/2
Falco eleonorae	Eleonora's Falcon	M	2	I
Falco naumanni	Lesser Kestrel	B	1	I
Fringilla coelebs	Common Chaffinch	R		I*
Lanius collurio	Red-backed Shrike	M	3	I
Lanius minor	Lesser Grey Shrike	M	2	I
Lullula arborea	Wood Lark	R	2	I
Parus ater	Coal Tit	R		I*
Pica pica	Black-billed Magpie	R		II/2
Streptopelia decaocto	Eurasian Collared dove	R		II/2
Streptopelia turtur	European Turtle dove	B	3	II/2
Sturnus vulgaris	Common Starling	R	3	II/2
Troglodytes troglodytes	Winter Wren	R		I*
Turdus merula	Common Blackbird	R		II/2
Turdus philomelos	Song Thrush	R		II/2
Turdus viscivorus	Mistle Thrush	R		II/2

[1] B: Breeding, M: Migrant that is breeding in the area, R: Resident
[2] SPEC 1: Species of global conservation concern.
   SPEC 2: Concentrated in Europe and with an Unfavourable Conservation Status.
   SPEC3: Not concentrated in Europe but with an Unfavourable Conservation Status.
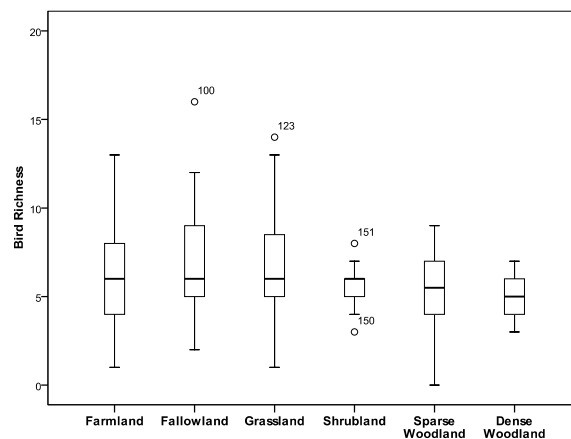
Figure 1: Boxplots for bird richness by habitat type.
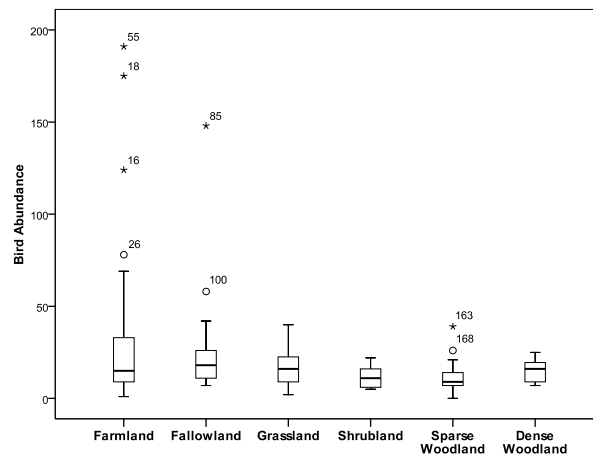
Figure 2: Boxplots for bird abundance by habitat type.
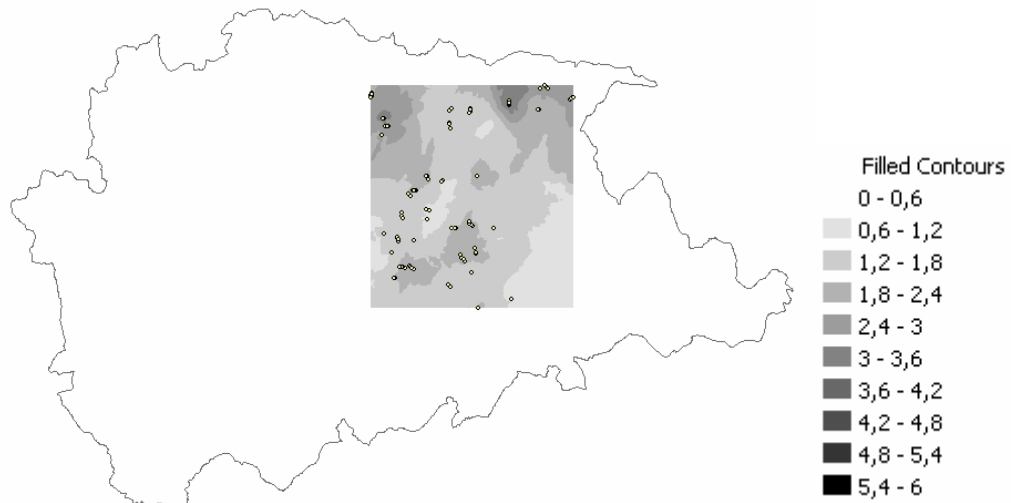
Figure 3: Map of modeled priority bird richness produced by the ordinary kriging model and location of sampling points.
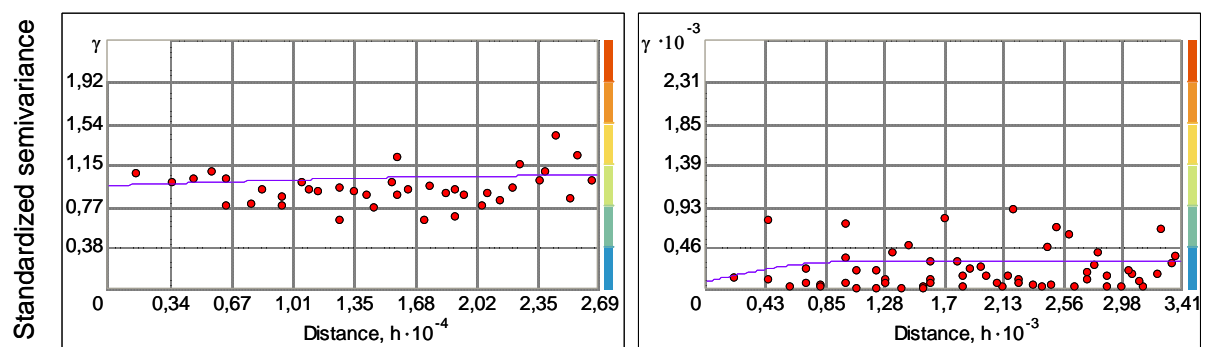
Figure 4: Semivariograms showing the standarized semivariance according to the distance between surveyed points for bird (a) richness and (b) abundance in this study.

Changes in structure and composition of forest stands at regional and national level in the last four decades - a consequence of environmental, natural or social factors?

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Abstract

Based on data acquired from the spatial information system Silva-SI, the majority of the entire forest area in Slovenia (22,220 forest compartments with a total area of 7,183 km^2) was analysed for changes in structure (growing stock, dbh structure) and tree species composition of forest stands in the period 1970–2008. Different statistical methods (data mining, GLM) and GIS-supported analyses were used to test influence of 20 variables on changes of forest stands: 11 environmental, 2 management, 3 stand and 4 social variables. In the observed period total growing stock significantly increased - from 190 to 293 m^3/ha, as well the shares of medium-diameter ($30 < dbh \geq 50$ cm) and large-diameter ($dbh > 50$ cm) trees in the total growing stock, from 43 % to 46 % and from 9 % to 18 %, respectively. Tree species composition changed significantly in the analysed period, resulting in a higher share of broadleaves, whereas the share of silver fir in total growing stock decreased from 17.5 % to 8.6 %. Changes in forest stand structure were of different magnitudes and directions; their variability was partly explained by different initial states of forest stands influenced by forest management, environmental and social factors included in the study.

Keywords: forest structure, spatiotemporal dynamics, forest management, environmental factors, social factors, spatial information system

1. Introduction

Temperate forests in Europe cover a large bioclimatiological range and play a prominent role in timber production, nature protection, water conservation, erosion control and recreation. For centuries temperate forests in Europe have been affected by human activities. Forest management has caused large-scale changes in the spatial distribution, tree species composition, and structure of forest stands (Johann, 2007). In the 18th and 19th century, even-aged forestry created large areas of uniform, mainly conifer-dominated forest stands. In the past few decades, as nature-based forestry has become widely accepted, several phenomena associated to changes in the forest structure and species distribution occurred (Spiecker, 2003; Gold et al., 2000). These phenomena are easier to recognize and explain if long term changes have been precisely documented. Archival data such as forest management plans with inventory data, forest maps, land registers and felling records, which are often neglected source of information, enable us to quantify long-term changes and study the impacts of different factors on changes of forest structure and composition over the past decades or centuries (Chapman et al., 2006; Klopcic et

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al., 2009). The aim of this study was thus 1) to study spatiotemporal changes in forest structure and tree species composition in the last four decades at regional and national level and 2) to determinate impact of different environmental, natural and social factors on changes of forest structure and species composition.

2. Methodology

2.1 Study area

Slovenia lies in the south-eastern part of Central Europe, between Austria, Italy, Hungary and Croatia. Due to diverse environmental conditions (the Alps, the Mediterranean, the Dinaric Mountains, and the Panonian Basin), different forest management practices in the past decades and centuries and available archival data on forest stand structure and composition, Slovenia is appropriate study area to study changes in forest stand structure and composition on the landscape level. Forests cover 11,400 km^2, which represents 58% of the total land area. The underlying characteristic of the study area is a considerable variation of relief and climatic conditions (Poljanec et al., 2010). Zonality of forest vegetation in Slovenia is quite clearly defined due to distinctive orographic factors, different soil substrata and well-preserved forest structure. For the purpose of the research, forest vegetation was classified in eight forest types according to the terminology of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) (European forest types…, 2006), reflecting distinctive and unique patterns of human impacts, modification of species composition, latitudinal/altitudinal zonation of vegetation, climatic and edaphic variability, silvicultural systems applied and forest management intensity: Alpine coniferous forest (EFC 3; 225 km^2), acidophilous oakwood (EFC 4.1; 241 km^2), sessile oak–hornbeam forest (EFC 5.2; 577 km^2), Central European submountainous beech forest (EFC 6.4; 1,901 km^2), Illyrian submountainous beech forest (EFC 6.6; 1,505 km^2), Illyrian mountainous beech forest (EFC 7.4; 2,612 km^2), thermophilous deciduous forests (EFC 8; 77 km^2) and floodplain forest (EFC 12; 45 km^2).

2.2. Data description and analysis

The study is based on data acquired from the spatial information system Silva-SI (Poljanec, 2008), which covers the entire forest area of Slovenia (N of compartments = 32,597; 11,400 km2). The analysis included 22,220 compartments (7,183 km2) with an average area of 34 ha for which reliable data on forest condition for 1970 and 2008 are available. An attributive database comprising seven dependent and 20 independent variables describing the site, forest management and social conditions of the compartments was designed. Among 20 independent variables, the first 11 describe site conditions (INC - mean incline, INC_SD - standard deviation of incline, ELV - mean elevation, ELV_SD - standard deviation of elevation, ASP - aspect, ASP_VAR - variation of aspect, ROC - proportion of area covered with rocks, BEDR - bedrock, T - mean annual temperature, PRCEP - mean annual precipitation, RK – site productivity), the next 4 are social variables (OWN - ownership, N_OWN – number of owners in the compartment, HS - holding size, SUCC - share of abandoned land), 3 variables describing state of the stands in 1970 (GS1970 - growing stock in 1970, VOL_C - proportion of large-size diameter trees in growing stock, P_CON - proportion of conifers in growing stock) and the last 2 variables describe the intensity of management (FMR – forest management region, CUT - annual allowable cut (m3 ha-1) in the period 1970-2008). Data were acquired from various sources, mostly through forest inventories; this is a combination of a field description of all stands and of tree measurements (dbh $\geq$ 10 cm) at permanent 500 m2 sampling plots (N = 100,178) with a dominant sampling network size of 250 m × 250 m and 250 m × 500 m (Poljanec et al., 2010).

Differences in changes of forest stand structure and composition was investigated by eight forest types with seven variables: the variables ΔGS, ΔS, ΔM and ΔL denotes the differences in the total growing stock, growing stock of small, medium and large diameter trees between 2008 and 1970, while the variables ΔP_Beech, ΔP_Fir and ΔP_Spruce denotes the differences in the proportion of European beech (*Fagus sylvatica* L.), silver fir (*Abies alba* Mill.)and Norway spruce (*Picea abies* (L) H. Karst.) in the growing stock of forest stands in 1970 and 2008. The Welch test (Welch, 1947) was used due to the non-homogeneity of variances and different sample sizes and the Tamhane's T2 test (Tamhane, 1979) for post hoc multiple comparisons of mean values. The impact of selected site, stand, forest management and social factors on changes of forest stand structure and composition were investigated with multiple regression approach (GLM). All statistical analysis was carried out in the SPSS 17.0.

3. Results

The analyses showed that the structure of forest stands changed significantly in the period 1970-2005. In 1970–2008 growing stock increased from 190 m^3/ha to 293 m^3/ha. An increase of total growing stock was registered in most of the compartments (N=19,775). In 358 compartments, however, there was no observed change in growing stock, and in 2.087 compartments growing stock dropped (Figure 1). Changes in diameter distribution are evidently reflected in the gradual ageing of stands, as the share of small-diameter trees dropped (from 49% of total growing stock in 1970 to 31% in 2005), the share of medium-diameter (30 cm ≤ dbh < 50 cm) and large-diameter trees (dbh ≥ 50 cm) increased substantially (from 43 % to 46 % and from 9 % to 18 % of total growing stock). Rather than uniform, the changes in conifers and broadleaves are characteristically different. A considerable increase in the growing stock of small- (10 cm ≤ dbh < 30 cm) and medium-diameter trees was recorded for broadleaved species, whereas for conifers an increase in the growing stock of large-diameter trees and a decrease in the growing stock of small-diameter trees is evident. Furthermore, the tree species composition of forests changed substantially in the period 1970–2005. The changes are reflected in higher share of broadleaves (rising from 40 % of total growing stock in 1970 to 48 % in 2008) and improved conservation status of forests. The growing stock of beech doubled, whereas the share of silver fir decreased from 17.5% to 8.6 % of total growing stock. Changes were less evident for spruce, resulting in smaller increase of its share in the total grooving stock (rise from 34 % to 37 % of total growing stock).

Changes of growing stock were significantly different among forest types (Welch statistic = 42.547, p=0.000). The increase in growing stock was the highest in EFT 6.4 and EFT 6.6, while changes of growing stock are the smallest in EFC 3 and EFC 8. The increase of growing stock is also correlated to an increase of the proportion of small- and medium-diameter trees, while the increase of large-diameter trees was the highest in forest types where changes of growing stock were the smallest (EFC 3 and EFC 7.4). Furthermore, changes of the proportion of Norway spruce (Welch statistic = 77.127, p=0.000), silver fir (Welch statistic = 182.214, p=0.000) and European beech (Welch statistic = 38.780, p=0.000) were significantly different among forest types. Proportion of spruce decreased in forest types where spruce is not present in potential vegetation (EFC 12) and increased the most in mountainous vegetation belt, especially in forest types EFC 7.4 and EFC 3. The proportion of beech in the total growing stock dropped in EFC 3 and EFC 8 which is particularly distinguished from the changes in other forest types where the proportion of beech increased in the observed period. The proportion of silver fir in the total growing stock dropped in all forest types. The regression process is distinctive in forest type EFC 7.4.

Changes of forest structure, occurred in the period 1970–2005, were mainly influenced by forest management; forest management is reflected through the harvest intensity and various forest management concepts in forest management regions. In addition, changes of forest stands were significantly influenced by the initial state of the stands. The increase of total growing stock was the highest in forests with lower growing stock, high proportion of broadleaves and less intensive management. In these forests the growing stock of low-diameter and medium-diameter trees rose, too. Ownership, holding size and share of abandoned land in a compartment were the most important social factors, whereas the main environmental factors were altitude, mean annual temperature, mean annual precipitation and site productivity.

4. Discussion

Forest stands in the study area and more broadly in the central Europe changed significantly in last centuries (Klopcic et al., 2009; Spiecker, 2003). In the observed period changes are reflected in constant increase of growing stock, general aging of forest stands and shifting tree species composition closer to current climatic and edaphic conditions. In spite of the general trends of changing composition and structure of forest stands, this study and several others (e.g. Poljanec et al., 2010) indicate that changes varied in nature and magnitude between different forest types and different areas. Forest resources in extreme site conditions were least affected, in particular in the mountains where forest changes are slow due to harsh growing conditions, while in other forests types, changes of forest structure and composition can take on different forms. Varying magnitude and orientation of changes in stand parameters can be linked to the impact of different site conditions (Oliver and Larson, 1996), initial state of forest stands and different natural and anthropogenic disturbances (Pickett and White, 1996), as well as the selection of indicators and scale in which changes are observed.

Initial state of forest stands in 1970 and forest management are the most important factors explaining changes in forest stand structure and composition in last four decades, while the impact of natural and social factors is indirect as they point to differing conditions for forest management. Initial state of the forest stands in 1970 are a result of interplay between different site conditions (Oliver and Larson, 1996) and different past forest management and land use history (Spiecker, 2003; Johann, 2007). In the most of the study area intensive harvesting and even-aged forestry promoting spruce significantly change stand structure and composition, while the application of uneven-aged systems in the 19th and beginning of 20th century particularly in the Dinaric region resulted in more preserved forest stand structure and composition. In the past few decades nature-based forestry (Diaci, 2006) was applied through intensive forest management planning on the entire study area. The harvest intensity decreased and only in exceptions reached the net annual increment, natural tree species and more diverse, site oriented forest structure was promoted through silvicultural measures.

Current structure and composition of forest stands in the study area showed significant improvement of forest stands over the period under research. In fact, some stand parameter values such as average growing stock, current annual increment and diameter distribution came close to goal values. The development of species composition is generally favorable, since alteration of natural tree species composition decreased. Despite overall improved conservation status of forests, the status and future development of silver fir population is unfavourable (Boncina et al., 2009).

In the future, regeneration and tending of appropriately structured growing stock is given priority over growing stock accumulation. On account of significant differences inside of study area a differentiated approach adapted to local forest conditions will be needed to ensure even

accumulation of growing stock, its maintenance or active regeneration of forest stands. Special focus will need to be placed on alleviating forest management risks, which depends mainly upon implementation of silvicultural, protective and other measures intended to increase resistance of forest stands.

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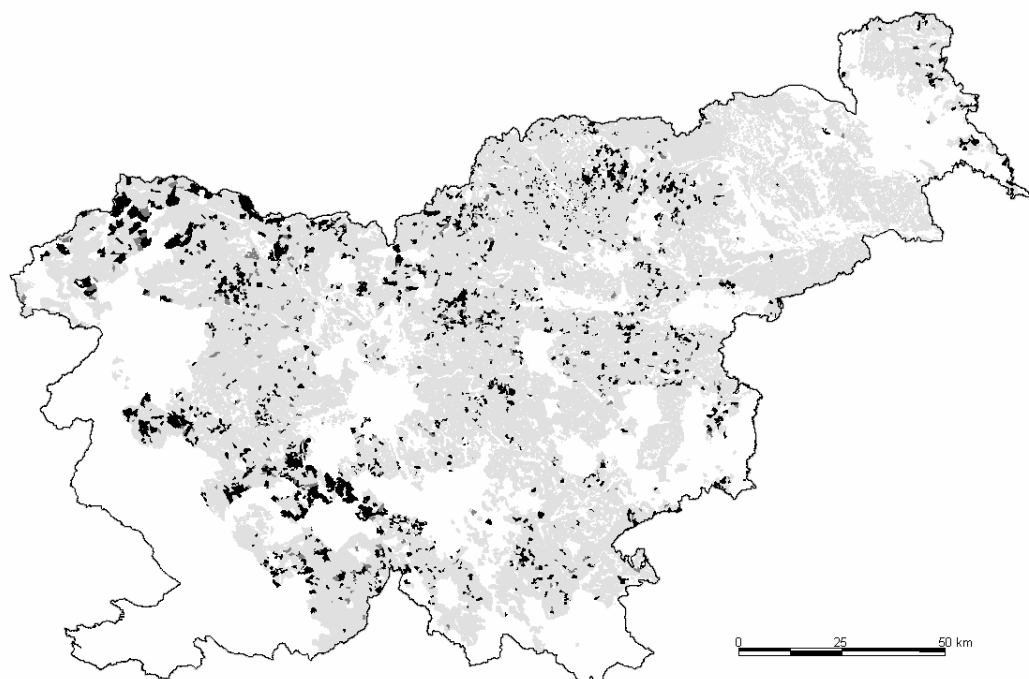
Figure 1: Changes of growing stock (ΔGS) in period 1970-2008; light gray – increase of total growing stock, dark gray - no observed change in growing stock, black – decrease of total growing stock.

Tengmalm owl (*Aegolius funereus*) and Pygmy owl (*Glaussidium passerinum*) as a surrogate for biodiversity value in the French Alps Forests

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Abstract

The problem in biodiversity monitoring and conservation is that usually exist vast gaps in available information on the spatial distribution of biodiversity that poses a major challenge for the development of biodiversity indicators and regional conservation planning.

Within this context, the concept of habitat quality is fundamental to the study of ecology. Measurements of habitat structure offer the potential to directly predict quality (in terms of physical structure and plant species composition). An example using two bird species, Tengmalm owl (*Aegolius funereus*) and Pygmy owl (*Glaussidium passerinum*) is presented as indicator of forest biodiversity. Maximum entropy (Maxent), a presence-only modelling approach, is used to model the distribution of these two species within a large study area in the French Alps. Despite biased sampling design, this method performs very well in predicting spatial distribution of the two owl species. Results are then used as criteria in the habitat biodiversity value index.

Key words: Habitat quality, Maxent, distribution modelling, biodiversity indicators, French Alps

1. Introduction

Improving knowledge on the distribution of indicator and emblematic but locally poorly known species is of great importance for managers as well as for naturalists (Baldwin, 2009). These species can be used as a surrogate for biodiversity monitoring and conservation (Lindenmayer *et al.*, 2000). Still vast gaps in available information on the spatial distribution of biodiversity exist, that poses a major challenge for the development of relevant biodiversity indicators for regional conservation and forest management planning.

In addition, the development of spatial knowledge on the habitat requirements and ecology of these species would facilitate conservation of a great number of related species.

Models that establish relationships between environmental variables and species occurrence have been developed and are widely used with many applications in conservation and management-related fields (Cowley *et al.*, 2000; Elith *et al.*, 2006; Gibson *et al.*, 2004; Pearce and Ferrier, 2000; Stockwell and Peterson, 2002). They can help to guide additional field work, by identifying unknown population locations. It also supports management decisions with regard to biodiversity, to determine suitable sites for reintroductions or to assist selection of protected areas (Baldwin, 2009). First, these models were mainly developed for presence-absence data modelling. However, absence data are often lacking or biased and a new generation of models adapted to presence-only data modelling have been proposed (Baldwin, 2009)(Hirzel *et al.*, 2002; Phillips *et al.*, 2006). A huge number of such methods exist and differ from their data requirements, statistical models used, output formats, performance in diverse situations (Elith *et al.*, 2006; Guisan and Zimmermann, 2000). Much of them are based on the ecological niche theory (Hirzel and Le Lay, 2008)(Phillips *et al.*, 2006). Ecological-niche based models generally define a function that links the fitness of individuals to their environment

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(Hirzel and Le Lay, 2008).Thus, theoretically, if we know precisely the habitat characteristics of a species, it is possible to rebuild its ecological niche from the environmental variables describing its habitat.

In this study, we have chosen to use the Maximum Entropy modelling approach, which is a relatively recent method developed by Phillips (2006). Maxent is a presence-only modelling approach with a proved good potential to predict wildlife distribution. Despite biased sampling design, this method performs very well in predicting spatial distribution of species data (Elith *et al.*, 2006). It estimates the less constrained distribution of training points compare to random background locations with environmental data layers defining constrains (Baldwin, 2009). The results show how well the model fits the location data as compared to a random distribution (Phillips *et al.*, 2006; Phillips *et al.*, 2004).

Herein we aim to predict the distribution of two owls' species, Tengmalm owl (*Aegolius funereus*) and Pygmy owl (*Glaussidium passerinum*), in the French Alps. These species have specific habitat needs and their presence reflects those of numerous other forest-dwelling species. They are considered as relicts from Ice Age and need quite cold areas, which make them good candidates to develop further studies in relation to global climate changes. In addition, their distributions are poorly known and their protection status are not well defined. It is also important to denote that Pygmy owl populations in the Vercors Mountain (Alps range) represent the occidental limit of the European range of the species. It represents also an additional stake to learn more about distribution and habitat structure of this species at the limit of its range. Requirements and distribution of Tengmalm owl are less well known because this species is nocturnal and discreet, therefore census data are difficult to gather. Modelling its potential distribution will allow to improve knowledge on its habitat and ecological needs. Several local surveys efforts took place in order to develop a census of the populations within the "Vercors" region. But these works are limited to very small areas, and a distribution model which covers the entire mountain region would be very useful to help to define adequate surveys efforts for the future while at the same time will provide an overview of the likely distribution of the two species.

2. Material and methods

2.1 Case study area and species occurrence data

This work was conducted within Vercors Natural Regional Park (VNRP), located at the frontier between northern and southern French Alps (Figure 1). It covers 206 000 hectares with 139 000 hectares of forests. Approximately a half of these forests are Public (State and municipalities forests) and the rest is in the hands of private stakeholders. The main tree species are Fir (*Abies alba*), Spruce (*Picea abies*) and Birch (*Fagus sylvatica*).

We used Tengmalm owl (*Aegolius funereus*) and Pygmy owl (*Glaussidium passerinum*) point counts data from several surveys conducted in the 'Hauts Plateaux du Vercors' Natural Reserve (HPVNR), which is located within the VNRP. The Reserve is mainly composed of three main forest types: i) mixed uneven-aged birch/spruce/fir forests, ii) pure quite sparse even-aged or uneven-aged spruce forests and at high elevation, iii) pure sparse naturally even-aged Mountain Pine forests. The bigger State forest in the Reserve has recently been classified as an Integral Biological Reserve (IBR).

All local surveys have take place in this State forest and mainly in the IBR. The two owls' species are from the North European boreal forests and the cold sparse spruce Reserve forests look-like their original habitat. Therefore, local people generally thought that the range of the two species is limited to these particular forests in the Vercors. In this part of the Alps, Pygmy owl depends on cavities carved by the Great spotted woodpecker (*Dendrocopus major*) and Tengmalm owl by the Black Woodpecker (*Dryocopus martius*) for breeding.

These cavity providers favour respectively spruce and birch trees to breed. It implies that the presence of the woodpeckers and their host trees are likely to be important habitat variables for the two owls.

The point counts data come from the naturalist network of the National Forest Office and the "Ligue de Protection des Oiseaux", an organism which aims to improve knowledge on the local fauna species.

These data are a combination of visual and eared bird contacts in addition to nests locations. Each contact point is located with a Global Positioning System (GPS). The reliability of these data is very heterogeneous because each data source has its own sampling design and its own database system. We therefore harmonize data before integration into a common database.

It is important to denote that despite the low precision of visual and eared occurrence data we include them into our database since these are owl's activity centres within their territory.

The resulted dataset is composed of presence points represented as latitude/longitude coordinates, then no absence points are considered. This is a common issue when someone works with wildlife surveys data (Anderson *et al.*, 2003; Chefaoui and Lobo, 2008). Therefore the interest of models like Maxent, as aforementioned, is the use of presence data only for the computation of the habitat modelling.

2.2 GIS environmental data

We used a set of environmental data based on the knowledge of the species ecology and factors affecting distribution of the species within the entire study area**:** elevation, aspect, slope, topography, forest habitats (from Alpine National Botanic Conservatory topology), related woodpeckers species presence (*Dendrocopus major* for Pygmy owl and *Dryocopus martius* for Tengmalm owl), land cover (Corine Land Cover 2006 level 3), mean annual temperature, woodpeckers host tree species (Spruce and Birch).

These data are represented as raster layers with a 50 m resolution; we used ArcGIS 9.3 to prepare the different data layers.

A single raster mask delimiting the study area was used to assure that all raster layers have the same dimensions.

For the two species, we used 20% randomly selected occurrence data for cross-validation, leaving the remaining 80 % for analysis.

We implemented the model with freeware Maxent developed by (Phillips *et al.*, 2005). It is friendly use, as species occurrence training and test files and environmental data layers are automatically recognize by the application.

We used simultaneously continuous and discrete data. We let almost all default parameters, but we set the regularization value to 1 for the two species. We also chose to see the jackknife test of variable importance and the response curves to evaluate the relative contribution of each variable to the model.

We first include all the environmental variables in the model. Then, we delete those which did not show any significant contribution to the model.

Five variables were finally selected for the two species: elevation, topography, land cover, mean annual temperature and presence of Spruce for Pygmy owl and Land cover, elevation, mean annual temperature, slope and Birch presence for Tengmalm owl.

Maxent provides three output formats. We select the logistic output as generally recommended. The result is a continuous value between 0 and 100. Each resulting raster pixel contains a value reflecting how well the predictive conditions for each pixel are.

We then export results into ArcGIS 9.3 in order to apply a threshold value to produce the occurrence map. Many methods exist to determine the presence threshold. We used 10 percentile training presence (threshold= 0.305 for Pygmy owl and 0.227 for Tengmalm owl) as suggested by (Phillips and Dudík, 2008). This threshold value provides a better ecologically significant result when compared with more restricted thresholds values.

3. Model evaluation

To evaluate models of species distribution, the best method would have been to use an independent data set. However, for the two owl's species, observation data are spatially aggregated and it would have had no sense to use data located in the same place than the training data to evaluate the performance of the model.

We test models performance with several other tools.

Maxent calculate the AUC (Area Under the receiver operating Curve) for each run. It is a standard, threshold-independent method for model evaluation. This method was initially developed for presence-absence data. In Maxent, absence data are replaced by random points (Phillips *et al.*, 2006). AUC tests if a prediction is better than random for any possible presence threshold. It varies between 0.5 when the result is not better than a random selection and 1 when the result is significantly better than random.

Maxent also calculates an omission rate for training and test data. Omission rate indicates the percentage of test localities that falls into pixels not predicted as suitable for the species (Phillips *et al.*, 2006). It should be low for a good model performance.

We also verify if all training points where predicted with a high probability.

In addition, we compare environmental variables values between training sites and the same number of points randomly selected among positively predicted sites. As observation data represent activity centres but rarely nesting sites, we used circles representing owls living territories to make the comparison (Hakkarainen *et al.*, 2008; Ribe *et al.*, 1998). Each selected point was the centre of one living territory (i.e. this include nesting sites) considered with a radius of 670 meters for Pygmy owl and of 1000 meters for Tengmalm owl. Mean of quantitative variables and dominant value of qualitative variables were used for the comparison. As data do not follow a Gaussian distribution, we used non-parametric statistic tests implemented in R 2.8.1 (Gentleman & Ihaka, 1997).

4. Results and discussion

Despite biased sampling design, Maxent model performed very well in predicting potential spatial distribution of the two owl species. Test omission rates are null at minimum training presence threshold (0.000 for Pygmy owl and Tengmalm owl) and low at 10 percentile training presence threshold (0.176 For Pygmy owl and 0.067 for Tengmalm owl).

For the two species, models show an AUC value very close to 1. However, when species have a narrow range (or training data are spatially aggregated), AUC is overestimated (Phillips and Dudík, 2008), which is certainly the case here.

Mean training data predictive rate is 0.58 (SD= 0.20) for Pygmy owl and 0.55 (SD= 0.20) for Tengmalm owl. The model performance seems to be good then based on the well predicted calibration points. In addition, for the two species, there are no significant differences in environmental variables values between training and randomly selected species living territories. It indicates that habitat is suitable within areas where the species occurrences are predicted.

For the two species, the resulting distribution is wider than would be expected by local knowledge (see Figure 2). This result is not surprising because some observations have been done in Vercors forests outside of the HPVNR and in an adjacent mountain massif with a different kind of forest habitats (i.e. more humid, productive and with closed canopy conditions).

The distribution maps bring new information on these poorly known species. They represent very useful data on owl species probability presence with a grain that allow their use at different scales.

However, it is important to note that species could not be present in a site even if they are predicted. Other factors, not taken into account in the analysis, can explain species absence. They can be for example: predator presence (notably Tawny owl (*Strix aluco*) for the two owls and European pine marten (*Martes martes*) for Tengmalm owl), sites far from existing

population and not yet colonized and a lack of prey resources (little mammals, passerine birds, etc.).

Therefore, sites of predicted presence would guide naturalists' future work in order to identify other suitable sites were the bird distribution is unknown while at the same time facilitate selection of areas with high ecological value. As numerous public forests are managed for wood production in the Vercors, these maps would allow to better integrate biodiversity conservation into management planning. In addition, as these species are linked to cold habitats, they could serve as good indicators of climate change with further work including temporal analysis. The kind of models used here would be useful to follow the evolution of their spatial distribution in years to come. Furthermore, the tools developed can be applied in assessing biodiversity value of both managed and protected forest areas to help decision-making concerning the protection of valuable habitats. Distribution modelling of these species is among the first attempts to model suitable habitat distribution of cavity-nesting owl species in France. We hope it will launch the use of such methods, which aim to improve species ecological knowledge and facilitate species censuses and conservation.

Figures
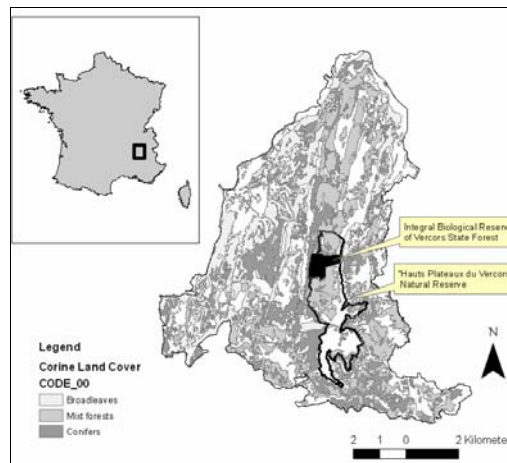
Figure 1: Study area localisation
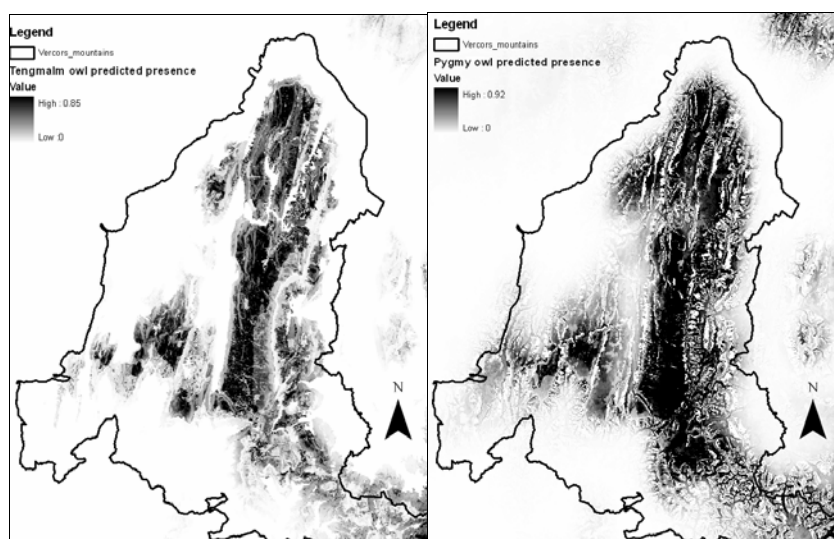
Figure 2: Result of Maxent model for Pygmy owl, with 10 percentile training presence threshold (left) and Tengmalm owl, with 10 percentile training presence threshold (right). Darker tones indicate higher probability of occurrence.

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Contribution to the characterization of *Gentiana pneumonanthe* L. and *Maculinea alcon* L. distribution in the Alvão Natural Park

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Abstract

The aim of this research was to study the distribution of *Gentiana pneumonanthe* in the geographic area of Alvão Natural Park, in order to determine the area of *Maculinea alcon* L. expansion as well the region's potential for development and conservation this butterfly species. Due to the ecology needs of *Maculinea alcon* L (simultaneous presence of *G. pneumonanthe* - the host plant - and *Myrmica* sp. - Ant that feeds the larvae of *M. alcon* in its larvae stadium), we made a survey of plants, butterflies and ants' nests, using a DGPS. Data collected during filed work was then used to create a GIS, in order to analyse the relationship between plants, ants and butterflies.
The results show that the land with less human activity are the most favourable to the plants development as well to the ants development and, therefore, to the presence of butterflies.

Keywords: Maculinea alcon L, Gentiana pneumonanthe, Myrmica sp, Alvão, GIS

1. Introduction

The study and monitoring of *Maculinea alcon* (Dennis & Schiffermüller 1775) meta-population of, in Parque Natural do Alvão – Northern Portugal - began in 2006. This is a butterfly of the family Lycaenidae Lepidoptera, with a life cycle very *sui geniris* and which is listed in the Red Book of endangered species (Swaay et al 1999). The host of the early life of the larva, of this butterfly, is a plant, *Gentiana pneumonanthe* L., and its host in the final larval stage is an ant in the order Hymenoptera and the family Formicidae, which is genus and species is *Myrmica Alobar* (Forel 1909).
According Nowicki et al. 2005, based on studies developed in southern Poland, in wet meadows in the valley of the Vistula, egg-laying by females of *Maculinea alcon*, has a high correlation with the number of flowers that each plant *Gentiana pneumonanthe* has during flowering season. Thomas and Elmes 2001, in the Valley Tidna, Cornwall, confirmed that each species of Maculinea has a remarkably short period of oviposition in relation to the growth stage of *Gentiana pneumonanthe*. According the research results, these researchers state that *Maculinea teleius* and *Maculinea nausithous* have different sites of oviposition, which is also related with the local distribution of ant host species. These two species of Maculinea have preference for floral buds, to deposit their eggs in places where it occurs *Myrmica scabrinodis* with a short vegetation cover between 0 and 30 cm in the case of *Maculinea teleius* while *Maculinea nausithous* prefers the flower buds with neighborhood predominant *Myrmica rubra* and plant strata higher.

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In studies developed in central Europe by Schlick-Steiner et al., 2004, the author concluded that *Maculinea rebellion*, produces or secretes a complex substance whose composition is based on carbohydrates, which attracts the ants of the genus Myrmica. These ants, when found the larvae, in their third instar, in soil, take and lead them to the ants' nest and feed them over the winter until the pupal stage and chrysalis. Over this instar, there is no segregation of that substance and *Maculinea rebellion* butterfly must leave ants' nest and fly out.

This secretion, has similar characteristics to the ants odoriferous, which allows the larvae to be treated as pairs, inside the ants' nest and is thus safeguarded from serving food to the colony. In that case, the substance studied, shows a capacity citron multiple of mimicry to the odorous of the Myrmica species of the region (*M. sabuleti* and *M. schenck*), presenting himself as a chemical strategy to guarantee that at least one of those species, take responsibility for their introduction.

The aim of this work is to create a GIS to Parque Natural do Alvão, for mapping the current geographical distribution of *Gentiana pneumonanthe* L.and for mapping the location of *Maculinea alcon* meta-populations, as well traces of their presence (e.g. eggs on flowers)

2. Methodology

In October 2008 and March 2009, research team performed an intensive field work for data collection and survey, in order to updating GIS with the distribution of *Gentiana pneumonanthe* L., the location of nests of *Myrmica alobar*, the location of *Maculinea alcon* eggs on flowers and the capture of butterflies.

This field work was supported by a GIS (Geographical Information System) installed on a PDA (Personal Digital Assistant) with DGPS (Differential Global Positioning System).

3. Result

Gentiana pneumonanthe grows well in shrub land, with good exposure to sunlight, gentle slopes and proximity of running water. In the fringe of agricultural land, close to irrigation channels, which minimises the effects of frost in the winter, it was also noticed its presence.

In almost all the observation, it was notice the presence of *Quercus robur* and *Quercus pyrenaica* trees in the surrounding area.

Many mapped *Gentiana pneumonanthe* plants evidenced *Maculinea alcon* eggs presence or eaten flowers.

It was also noticed that *Gentiana pneumonanthe* grows well in abandoned agricultural land, but the development of high shrubs (Genista sp., Erica sp.) make difficult the flowers' access by *Maculinea alcon,* which was evidenced by the eggs' absence.

4. Discussion

Results from field work and GIS data management and processing enable to state that *Maculinea alcon* ecology is characterised by shrub land, with good exposure to sunlight, gentle slopes and proximity of running water, with *Quercus robur* and *Quercus pyrenaica* trees in the surrounding area.

Due to *Maculinea alcon* butterfly dimension and flying characteristics, high shrubs make difficult to access flowers and, this way, eggs' deposition on flowers.

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Using Business and Biodiversity to put Conservation into practice: The Herdade do Esporão Case study

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Abstract

Although Esporão estate has a great potential to include High Conservation Value areas, this will only happen if adequate Biodiversity management and ecological restoration are put into practice. The results will be presented in the form of indicators relating land use and the type of landscape. The landscape is dominated by vineyards, olive groves, oaklands, streamside galleries, scrublands and grasslands. The vegetation units of Esporão are assessed using phytosociology (Braun-Blanquet, 1979) and cartography, which are the bases for the 'Habitat Approach' methodlogy. The forested landscape is quite diverse, consisting mainly in 750 ha of Holm oak Montado (*Quercus rotundifolia* Lam.) although most areas are extremely degraded as a result of inadequate stone pine afforestation within the Montado areas. Also highly relevant is the streamside gallery and mixed woodland patchwork covering the area of the Caridade stream and subsidiaries, which include several High Conservation Value areas spread across the whole estate.

Keywords: Biodiversity management, ecological restoration, High Conservation Value Areas, phytosociology, Habitat Approach

1. Introduction

The Esporão estate has signed the Business & Biodiversity (B&B) protocol in 2007, in order to promote Biodiversity and with the compromise that their activities wouldn't affect the Esporão natural values. As a brand, Esporão is dedicated to producing premium wine and olive oil and is situated (Figure 1), according to Costa *et. al.* (1998), between the biogeographic superdistricts Baixo Alentejano and Alto Alentejano (Mariânico-Monchiquense Sector). As a result of a four-year field-work surveys of natural and agricultural units of landscape, which have resulted in a formulated Biodiversity Action Plan (BAP), we will present and describe Esporão natural heritage and the main goals of the Project. The Esporão BAP phase I was finished in November 2008, and is by now in the second year of monitoring. A BAP is a management tool that a) evaluates and monitors wildlife and habitats with regional/local interest, with conservation status (IUCN/ICN Red Book) and included in EU Directives, b) evaluates species with importance in crop protection and soil conservation; c) defines biological indicator groups to assess and monitor the performance of pro-Conservation practices and c) target both crop areas and surroundings, including woodlands, wetlands set-aside areas, inter alia, for proper habitat management. A BAP focus strongly in the concept of High Conservation Value Areas (HCVA). HCVA are landscape level units with important natural values, i.e., habitats, fauna, flora, and frequently occur in agroforestry scenarios.

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2. Methodology

In spite of the estate dimension, we needed to develop a useful and scientific approach which was successful to our work. So, our main methodology, designated by 'Habitat Approach', is focused on assessing the structure and development of an habitat mainly through the analysis of plant communities (Braun-Blanquet, 1979). A phytosociological approach can integrate the environmental variables and summarize practically the whole floristic diversity as well as many of the ecological relationships between the different organisms (Loidi, 1994). Further on, we've got to know if the habitat structure provides area, shelter, food and/or mutualism areas for different fauna species. At the end, we analyze the whole Esporão estate at a macro scale level, through the units of land use and conservation types, to see if these areas act as ecological corridors. GIS was used for mapping all the habitats, plant communities, RELAPE (rare, endemic, localized, threat and endangered) species. According to Lengyel *et. al* (2008), habitat monitoring scheme should be based on remote sensing to record changes in land cover and habitat types, with complementary field mapping.
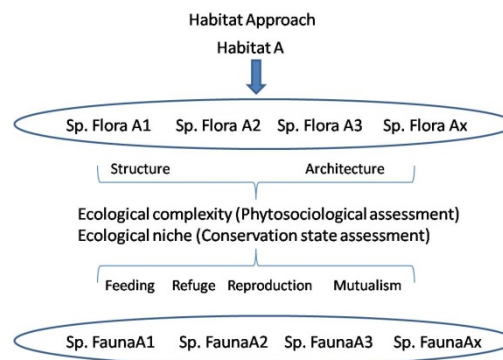
Figure 1: Habitat approach scheme

3. Results

The Biodiversity Action Plan (BAP) includes the flora, habitats and fauna assessment, and also the evaluation of the vineyard's natural enemies, as well as definition of High Conservation Value Areas (HCVA) and agroforestry management. There were identified 11 RELAPE species, namely: 6 orchids which are listed in CITES (*Serapias strictiflora* Welw., *Serapias lingua* L., *Serapias parviflora*Parl., *Orchis papilionacea* L., *Orchis morio* L. and *Ophrys tenthredinifera* Willd.), 1 Directive Habitat specie (*Narcissus bulbocodium* L.), 3 european endemism (*Linaria spartea* (L.) Chaz, *Verbascum thapsus* L., *Phlomis lychnitis* L.) and 2 iberian endemisms (*Genista polyanthos* R. Roem.*, Narcissus jonquilla* L.).
We will describe the main land uses and the Habitats Directive 92/43/CEE of Esporão Estate (Table 1), which can contain different varieties of vegetation types with different conservation values, as seen bellow. The current paper will focus only on plant ecology, leaving the fauna analysis for a next paper.

Vineyards and Olive groves

As wine and olive oil production is the main business of Esporão, it was necessary to make an evaluation of these areas. A lack of proper ecological structures was found, namely habitats for enhancing natural enemies. Some of these structures are the Beetle Banks and usually are made of flowers, from *gramineae* and *compositae* family, and are used mainly as a form of biological pest control to reduce the use of pesticides and insecticides. So, restoring grassland margins in

the Esporão Vineyards and Olive groves is one of the main goals to achieve biodiversity in this landscape unit, through ecological restoration of the set-asides areas and by installing meadow and grassland patches. In order to reduce tillage, we also propose the use of grazers, in this case sheep, to control the weeds.

Table 2: Types of land use in Esporão Estate

Land use class	Total Area (ha)	Council Directive 92/43/CEE habitat code
Vineyards	450	N/A
Olive groves	95	N/A
Holm oak Montado (Parklands)	750	6310 – Montados with evergreen *Quercus* spp.
Holm oak Woodlands	28	9340 – *Quercus ilex* and *Quercus rotundifolia* *forests*
Stone Pine plantations	128	N/A
Stone Pine plantations with sparse Holm oak	87	N/A
Orchid meadows	2.68	6210 – Semi-naturaldry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites)
Grasslands	83	N/A
Streamside woodlands and grasslands	189	8230 – Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*
		3270 – Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p.
		3150 – Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation
		3140 – Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
		92D0 – Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)
		91B0 – Thermophilous *Fraxinus angustifolia* woods
		3260 – Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
Rosemary scrubland	0.16	N/A
Gardens	5	N/A
Social areas	145	N/A

Holm Oak Montado (Parklands) and Holm Oak Woodlands

The Holm Oak Montado, a parkland like system, represents the largest landscape unit of Esporão estate. It consists in similar distinct types of land use which promote annuals and perennials grasslands and scrublands. In these areas grazing was redefined in order to preserve sensitive areas like closed woods and wetlands. Some of these areas were converted through stone pine afflorestation as a result of an inadequate policy actually promoted by the Portuguese governments. In historical times, an edapho-climatic climax forest must have existed in Esporão estate, but almost all these climax habitats have disappeared due to convertion, mismanagement and fires. Although all the human pressure, a few habitat patches remain defined by ***Pyro***

bourgaeanae-Quercetum rotundifoliae woodlands. These few areas are restricted to streamsides and damp areas which display enormous diversity. *Pyro bourgaeanae-Quercetum rotundifoliae*, is a sandy meso-Mediterranean, dry to sub-humid Holm oakland which occurs in the Luso-Extremadurense Province (Pereira, 2004). Areas were this plant community occurs have a good conservation status despite their size, and are characterized by the presence of *Quercus rotundifolia* Lam. and *Pyrus bourgeana* Decne.. Currently, there is some significant effort to restore these areas , being the main goal providing food and shelter for fauna populations, by planting myrtle, rosemary, lavender, edible fig, hawthorn, strawberry tree and elmleaf blackberry species.

Synthetic table of the ***Pyro bourgaeanae-Quercetum rotundifoliae*** Rivas-Martínez 1987, at slope of Caridade streamside, slopes with high inclination, N, 100 m². Characteristics: *Quercus rotundifolia* 2, *Pyrus bourgeana* 1, *Olea sylvestris* 1, *Thapsia villosa*; Companions: *Cytisus scoparius* 2, *Cistus ladanifer* 2, *Lavandula luisieri* 1, *Asphodelus ramosus* 1, *Umbilicus rupestris* +, *Allium massaessylum* +.

Stone Pine Plantations and Stone Pine Plantation with sparse Holm oak

As referred above, to the government decision of financing afforestation projects was allegedly to get more land productivity and environmental gains (Biodiversity, carbon, soil…). Due to heavy soil preparation, excessive tillage and excessive tree density the Holm oak trees present in these areas are dying, suggesting that their roots were damaged, destroyed and infected. We suggest progressive removal of all Stone Pine, good management of scrubland and investigating Holm oak decline for further reforestation.

Orchid meadows and grasslands

In the Esporão estate the orchids are present in open grasslands and meadows between February and June. These are managed for low grazing intensity, since they are mainly present in sensitive areas. This allows orchids to grow and seed to provide a pretty 'postcard' for the visitors as well as raises the attention of botanists. In these habitats six orchid species can be found (*Serapias strictiflora*, *Serapias lingua*, *Serapias parviflora*, *Orchis papilionacea*, *Orchis morio* and *Ophrys tenthredinifera*). Orchid genus *Serapias* and *Ophrys* metapopulation reached over 20 individuals, making this a HCVA. This is a hemicriptofit, meso-xerofitic meadow that grows in shallow soils rich in bases and characterized by the presence of *Phlomido lychnitidis-Brachypodietum phoenicoidis* communities. At this point, it is important to reinforce the importance of this habitat for conservation, being a priority (as listed in the Council Directive 92/43/EEC) if one of the following criteria is observed: rich orchid composition (> 4 species); presence of an important population (> 20 individuals) of one or more orchid species.

Synthetic table of the ***Phlomido lychnitidis-Brachypodietum phoenicoidis*** Br.-Bl., P. Silva & Rozeira 1956, at edges of tracks, with low inclination, E, 10 m². Characteristics: *Phlomis lychnitis* 4; Companions: *Paronychia argentea* 2, *Gynandriris sysrinchium* 1, *Vulpia ciliata* 1.

Streamside woodlands and grasslands

This is possibly the clearest example of the 'Habitat approach' importance to our work. The habitat evaluation shows the right conditions for fauna settlement. Despite this first analysis, the amphibian populations that should be present in the Caridade stream were not settled (to be further explored in upcoming paper). The main reasons are suspected to be high populations of red swamp crayfish (*Procambarus clarkii*) and low input of water from the dam discharge. Red swamp crayfish, an alien species, prefers marshes, ponds and slow moving rivers and streams. They are tolerant to fluctuating water levels and can survive long dry spells by remaining in burrows. Red swamp crayfish are omnivorous, feeding on aquatic plants, snails, insects, fish and amphibian eggs and young. It seems that this alien species tend to reduce amphibians

populations in the Caridade stream (the main watercourse, which also floods the dam). This problem can partially be solved in time as the european otter (*Lutra lutra*) and some waterfowl are increasingly feeding on the crayfish. The ecological flow regime recognizes that flow magnitude, duration, frequency, timing, and predictability must be incorporated into any flow management strategy (Suen, 2005). So, changes in hydrologic trends, in concern to the continuing decline in the water levels in Caridade stream were solved through ecological flow management.

Five RELAPE species were found in the areas surveyed (*Ophrys tenthredinifera, Narcissus bulbocodium, Linaria spartea, Narcissus jonquilla* and *Genista polyanthos*). Caridade vegetation is dominated by *Fraxinus angustifolia* Vahl galleries and woodlands (***Ficario ranunculoidis – Fraxinetum angustifoliae***). Beneath and next the mature canopy it also can be described a high scrubland community of ***Rubo ulmifolii – Nerietum oleandri***. Aquatic vegetation is also present, with *Chara* sp., *Ranunculus peltatus* Schrank and *Callitriche stagnalis* Scop. communities. These aquatic communities are extremely important to amphibian population, as refuge areas.

The dam area is the most important for aquatic birds, despite the poor presence of vegetation communities. There are some communities of *Typha angustifolia* L. and *Phragmites australis* (Cav.) Trin. in the South East of the dam (***Typho angustifoliae – Phragmitetum australis***), but all the remnant area hasn't vegetation. So the main action is to increase patches of vegetation by rooting some adequate plants.

Synthetic table of the ***Ficario ranunculoidis – Fraxinetum angustifoliae*** Rivas-Martínez & Costa in Rivas-Martínez, Costa, Castroviejo & E. Valdés 1980, at Caridade stream, with low inclination, N, 100 m². Characteristics: *Fraxinus angustifolia* 2, *Crataegus monogyna* 2, *Ranunculus ficaria* 1, *Aristolochia paucinervis* 1, *Scilla peruviana* +; Companions: *Pyrus bourgeana 2, Nerium oleander* 1, *Asparagus acutifolius* 1, *Smyrnium olusatrum* 1, *Gynandriris sysrinchium* 1, *Dactylis hispanica* 1, *Geranium molle* 1, *Ornithogalum baeticum* +, *Narcissus bulbocodium* +, *Ophrys tenthredinifera* +.

Rosemary scrubland

Scattered throughout the Esporão landscape, many patches with rosemary scrubland which have importance to pollinator ecosystems service can be found. These also provide stepping-stone corridors to many species of invertebrates, reptiles, amphibians and birds.

The flowers of rosemary produce pollen and nectar to attract insect populations so the maintenance of scrub dominated vegetative complex within *Lavandula stoechas* L. is important. In order to effectively conserve these scrubland areas, management of HCVA must restore and maintain rosemary habitats. To achieve this, land managers must minimize grazing intensity. Further work will include the measure of pollination services, so it is important to assess the rosemary scrubland habitat to measure its ecosytemic value. Also, the maintained of these habitats in Esporão landscape tend to safeguard and enhance pollination function in order to ensure effective pollination of wild plants (Potts, 2006), specially orchids species that are pollination limited, may also be enhanced by maintain rosermay patches in landscape.

4. Discussion

The Esporão estate habitats and landscapes are quite diverse, with important high conservation value species despite some forest areas degradation. We have assessed that dynamic plant communities are present, which are intensively interconnected in ecotone regions defining different ecological corridors. Also, Biodiversity Action Plans (BAPs) are, to some extent, a valid tool for land owners / managers, by facilitating the identification and mapping of High Conservation Value Areas (HCVA) and important plant communities/assemblages that include rare, endemic, localized, threatened and/or endangered plant species, thus allowing the

definition of specific management actions for each conservation area/value identified. Since 2008 the following issues are ongoing: ecological evaluation of the vineyards natural enemies and ecological infrastructures; halting all predator control programs; reformulation of the forestry management plan; reduction of the area of pine plantations and implementation of biodiverse forest patches. In respect to agricultural landscape, olive and vineyards they are being redesigned to achieve the following goals: optimize productivity, facilitate management and operations, prevent soil erosion and reduce the use of pesticides.

The use of plants and plant communities as indicators for land planning to describe and evaluate Esporão Estate has proven useful since it for HCVA protection. As well as the use of phytosociology can be used to describe the landscape units, it also is important in what takes concern to ecological restoration. If habitats can be maintained then also species conservation is facilitated. The most represented phytosociological classes are: the Holm oak woodlands *Pyro bourgaeanae-Quercetum rotundifoliae* and at streamside woodland communities of *Ficario ranunculoidis – Fraxinetum angustifoliae*.

Future research will focus on the validation of management effectiveness and on community dynamics.

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Legal efficiency and cumulative effects in environmentally protected area

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Abstract

Decisions must be taken according to the impacts observed over a temporal sequence of human action. But there is another side to consider - the efficiency of the legal action after decree. In summary, landscapes are complexes and involve a system of multiple overlapping of land use and legal decisions. The objective of this study is interpret the chains of cumulative effect four decades to estimate the cumulative of these impacts in the future and relate the results of these chains in the face of environmental laws in force in that period. The study area was composed by three regions adjacent one each other: the Sustainable Development Reserve of Despraiado, the Ecological Station of Juréia-Itatins and the buffer zone. The cumulative effects were inferred by constructing scenarios of past and present. This strategy should explain state changes along the series of land use and simulate the changes in the coming years.

Keywords: cumulative effects, protected area, legal action

1. Introduction

The increase in human population causes changes in land use, affecting the properties of the landscape. Certain human actions that commonly occur in sequence, as deforestation, burning and opening of roads, can cause significant changes on the natural processes (Thomaziello, 2007). The acceleration of the processes of environmental degradation and the cumulative effects occur in the concentration of humans in a physical space and the expansion of land use which is related to the increase of human population, with increasing demand for consumer goods and increasing consumption of materials and energy (Coelho, 2001 and Chen, 2006).

The cumulative effects are the changes in the environment caused by the combination of human actions in the past, present and future (Hegmann *et al.* 1999). Human activities have their effects accumulated when the second disturbance occurs in the same location in which the first one occurred, while the ecosystem is recovering from the effects of the first one (NEPA, 1997). The cumulative effects are currently resulting of multiple activities in the territory that persist for a long time. Therefore, the attribute space becomes important when integrated with variable time. In summary, landscapes are complex and involve a system of multiple overlapping in space and time and are subject to multi-use over a number of anthropogenic changes (MacDonald, 2000). It is common that cumulative effects are greater than actually seem to be, because the summation of individual impacts can be interacting or multiply the effects (Halpern *et al.,* 2008), in the other words they may have actions of synergism or addition. Therefore they are difficult to mensure.

Santos & Santos (2008 a, b), who studied the region's agricultural Andradina (Sao Paulo), the main observed change in land use was strongly associated with the decline of agriculture, the loss of plantation areas due the expansion of pastures and the increase soil areas with difficult recovery. They applied measures for change of land use or destination of the land along thirty years, which coincided with significant differences about historical changes, linked

to political and government actions. In these studies, the spatial measures were made by applying the rates of change and to better understand them, the historical information of the region were associated with the own perception of the community about the facts.

The implementation of Conservation Areas (CA) in Brazil occurs on regions already occupied with a history of impacts, traces left by human action. When a CA is established, it is expected that its impacts are at least reduced through management actions, hoping that the reversibility of the process occurs toward conservation. Therefore, decisions must be taken according to the impacts observed over a temporal sequence of human action. Should be considered, for example, that an Ecological Station cannot have human occupation, according to SNUC (National System of Conservation Units), however it is inevitable that the area bring the impacts that have been made by human occupation in the past and it reflect in the present observed. In addition, each CA has its own characteristics, with specific objectives to achieve a degree of conservation. So, the actions of management will be different between an Ecological Station and a Sustainable Development Reserve. But there is another side to consider - the efficiency of the legal action after decree. In summary, landscapes are complexes and involve a system of multiple overlapping of land use and legal decisions. Therefore, the objective of this study was interpret the effect chains for two decades to estimate accumulation of these impacts in the past and present and relate the results against environmental laws in force in that period.

2. Method

The study area is located at the southern of Sao Paulo state, and covers parts of three distinct adjacent regions: the oldest Sustainable Development Reserve of Despraiado (SDRD), the Juréia-Itatins State Ecological Station (JISES) and buffer zone (BZ) adjacent to these two conservation areas (Figure 1). These three regions have an area of about 100ha each one.

The impacts were inferred by the analysis of overlapping land use from the scenarios of past. The overlapping was made by the tool spatial statistics available in the software Arc Gis 9.2.

The scenarios were constructed from the photointerpretation of 11 types of land use, namely: agriculture; grazing fields; fields like lawns/gardens and grounds around the building originating fields; fields of infrastructure; construction; water tanks; Tropical Rainforest Secondary Initial; Tropical Rainforest Secondary Medium; Tropical Rainforest in areas with bananas; crop rotation/abandoned areas; access roads. The scenarios were constructed for 1980 and the 2007. The aerial photograph of 1980 was acquired in digital format arising directly from the roll of photographic film, scanned in photogrammetric scanner Vexcel Ultrascan 5000, with 1200 dpi resolution. For the scenario of 2007 was used a satellite image of World View with spatial resolution of 0.5 PAN (provided by the Foundation Forest-Brazil).
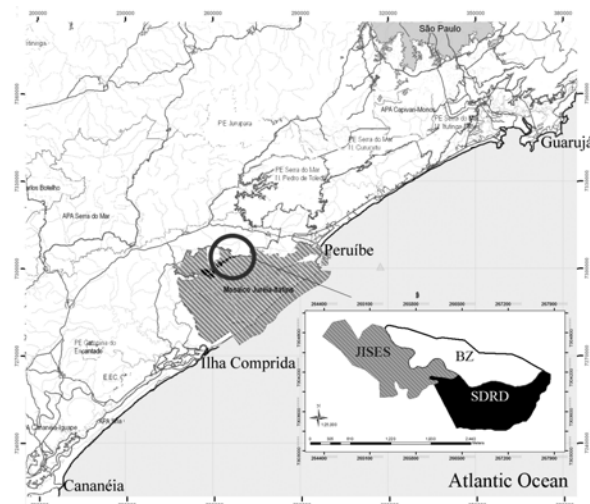
Figure 1: Localization of study area.

3. Result and Discussion

In 1980, the predominant element in the both conservation areas was the Tropical Rainforest both in Sustainable Development Reserve of Despraiado like in Juréia-Itatins State Ecological Station (Figure 2). After 27 years of the federal act of the JISES was observed that the land uses increased and vegetation cover decreased dramatically. In this unit left 34% of the Tropical Rainforest and had an increased by 47% in agriculture and 83% the banana inserted into the forest. The data indicate that most of the forested areas have been transformed by man in uses, such as for crops, pastures, buildings and access roads.

On the other hand, the agriculture gained area in the JISES and in the SDRD. Observed that in SDRD, the area of Tropical Rainforest Secondary Medium lost area for the agriculture, for the Tropical Rainforest Secondary Initial and for the forest with bananas. The fact is this area has been suffered strong influence of human activities and the legal acts have not been respected (Figure 3).

The buffer zone is an area that has strong impact since 1980. The probable reasons are the little distance from an important highway, the road Padre Manoel da Nóbrega. Moreover, it is surrounded by many little cities. In 1980 can be observed a big area for agriculture like as banana plantation and in 2007 the area decreased. In terms of gains and losses relating, this area presents a lose in terms of Tropical Rainforest but gained in terms of uses that caused impacts in the area.

In this way, we can conclude that the main goal of the creation of conservation areas has not been reached, in other words, recovery, conservation and protection of the forest, which was established by National System of Conservation Units.
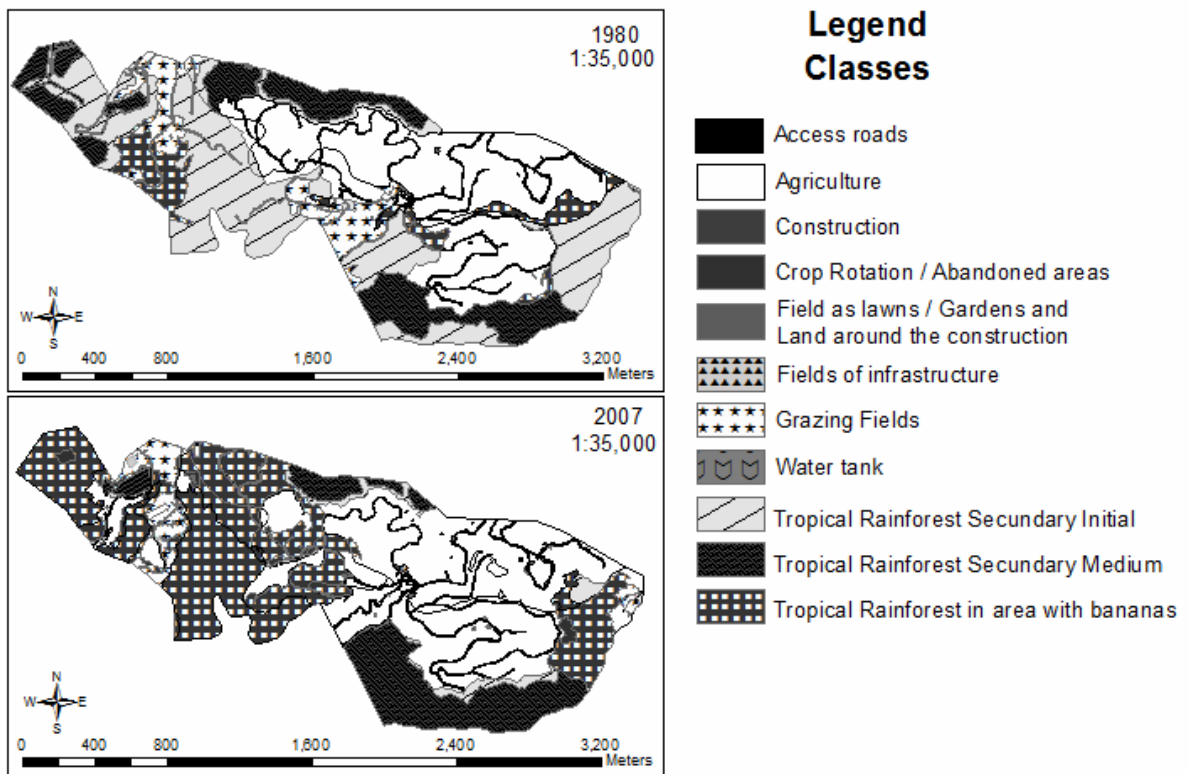
Figure 2: Maps of land-use and land-cover change in 1980 and 2007, scale 1:35.000.
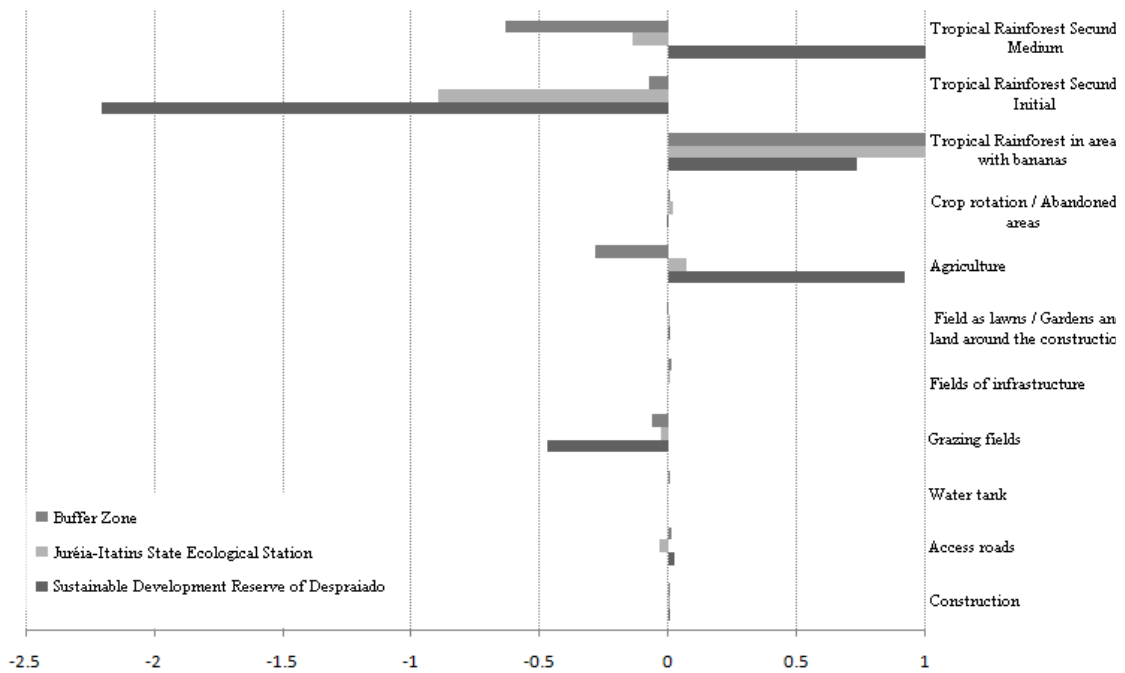
Figure 3: Relative change in the use and occupancy of the study area between 1980 and 2007.

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Relationships among landscape structure, climate and rare woody species richness in the tropical forests of the Yucatan Peninsula, Mexico

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Abstract

Two key concerns about the tropical forests of the Yucatan Peninsula are: the effects of land-use and climate change on biodiversity, and the scant knowledge about rare plants species, which are most vulnerable to these changes. We assessed the association of rare woody species richness of tropical forests of the Yucatan Peninsula, classified in three levels of rarity (low, medium and high), with landscape structure, climate and spatial dependence. We estimated the number of rare species within $25km^2$ landscape units, which were characterized using climate, altitude and landscape configuration. Principal Neighbor Coordinate of Matrices (PCNM) and regression analyses were performed to decompose variation of rare species richness into environmental and spatial components. Space was the most important variable related to the number of rare species in each of the three levels of rarity. These results suggest that dispersal limitation or other environmental variables not considered drive richness of rare woody species.

Keywords: Landscape structure; rare woody plant species; spatial dependence; Tropical forest.

1. Introduction

Tropical forests of the Yucatan Peninsula have been converted to other land uses with unknown effects on biodiversity. The floristic diversity of these ecosystems is mainly composed of rare species –those having small populations, high habitat specificity and/or restricted distribution– which are most vulnerable to extinction due to transformation and loss of habitat (Rabinowitz 1981).

To preserve rare plant species we need to know where they occur and what factors determine their presence and abundance. Many factors affect the distribution of rare species, such as historic events, climate, biotic interactions and spatial structure. Several studies have demonstrated that environmental conditions (climatic, topographic and soil factors) constrain the abundance or restrict the distribution range of these species. However, the factors that determine species distribution vary depending on the way in which rarity is defined (Gaston 1994).

Several studies report a significant relationship between landscape configuration and plant species diversity (Bascompte and Rodríguez 2001; Hernandez-Stefanoni, 2005). However, few studies have related landscape structure and habitat heterogeneity to rare plant species, due to difficulties involved in obtaining field information of this group of species (Luoto 2000).

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The aim of this study was to evaluate the association of rare woody species richness at different levels of rarity with landscape structure, climate and spatial dependence, to generate scientific knowledge necessary to promote the conservation and management of biodiversity of tropical forests.

2. Methodology

2.1 Study area

The study area is located at the Yucatan peninsula in SE Mexico (17° 50´ to 21° 30´ north latitude and 87° 00´ to 91° 00´ east longitude), covering a total area of 141,523 km^2 (Figure 1). The peninsula is constituted almost entirely of limestone Karsts from the Eocene. Around 95% of the territory consists of flat lowlands < 100 m above sea level, but some hills reach 275 meters (Ferrusquía-Villafranca 1993). Seven types of tropical forests, in different stages of secession, cover the peninsula (Flores and Carvajal 1994; Durán et al. 1999) and their distribution patterns are determined by precipitation and soil type (Carnevali et al. 2003).
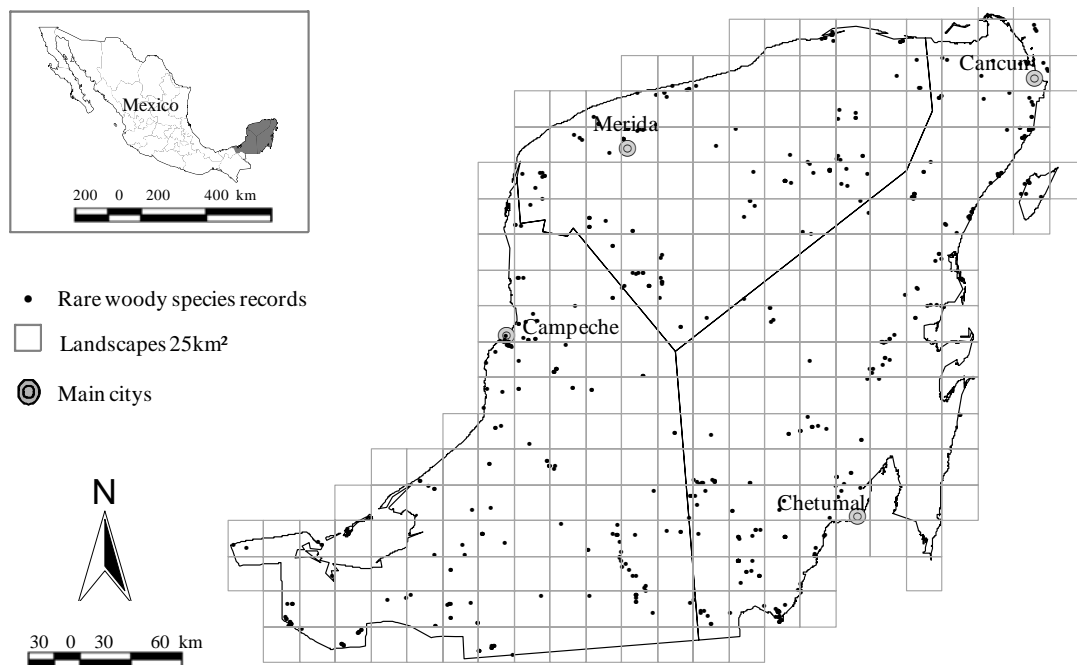
Figure 1: Study area and rare woody species records within 25 km^2 landscapes.

2.1.2 Rare woody species richness

Using herbarium records (Centro de Investigación Científica de Yucatán CICY) we identified rare woody species, which were classified in three levels of rarity – low, medium and high– according of their frequency, habitat specificity and range of potential distribution (modelled in DOMAIN, Carpenter et al. 1993). To calculate rare woody species richness we generated a 25 km^2 grid (landscapes) covering the whole study area (Figure 1).

2.1.3 Environmental variables

Three groups of environmental variables were considered as explanatory variables in the regression models in those landscapes containing at least one rare species registered: (1) climate,

(2) topography and (3) landscape configuration. Several digital climatic maps were interpolated using kriging and the software GS+ (Version 9) to extract information of the average, standard deviation and coefficient of variation of annual precipitation as well as mean, maximum and minimum annual temperature. We also extracted the altitude from a digital elevation model (DEM). We calculated the following landscape metrics: number of patches (NP), patch density (PD), largest patch index (LPI), edge density (ED), landscape shape index (LSI), total edge contrast index (TECI), patch richness (PR), Shannon's diversity index (SHDI) and Simpson's diversity index (SIDI) using FRAGSTATS 3.0 (McGarical et al. 2002).

2.1.4 Data analyses

To determine the spatial structure of landscape locations and include this as a variable to predict rare woody species richness, we used principal coordinate of neighbor matrices (PCNM, Bocard et al. 2004). To partition the variability into environmental and space components, we used three sets of multiple linear regression models using different independent variables: (1) PCNM vectors, (2) environmental variables, and (3) all selected variables in (1) and (2).

3. Results

To divide rare species into groups, we first selected those species representing the 25th percentile of frequency distribution of herbarium records to identify species having low frequency. We then assigned these species into 2 categories of habitat specificity according to information from the CICY and Missouri herbariums: high habitat specificity (species restricted to 1 or 2 vegetation types) and low specificity (species reported in > 2 vegetation types). Finally, we used the 25th percentile of the modelled area of potential distribution to assign species into narrow and broad classes (Table 1).

Table 1: Criteria used to define rarity levels of woody species.

Frequency	Specificity	Distribution	Rarity level
Low (< 5 records)	Low (3 - 6 habitat types)	Wide (> 9886.25 km²)	Low
Low (< 5 records)	**High (1 - 2 habitat types)**	Wide (> 9886.25 km²)	Medium
Low (< 5 records)	Low (3 - 6 habitat types)	**Narrow (< 9886.25 km²)**	Medium
Low (< 5 records)	**High (1 - 2 habitat types)**	**Narrow (< 9886.25 km²)**	High

We found 242 rare woody plant species (133 trees, 85 shrubs and 31 lianas) out of the 955 woody species registered in the herbarium for the Yucatan peninsula. Due to the lack of data to model the potential distribution of rare woody species, we only used 138 species (76 trees, 45 shrubs and 17 lianas) to generate the potential distribution maps of these rare species, since the remaining 104 species had only 1 herbarium sample. We found 18 species belonging to the low level of rarity, and 34 and 86 belonging to the medium and high levels, respectively.

Total variation in rare species richness explained by environmental variables ranged from 3 to 16% (Table 2). The medium level of rarity had the highest percentage of variation explained and was associated with the highest number of environmental variables. Species richness was negatively associated with maximum temperature and positively related to precipitation. Relationships involving TECI and LSI were negative, indicating that rare species richness decreases as the contrast of patches increases and as the shape of a landscape becomes more irregular. On the other hand, the number of patches and edge density were positively related to rare species of this level.

On the other hand, variation partitioning revealed that spatial dependence was the variable most strongly associated with rare species richness; the amount of variation explained by this variable ranged from 13 to 17% for the different levels of rarity (Figure 2). Environmental variables explained a higher percentage of variation for the low and medium levels of rarity, compared to the high level and to all rare species.

Table 2: Regression standardized coefficients and partial multiple correlations for predicting rare woody species richness from environmental attributes.

CLIMATE AND LANDSCAPE STRUCTURE	All rare spp.	Level of rarity		
		Low	Medium	High
	$(R^2 = 0.05)$*	$(R^2 = 0.08)$*	$(R^2 = 0.16)$*	$(R^2 = 0.03)$*
MEAN PRECIPITATION		-0.22 (0.05)	0.17 (0.03)	0.17 (0.03)
MEAN TEMPERATURE MAXIMUM	-0.17 (0.03)		-0.20 (0.03)	
SD ALTITUDE	-0.17 (0.03)			
TECI		0.25 (0.03)	-0.27 (0.02)	
LSI		-0.20 (0.02)	-0.46 (0.03)	
ED			0.58 (0.03)	
NP			0.24 (0.03)	

* Coefficient of determination for the model.
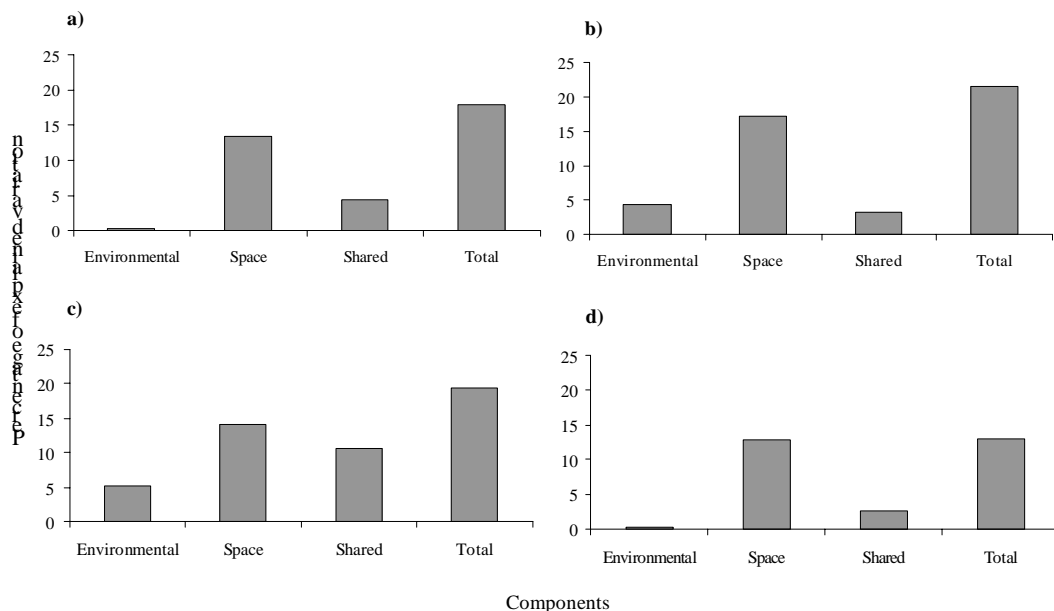
Figure 2: Partitioning of the variation of rare species richness by environmental and space components. All species (a), low level of rarity (b), medium level of rarity (c), and high level of rarity (d).

4. Discussion

The most important variable explaining variation in rare woody species richness was spatial dependence (Figure 2). This result suggests that the distribution of these species is strongly affected by dispersal limitation (Hubbell 2001). Alternatively, rare species distribution may be influenced by other environmental variables operating at local scales, such as physical and chemical soil properties, and microclimate (Jones et al. 2008; Lindo and Winchester 2009). However, the relative contribution of spatial and environmental components varied among the different levels of rarity. We found that as the level of rarity increases, the amount of variation explained by environmental variables decreases. This suggests that dispersal limitation or local environmental factors may be most important for species with the highest level of rarity, that is, those with low frequency, high levels of habitat specificity, and restricted distribution. Since the majority of rare species studied belonged to the highest level of rarity, the patterns shown by all rare species were very similar to those of species with the highest level of rarity.

On the other hand, we suspect that landscape structure and climate are more relevant for species with low and medium levels of rarity. In particular, species with medium level of rarity were positively associated with precipitation and negatively associated with maximum temperature. This result suggests that rare species tend to be more common in mesic environments. For example, Gaston (1994) reported that precipitation is an excellent predictor variable of patterns of distribution of rare species. In this study the highest number of rare species was found in the south of the Peninsula, according to the precipitation gradient from the North-West (lowest) to the South-East (highest).

We found apparently contradictory results regarding the relationship between landscape structure and the number of species with medium level of rarity (Table 2). On the one hand, rare species richness decreased as the contrast among patch types increased and as their shape was more irregular, suggesting that landscape heterogeneity has a negative effect on rare species richness. On the other hand, edge density and number of patches were positively related to rare species richness, suggesting an increase in the number of species in more heterogeneous landscapes. These results may indicate that small disturbances promote spatial variation of patches, which create habitat diversity allowing an increase in the number of species. However, large amounts of disturbance increase the contrast of patches, indicating a major degree of fragmentation that negatively impacts rare plant species (Honnay et al. 2003).

Finally, our results indicate that most of the variation in rare woody species richness was unexplained indicating the need for more detailed studies to elucidate the factors determining rare species distribution and richness. However, we did find some relationships between environmental factors studied and rare woody species richness, which can contribute to the conservation and management of these species.

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Economic estimations in planning of using and preservation of natural landscapes

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Abstract

The very important task in preserving the natural landscapes is to include the non-economical values in territory development management. Economical value definition of the natural resources based on market and non-market methods allow us to take into account ecological and social aspects in economical estimation of the territory natural resources and to choose natural landscapes using directions.

Article is short presentation of results of the economic-geographical analysis of wildlife management in the Tomsk region.

Taking into account a social factor, natural resources monetary estimations reflect economical-geographical features of the territory, and indicate the stability of wildlife management and can be used in the natural landscapes management.

Keywords: economical estimation, natural capital, landscape

1. Introduction

In accordance with the concept of sustainable development, striving for favourable living conditions and natural environment should be the basis of economic policy.

Natural resources (mineral and raw material resources, forest and water, biological and other resources) are of great importance for social and economic development of Tomsk region.

Tomsk region is located on West Siberian plain in the middle stream of River Ob', its area making up about 316.9 thousand square kilometers. The climate of Tomsk region is continental due to its geographical location (temperate zone, in latitude 55-61° North). The average annual temperature is negative: –0.5°C to –3.5°C. At the same time the temperature may go up to more than +30°C in summer months, and go down to – 30°C in winter months. The population of the region is about 1.04 million people, including 67 % of city-dwellers.

Tomsk region is an industrial region with highly developed technology, gas-and-oil production, petrochemistry, science, culture, and agriculture in southern areas.

Total geological resources of oil and gas in Tomsk region are estimated at 5.4 billion ton standard units. (1 ton of oil is equal to 1 thousand cubic meter of gas and comprises 1 ton standard units of raw hydrocarbon).

Forest covers about 61 % of the territory. Pine nut resources in average productivity years comprise up to 58.7 thousand ton. 16 sorts of mushrooms out of 72 sorts growing in the region are in use. Total regional biological resources of fruit and berry of all kinds comprise 58627 ton. 59 sorts of medicinal herbs are found throughout Tomsk region. Raw material of 38 sorts of medicinal herbs is being prepared for the needs of drugstores, individuals, and market sales.

An important contribution of the natural resources component to gross regional product, as well as potential increase of GRP owing to nature management, are proved by the results of a number of projects on natural resources evaluation. Natural resources provide stable flow of economic revenue. Along with the above mentioned, natural resources are of great social importance in rural areas, as they provide countrymen living. Natural forest resources are the

only source of revenue, and therefore the only means of subsistence for the majority of countrymen.

Social and ecological significance of natural resources is often underestimated at managerial decision making due to the absence of any relevant information regarding their full economic value at the stage of economic analysis (Tsibulnikova, 2003).

2. Methodology

Methodological approaches to natural resources evaluation recommended by UN analysis department allow to define full economic value of natural objects.

The peculiarity of the methods is that natural resources value is defined as capitalized annual rent over the period of their full utilization. Estimation of total volume of utilized natural resources is the key point of this methodology. Nonmarket and subjective evaluation methods allow to define the full volume of utilized resources, including those used by private households, and make overall economic evaluation of territories.

The methods were first approved in Tomsk region for the evaluation of the area between Ob' and Tom' rivers, with the aim to study the problem of social and ecological factors synthesis in economic evaluation of natural resources capital, and develop mechanisms for unique territories preservation (Adam, Tsibulnikova, 2001).

2.1 Local methodology approbation

To study the problem of combination social and ecological factors in the economic estimation of the territory natural capital the local territory between the rivers Ob and Tom'- the unique natural complex providing a basic need of Tomsk in recreational resources and water has been used. The territory square is 3600 square kilometers, population – 32000 people.

Now there is a real threat of degradation of the territory ecosystem because of amplifying anthropogenic loading. The natural resources of this territory are a state property, except the land where there are settlements. About 50 % of the territory is completely limited for any economical activities.

Forest non-wood recourses estimation was based on the survey data that were used to define the forest products consumption volume and Ob-Tomsk inter-river region and Tomsk population expenses to collect and deliver the forest products.

There is an opinion, that if the household collecting the wild grow resources for personal needs it has the income the same as on the market. The results of the research have shown the stable level of the economical value of the Ob-Tomsk inter-river territory for the local population and for the Tomsk city population. That flow is in several times bigger than the wood resources cost. Also the wildlife resources have the social importance because they provide the major income for the family budget of the not too wealthy people.

Indirect cost of the Ob-Tomsk inter-river territory using (indirect cost of the forest) is based on the capacity of the trees to absorb carbon. The calculation was based on the World Bank methodology.

That's why in the natural capital estimation of the Ob-Tomsk inter-river territory the major part of the useful information was received on the base of the questioning. According to the questioning we could estimate the wood consumption and the non wood resources of the forest and also receive information how the local population is ready to bear expenses to preserve this territory.

Estimation of the animals and fish was received on the actual shooting of the animals and catch of the fish data (on the base of the questioning), the market prices, and the time spent on the fishing and hunting.

Direct use value of the wood is 125 000 dollars – 3% from the total cost of the forest. The economical value of the forest is in 4,5 times higher in comparison with the simple wood,

because the forest is using by the households as the source of the food products. Applying the specific estimation methods allow to increase in 30 times the economical value of the forest.

The net value of the Ob-Tomsk inter-river territory forest resources on the base of the survey is about 2,9 million dollars per year. If the discounting rate will be 3 % and the usage time of the non-wood resources of the forest will be 100 years, the total cost of them is about 91,6 million dollars. To compare, the total revenue from the complete felling of the Ob-Tomsk inter-river trees plus the second trees felling 100 years later (the forest renewal period), with the same discounting rate 3 %, will be 26,9 million dollars.

Comparison ecology services distribution structure shows that practically on all the basic ecosystem services export to a city essentially exceeds internally consumption. From the positions of the natural capital movement analysis and fair distribution of the natural rent, directions and methods of preservation strategy and development of a natural landscape have been defined. Monetary estimations of territory natural resources have been applied by us as territorial indicators and indicators of steady wildlife management in particular economic-geographical conditions. (see Figure 1)

After reception of the results the questions of incomes increasing because of the natural capital and creation of conditions for forest products collateral preparation, fishing, cultivations of wild animals for the hunting tourism became priority.

The received results have allowed to develop actions for preservation and development of territory adjoining to a city because of the reinvestment the natural rent in preservation of a natural complex, according to sustainable development principles. On the basis of the received results of that work, an estimation of the area natural resources and creation of system of the ecological-economic account at regional level has been continued.
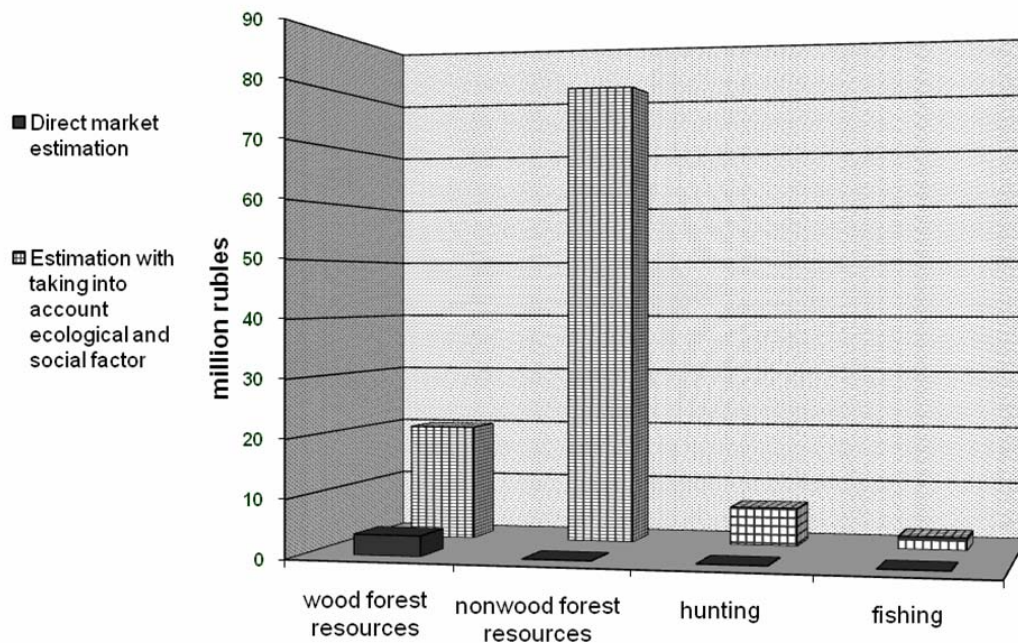
Figure 1: Economical estimation of the forest natural resources with taking into account ecological and social factor . (Tsibulnikova 2001).

2.2 Development of a system for ecological and economical registration in the region

Results of the approbation of pecuniary valuation of natural resources in Tomsk region were spread over the region with the aim to integrate the system of ecological and economical registration into management practice.

Further investigations in the region have shown that fuel-energy resources are most significant in the structure of natural capital of Tomsk region, comprising up to 96% of its total value. These factors defined the strategy of Tomsk region development aimed at priority development of oil and gas industry (Adam, Tsibulnikova, 2009).

At the same time, in spite of growing dependence of regional economy on petroleum production, biological resources significantly account in the structure of natural capital. (see Figure 2).

Such conditions set a task to support stable flow of natural resources and ecosystem services of forest landscapes.

The analysis of information coming from regions has shown that petroleum production does not play the key role in regional population employment. Petroleum production is realized in three regions with total population comprising only 9% of Tomsk region population. 25% of the population of Tomsk region reside in 12 region occupying 50% of the territory of Tomsk region, where people earn their living mainly by biological resources. Tomsk region is subdivided in 16 municipal regions. Small scale entrepreneurships and businessmen are engaged in fishing or forest resources storage.

In addition to forest foodstuff storage, some regions organize storage of some crude drugs, food plants, and other resources, used by the population in the development of local production. Total economic value of nonwood forest resources amounts to $979.3 million. The estimation is not final, as it is made on the basis of 12 regions out of 16. Moreover 8 of them carry out registration of foodstuff forest resources only, and only 2 regions carry out registration of all kinds of nonwood forest resources. According to peer review, only 30% of total economic value of forest landscapes is being registered presently.

Economic evaluation of forest resources has proved mushrooms, berries, and medicinal herbs to be the full source of revenue for the local population. Thus, economic value of nonwood forest resources is 6 times higher than that of wood. At that, mushrooms and pine nuts represent the greatest part in total value (47% and 24% of total value accordingly). Due to the absence of official resources registration system in the state, planning of efficient use and preservation of natural landscapes involve difficulties. As a result, in the course of industrial wood harvest and mining, the population loses nonwood resources playing significant role in life support.
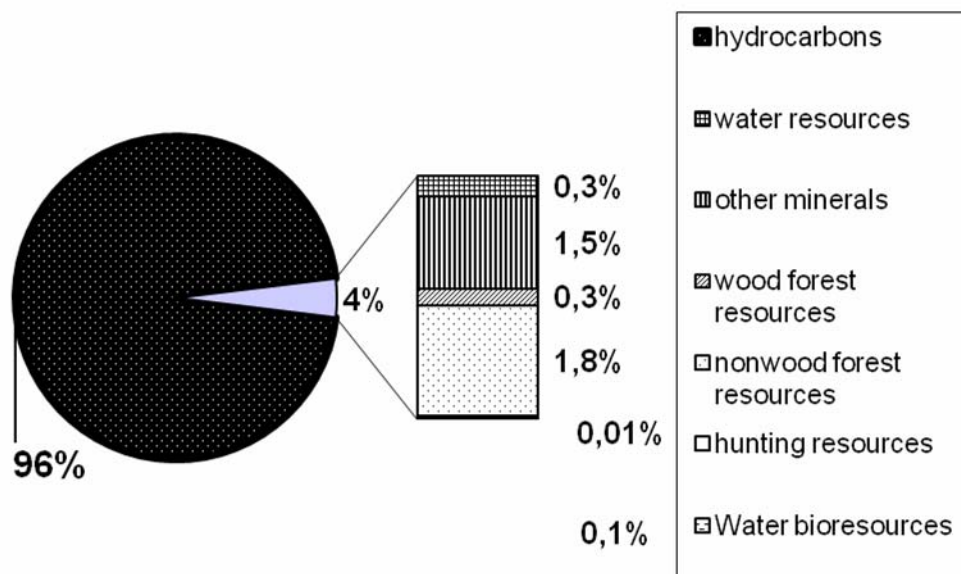
Figure 2: Natural capital structure of the Tomsk Region (economical value of the natural resources) (Tsibulnikova 2009)

3. Result

Current investigations change approaches to nature management. Economical information is an instrument providing calculations necessary for substantiation managerial decisions. Tomsk region administration directed official letters stating the necessity to organize better registration of profit gained from forests to municipal regions.

Two municipal regions have rather well organized registration procedures providing relevant information, and give preference to forest preservation rather than wood storage. One region decided to direct funds for berry plantations quality improvement. Another region decided to create natural recreation zone.

The necessity to preserve natural landscapes often conflict with the aims of social and economic development of regions. Local authorities empowered to manage natural resources, often fail to take into account that life of many people is dependent on natural resources (Tsibulnikova 2003).

Working out and adoption of Tomsk regional statute obliging mining companies to compensate for losses of natural resources have become the practical application of natural resources evaluation methods taking into account both social and ecological factors. The amount of compensation is calculated from the cost of natural resources directly or indirectly involved in the process of mining.

4. Discussion

1. Application of pecuniary valuation in natural resources evaluation methodology with the frame of landscape and ecological investigations allows to consider full economic value of nature at managerial decision making.

2. Economic evaluation taking into account social and ecological factors allow to define real material and money flows in nature management.

3. Pecuniary valuation of natural resources taking into account social factor show economic and geographical peculiarities of the territory, indicate nature management stability, and can be used both for natural and anthropogenic landscape management.

4. Economic and geographical analysis of nature management in Tomsk region has shown that in the effort to provide stable development of Tomsk region, preservation of natural ability of forest to provide foodstuff, crude drug, and other forest resources, will contribute to better economic efficiency

5. The analysis of money flows coming from nonwood forest resources gives the ground for local authorities to make right choice in territories use and define such forest resources as recreation, creation and further utilization of forest plantations, growing of forest fruit, berry, ornamental plants, and medicinal herbs, as priority ones.

6. In the effort to provide stable development of Tomsk region, preservation of natural ability of forest to provide foodstuff, crude drug, secondary forest resources, and accessory products of forest exploitation without landscape deterioration, will contribute to better economic efficiency. Such course can provide multiplicative effect from animal and fish natural habitat preservation, and forest recreation development for amateur hunting and fishing.

7. Evaluation of money flows in nature management allows not only to plan arrangements for natural resources preservation, but also to define volumes and mechanisms for compensation in case of landscape deterioration.

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Section 5
Monitoring landscape change

Mapping and Monitoring land cover and land –use changing using RS and GIS. Case study: Kaleybar, Iran

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Abstract

Arasbaran is located in East Northern part of East Azerbijan province. Because of the having montainus forests and special standing condition, fragile ecosystem is created.
In this study, maximum likelihood supervised classification and post – classification change detection techniques were applied to land sat images acquired in 1987 and 2002, to map land cover changes in the North Western forests of Iran.
A supervised classification was carried out on the six reflective bands for the two images individually.

Key words: Iran, Arasbaran, Remote sensing, GIS, Land cover

1. Introduction

Remote sensing techniques have recently recived lots of attentions in agriculture and natural resources. Natural resources and environmental conservation need a lot of attention especially on under devloped countries. Using remote sensing techniques and sateliate data for evaluation of environmental changes is rapidly growing.

2. Methodology

2.1 Study area

The study area is located in North West of IRAN and the North Eastern of the East Azerbijan province, which called Arasbaran, is a mountainous area with elevation between 300 and 2700 meters above the see level and very near to the Caspian Sea.

The area is located between $38°.48′$ and $39°.01′$ latitude and between $47°.14′$ and $46°.51′$ longitude. It covers diversity of elevation, slope, population and land use and includes a variety of seashore rivers, etc. There are above 785 plant species in this forest that 97 species of them are woody (Sagheb et al, 2004).
Arasbaran includes 11 basins. Kaleybar Chay is one of them, which is our study area. Aras river is in the Northern boundary of the study area.

2.2 Materials

Three sets of material were used here.

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First, land sat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) images acquired on 20 July 2002 and 19 July 1987, respectively. Land sat 4 and 5 carry the TM sensors. Second, digital topographic maps digitized from hard copy topographic maps with scale of 1:50,000 were made of IRANIAN surveying center and used mainly for geometric correction of the satellite data and for some ground truth information.

Finally, ground information was collected between 1997 until 2002for the purpose of supervised classification and classification accuracy assessment.

2.3 Geometric correction

Accurate per- pixel registration of multi- temporal remote sensing data is essential for change detection since the potential exists for registration errors to be interpreted as land cover and land- use change, leading to an overestimation of actual Change(stow, 1999).

Change detection analysis is performed on a pixel – by- pixel basis, therefore a misregistration greater than one pixel will provide an anomalous result of that pixel. To overcome this problem, the root mean – square error (RMSE) between any two dates should not exceed 0.5 pixels (Lune tta& Elvidge 1998).

In this study geometric correction was carried out using ground control points from topographic maps with scale of 1:5000 produced in 1986 by Iranian Army Surveying Center (IASC).To geocode the image of 2002, then this image was used to register the image of 1987.

The RMSE between the two images was less than 0.4 pixel which is acceptable. The RMES could be defined as the deviations between GCP and GP locations as predicted by the fitted – polynomial and their actual locations.

The goal of image enhancement is to improve the visual interpretability of an image by increasing the apparent distinction between the features.

The process of visually interpreting digitally enhanced imagery attempts to optimize the complementary abilities of the human mind and the computer.The mind is excellent at interpreting spatial attributes on an image and is capable of identifying obscure or subtle features (Lillesand & Kiefer, 1994).

Contrast stretching was applied on the two images and two false color composites (FCC) were produced.

These FCC were visually interpreted using on screen digitizing in order to delineate land cover classes that could be easily interpreted such as village.

Some classes were spectrally confused and could not be separated well by supervised classification and hence visual interpretation was required to separate them.

2.4 Image classification

Land cover classes are typically mapped from digital remotely sensed data through the process of a supervised digital image classification (Campbell, 1987), (Zobeyri & Daleki, 1988). The over all objective of the image classification procedure is to automatically categorize all pixels in an image and to land cover classes or themes (Lillesand & Kiefer, 1994).

The maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns when classifying an unknown pixel so that it is considered to be one of the most accurate classifiers since it is based on statistical parameters. Supervised classification was done using ground chek points and digital topographic maps of the study area.

The area was classified into seven main classes: High density forest, low density forest, ranglands, agriculture, bare land, river, and village.

Description of theses land cover classes are presented in Table 1.

In order to increase the accuracy of land cover mapping of the two images, a cillary data and the result of visual interpretation were integrated with the classification result using GIS in order to improve the classification accuracy of the classified image.

Table1. Classification details of land covers classes in study area

Class	Details
Forest stands	Mountainous forest stands ,which almost coppice stands and low forests including in study area. The area have the biggest forest stand in North West of Iran.
Range land	Areas which no ability for agriculture and forestry but have grasses. Some range lands is part of changing biocenose at positive line of ecosystem changing.
Cropland	Lands which cultivated vegetables, fruits, and annual crops. These crops are irrigated mainly from the water of rivers *Aras Ilghine chay* , or rain water and or ground water.
Bare land	Land areas of exposed soil surface as influenced by human impact mainly or natural causes. That is the last trying of ecosystem to protect its biocenose.
River	*Aras* and *Ilghineh chay* are two main rivers in study area and main resources for irrigation of croplands and human uses, after this, the area including springs.
Village	The biggest population community where human society is in it, at the study area. The place of villages did not change during the time of this study so they were not included in our classifications.

2.5 Land cover/use change detection

 Regardless of the techniques used, the success of change detection from imagery will depend on both the nature of the change involved and the success of the image pre processing and classification procedures. If the nature of change within a particular scene is either abrupt or at a scale appropriate to the imagery collected then change should be relatively easy to detect. Problems occur only if spatial changes are subtly distributed and hence not obvious within any image pixel (Milne, 1988, Darvishsefat et al, 2002).

In the case of the study area chosen, field observation and measurement have shown that the change between the image collection dates was both marked and abrupt .In this study post - classification change detection technique was applied. Post classification is the most abvious method of change detection, which requires the comparison of independently produced classified images. The CROSSTAB module of Ilwis software was used for performing cross tabulation analysis. CROSSTAB performs two operations.

The first image cross tabulation in which the categories of one image are compared with those of a second image and of the number of cells in each combination is kept in tabulation. The result of this operation is a table listing the tabulation totals as well as several measures of association between the images.

The second operation that CROSSTAB offers is cross- classification. Cross- classification can be described as a multiple overly showing all combinations of the logical AND operation (Shalaby.A&Tateishi.R, 2007).

The result is a new image that shows the locations of all combinations of the categories in the orginal images

A legend is automatically produced showing these combinations' cross- classification thus produce a map representation of all non- zero entries in the cross- tabulation table.

3. Result

The color composites generated from bands 4, 3 and were visually interpreted through on screen digitizing. The visual interpretation gave a general idea about the forms of land cover changes over the period. Many farmlands and new roads and range lands were noticed in the image of 2002 and not in the one of 1987. A noticeable change is detected in areas of forest stands, lime stone and shale Quarries in the Northern and South eastern parts of the study area where part of the forest stands, range lands and cropland were converted to range land, cropland and bare lands. On screen digitizing was carried out for forest, range lands, cropland, bare land, river, village classes as well as the road network. Supervised classification using all reflective bands of two images acquired on 20 July 2002 and 19 July 1987 was carried out using maximum likeli hood classifier. In order to increase the accuracy of land cover mapping of the two images, ancillary data and the result of visual interpretation were integrated with the classification results using GIS. The module used the overlay module in Ilwis 3.0 Academic Software. Through the overlay proccess, areas which were misclassified in the village forest, range lands and cropland and river classes were relabeled to the correct classes using the layer of visual interpretation.

This overlying of the visual interpretation on the result of the classification led to the increase in the overall accuracies by about 10 percent for both images.

The lowest accuracy was for range land and forest that could be explained by the fact that the study area is semi – humid and the vegetation intensity is between range lands and forest stands, especially in ecotons which gradually led to the confusion with them.

Remote sensing data and GIS provide opportunities for integrated analysis of spatial data. Cross- tabulation performs image Cross- tabulation in which the categories of one image are compared with those of a second image and tabulation is kept of the number of cells in each combination.

Post - classification change detection technique was carried out, through Cross- tabulation GIS module for the classification results of 1987 and 2002 images in order to produce change image and statistical data about the spatial distribution of different land cover changes and non- change areas .

We have to take in to consideration the accuracy of the classification of different classes since the error of the classification will affect the accuracy of the change detection figures.

Land degradation processes in the study area are: degradation of range land due to overgrazing and the converting of range land to cropland due to low incoming and bad economical condition of peopls who living in study area.

Mismanagement of natural resources specialy forest stands is another cause of forest degradation. In this view point people who living in villages need fuel and means and materials for their lifes. So with mismanagement of natural resources, the forest stands is the easy and best answer for solving their problems.

This could be seen on the land cover / land use map of 2002 where the crop land areas have increased from 400.52 ha crop land in 1987 to 654.76 ha crop land in 2002.(For more see table2).

Table2. Change detection details of study area

Class Name	1987 (area in ha)	2002(area in ha)
Crop land	400.52	654.76
Bairsoli	21128.71	21931.34
H.Forest	5089.26	4086.3
L.Forest	14036.59	13987.45
Rangeland	9049.88	9021.29
River	303.7	327.52
Total area	50008.66	50008.66

The next land degradation process cause in the study area is water erosion and wind erosion, which are so power full, in lands without vegetation cover or low vegetation cover.
Water and wind erosion let to the removal of the relatively fertile top soil and this could lead to desertification.

4. Discussion

The objective of this study was to provide a recent prespective for land cover types and land cover changes that have taken place in the last fourteen years, to integrate visual interpretation with supervised classification using GIS and to examine the capabilities of integrating remote sensing and GIS in studying the spatial distribution of different land cover changes.
The area of forest stands has decreased considerably. Integrating GIS and remote sensing provided valuable information on the nature of land cover changes especially on the area and spatial distribution of different land cover changes.
The main causes of land degradation in the study area are convertion of forest stands to range lands, range lands to crop lands, and convertion of crop lands to bare lands. This problem show sere to be continued for disclimax and needs to be seriously studied, through

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Forest patches in agricultural landscapes
(loess areas of SE Poland)

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Abstract

A mosaic of naturally and anthropogenically conditioned patches of terrain cover, which are diversified as regards the kind, size and shape, appears in the agricultural landscapes. The research was carried out in the 2 test areas located in SE Poland. They cover an area of 28 km2 and 35 km2. This is the area of the appearance of a specific landscape in the structure of which, a group of forms characteristic for its loess relief is dominant. The analysis of the changes in the land use were carried out on the basis of the three maps comparison four maps, representing the years 1840, 1890, 1935, 1997. The spatial analysis consisted of the assessment of changes of forest patches areas as well as some chosen statistical parameters prepared for the four time periods: 1840-1890, 1890-1935, 1935-1997, 1890-1997. The studies revealed differences in the scope of changes in the percentage of forest cover in the test areas.

Keywords: agricultural landscape, land use changes, loess areas

1. Introduction

Agricultural landscapes are characterised by a mosaic of naturally and anthropogenically conditioned patches of land cover that are diverse in kind, size and shape. Human activity is the main factor influencing the changeability of forms of land use in time and space. However, in many cases the influence of abiotic environment components can also be significant. A good understanding of the historical determinants of changes in land usage allows for a better anticipation of the tendencies developing in a landscape, and also enables a more effective landscape management (Bork 1989, Dotterweich 2008).

The research was carried out in two test areas, Wąwolnica (28 km^2) and Wilczyce (35 km^2), located in SE Poland. The structure of the unique landscape occurring in this area is dominated by a group of forms characteristic of loess relief. The deep Bystra and Opatówka river valleys form the morphological axes of the test areas. The plateaus and slopes are dissected by a system of dry valleys and gullies. The Wąwolnica area exhibits a greater diversity of relief as steep slopes and gullies occupy a larger part of the landscape (see Table 1). These areas were cultivated as early as the Neolithic, while the next strong expansion of settlements and farming began in the mediaeval period (Nogaj-Chachaj 2004). Nowadays, arable lands predominate in the land use structure, occupying from 55% to 63% of the whole area. The percentage of forest cover is quite high in the Wawolnica test area (18%), while it is significantly lower in Wilczyce (9%). It is a result of a large proportion of areas where cultivation has been discontinued because most of them are occupied by gullies and steep slopes (Baran-Zgłobicka and Zgłobicki 2004).

A typical community growing in gullies and on steep slopes nowadays are Tilio-Carpinetum forests; tree stands are composed of hornbeam (Carpinus betulus) with an admixture of small-leaved lime (Tilia cordata), Norway maple (Acer platanoides) and pedunculate oak (Quercus robur). Protected species occur among herbal plants (Kucharczyk 1992).

2. Methodology

The analysis of the changes in land use was carried out by comparing three maps: Karte des westlichen Rußlands 1: 100 000 (representing the year 1890), Tactical map of Poland WIG 1: 100 000 (representing the year 1935), and a modern land use map 1: 25 000 (representing the year 1997, elaborated based on aerial photographs and field mapping). The first two maps were digitized and calibrated. The next step consisted of the creation of maps (layers) of wooded areas with the use of ArcView software. The map compilation and the selection of chosen separations enabled the analysis of how the percentage of forest cover changed over time as well as the examination of the links between those processes and natural determinants. A map dating back to 1840 was also available but did not lend itself to cartometric analysis. Hence, only an approximate percentage was calculated for the forest cover in that year.

The above-mentioned cartographic materials indicate that woodlands and forests are the only land use category that could be examined in relation to such a long period of time. At the same time, they constitute the most "natural" component of the land cover. The spatial analysis included the assessment of changes in the area of forest patches as well as selected statistical parameters prepared for three periods: 1890-1935, 1935-1997, 1890-1997. In addition, an examination has been conducted with respect to the character of the abiotic components in areas covered by forests in various periods as well as in areas where forestation or deforestation took place.

3. Results

The studies revealed differences in the scope of changes in the percentage of forest cover in the test areas.
- In the Wąwolnica test area, the forest cover decreased by 2.8 km^2 over the last 100 years; the lowest forest cover occurred in 1935 (11%)
- In the Wilczyce test area, the percentage of forest cover increased more than fivefold over the last 100 years. At the end of the 19th and beginning of the 20th century it was less than 0.5% (see Figure 1)
- In Wilczyce, gullies are the only contemporary form of relief with a considerable forest cover. In Wąwolnica, the percentage of the forest cover on steep slopes is also relatively high.
- In Wąwolnica, an increased number of forest patches was observed, along with a decreased mean patch area. The diversity of the shapes of the patches has also increased (see Table 2). Nowadays, the mean patch area is particularly small in the case of Wilczyce.
- The loess plateaus as well as gentle and medium slopes were deforested in the Wąwolnica test area (see Table 3), while in the Wilczyce test area this process was not observed.
- In both test areas, the forests occupied the area of gullies and steep slopes.

4. Discussion

The presented results show the rationality of changes as regards the usage of the agricultural production space. In Wąwolnica, the plateaus and gentle slopes, convenient for agricultural cultivation, were deforested during the last 100 years, whereas in Wilczyce this process took place before the 19th century. After World War II, an increase of forest areas occurred in both test areas. The succession of forests occurred in areas with a significant threat of soil and gully erosion. Nowadays, this process also occurs in connection with a decline in the profitability of agricultural production.

The differences in the percentage of forest cover between the test areas should be linked with natural and socioeconomic conditions. The clearly larger area covered by forests in Wąwolnica results from the relief of the area, i.e. a large proportion of steep slopes and gullies. The

Wilczyce area was characterised by a more intensive agricultural activity connected with the existence of vast ecclesiastical estates in this area.

From the perspective of ecology, the current structure of forest patches is not favourable because forested areas are small and diverse in shape. On the other hand, forests in gullies and on steep slopes represent the only forest enclaves in the agricultural landscape. Such a situation clearly indicates the role of geodiversity as a determinant of biodiversity.

In some cases, however, the changes in usage structure were not determined by nature-related factors. In Wąwolnica, considerable deforestation took place within the medium slopes, whereas in the case of steep slopes the forestation area represented less than 50% of the previously deforested areas. At the same time, some changes in the agricultural character of land use are necessary in some parts of the analysed areas – most importantly in order to limit the threat of erosion.

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Table 1: Relief and land use within test areas

	Wąwolnica	Wilczyce
Forms of relief		
Bottoms of valleys	9	18
Gentle slopes (3-6°)	20	17
Moderate slopes (6-12°)	16	23
Steep slopes (> 12°)	9	4
Gullies	6	4
Plateau tops	42	34
Land use		
Arable lands	55	63
Orchards	3	14
Plantations	5	0.5
Grasslands/pastures	14	7
Forests	18	9
Wastelands	2	2
Built-up areas	4	4.5

Table 2: Changes in the structure of forest patches

	Forest area [km²]	Forest cover [%]	Number of patches	Mean patch area [ha]	Mean shape index
Wąwolnica test area					
1890	7.9	28	12	64	1.9
1935	3.1	11	33	10	1.4
1997	5.1	18	37	13	2.2
Wilczyce test area					
1997	3.1	9	87	3.7	1.7

Table 3: Changes in the forest cover within different forms of relief (Wąwolnica test area)

	Plateau tops	Gentle slopes	Medium slopes	Steep slopes	Gullies	Bottoms of valleys
1890	21	27	35	39	61	9
1935	9	10	13	20	33	2
1997	8	13	20	30	86	4
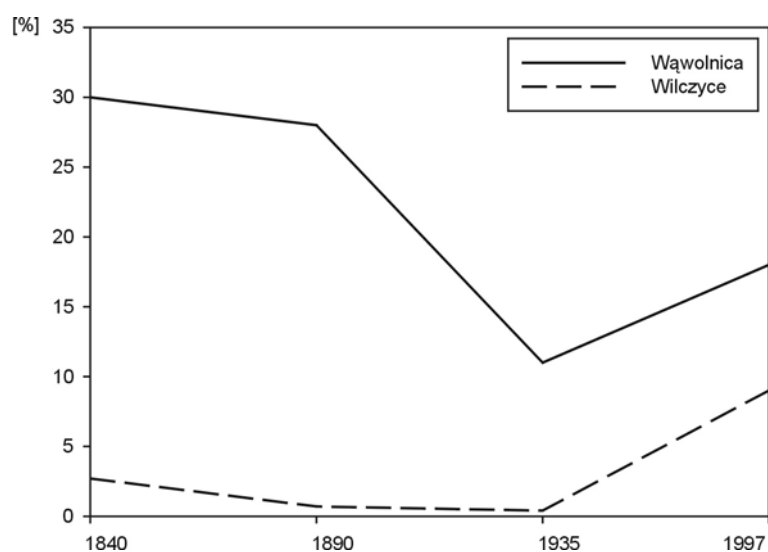
Figure 1: Tendencies of changes in the forest cover in the test areas

Integrating esthetical and ecological values at the central Asia landscape change

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Abstract

Desertification is the gradual transformation of usable land into desert; is usually caused by climate change or by destructive use of the land. The present study examines how a person interprets desert landscapes using phenomenological methodology. In ecological aesthetics pleasure is derived from knowing on how the part of the landscape relate to the whole. The objective of the present paper is to describe how to integrate landscape aesthetics into landscape planning of the Central Asia Silk Road area. A questioner was used as research tool to measure landscape preference. The questions were constructed following the principles of phenomenology. After qualitative and quantitative analysis, 7 main categories of cognitive aspects of natural landscapes were identified. Each landscape evoked each participant's memories and background, and altered through these influences, imagination/association, impression, aesthetic judgments, and meaning and attractiveness of nature. All the above played their role in the evaluation of desert landscapes.

Keywords: Desert landscape, aesthetics, landscape assessment, phenomenology

1. Introduction

There is mounting evidence pointing to the relationship between climate change effects and landscape preferences (Cambers, 2009). Landscape preferences and perceptions usually are influenced by demographic elements such as age, gender and ethnicity; as well as culture (Brunson & Shelby, 1992). With few exceptions, most of those studies have examined perceptions of environments within relative non-dynamic periods. There is therefore a scarcity of studies on perceptions of desert landscapes that are undergoing reclamation. In light of climate change, such investigations are crucial to the understanding of adaptation processes. It is argued, that to a great extent, tourists' perceptions have been left out of the debate on desert landscape adaptation and climate change.

Given that desertification within major tourism destinations is an inevitable consequence of climate change a deeper understanding of user perceptions can provide a holistic view to adaptation processes. As the morphological structure of desert landscapes changes, social driving forces will have to change not only in the way in which they visualize these areas but also in how they relate to these natural environments and how sense of place changes in those spaces.

The idea of beauty in landscapes has changed during the history of civilization and aesthetics has been a topic of debate for philosophers, artists and architects since at least the time of Socrates (Thorn and Huang, 1991; Carlson, 2002). At present, aesthetics is being taken into consideration by environmental managers and policy makers (Canter, 1996). Symmetry and other classical rules such as the 'golden mean' were the most important components of

landscape beauty in Greek and Roman gardens two thousand years ago (Botkin, 2001). The English garden, a much later development, represents the naturalistic (natural-like) idea of landscape beauty, and in the early Renaissance the wilderness and the power of nature symbolized the power of God and sublime beauty.

Landscape preferences studies usually adopt objective quantification or normative judgments methods (Burley, 2006, Panagopoulos, 2009). Unfortunately, such methodological approaches fail to account for people's subjectivity, a core element that informs their spatial preferences and evaluations of landscapes, and have resulted in simplistic interpretations of human-place interactions (Ohta, 2001).

According to Burke (1958) aesthetic of landscapes can be distinguished as "Picturesque" (dominated from asymmetry, scenes, nostalgic); "Beautiful" (feeling that induce in us a sense of affection and tenderness or "Sublime" (that is a pleasure that arises, from pain or fear). A violent emotion can be caused from sublime landscapes – especially with heightened spiritual feelings- and the elements of pathos and empathy exist in sublimity. During the second half of the 18th century the meaning of the word "sublime" shifted from rhetorical aesthetic to a psychological sense. The theory of "Peri Hipsous" had established the distinction between the elevated style beauty and the capacity to raise passion (Kaplan, 1987; Ramos & Panagopoulos, 2007).

Deserts can be valued aesthetically, if they are beautiful, sublime or picturesque. To identify whether a desert landscape is beautiful or not, a set of variables is to be investigated. These variables might be physical or not, they can be recognized visually and non-visually using our senses. The aesthetic value of the desert landscape can be recognized when the specialists and the community recognize together, the attributes of the aesthetic variables (Lothian, 1999).

Objective of the present study is to find how a person interprets desert landscapes using phenomenological methodology.

2. Methodology

A questioner was used as research tool to measure landscape preference. The participants were 11 men and five women, three of whom participated in preliminary (test) interviews. Participants ranged between the ages of 19 and 65, possessed a high school and above education, originated from Portugal and related to landscape planning and design. Thirty four color photographs of natural and designed desert landscapes were selected from landscape photographs. The interview style was semi-structured, beginning with basic open-ended questions were then made more specific.

The questions were constructed following the principles described by Patton (1980): 1) Experience/Behavior (what a person does or has done); 2) Opinion/Value questions (aimed at understanding the subject's cognitive and interpretive processes); 3) Feelings (emotional responses to experiences and thoughts); 4) Aesthetic knowledge (factual information); and 5) Sensory Experience (what is seen, heard, touched, tasted, and/or smelled).

The time frame of the questions may vary as necessary at the discretion of the interviewer. Typical questions for this study include the following: `What do you see on the photo?' What would you feel if you were there?' `Have you ever been to a place like this?', What element of the landscape attracted you? Other sections of the questionnaire included psychophysical questions and other with sustainability perceptions and economic preferences.

3. Results and Conclusions

Regardless of their fragile ecosystems and stigma of landscapes to avoid, decertified areas enjoy numerous human-based and natural attractions that are in some cases unique in natural world. Finding of this study well reveal that arid areas have a great number of potential capacities. Natural features like dunes, salt domes, erosion sculpts badlands, salt lakes, fresh and saline water springs, and animals well- adapted to hard-to-live circumstances, are just few instances of wonderful natural phenomena one can see in an arid area. cactus and halophyte plants, from small bushes to 6-meter high shrubs, are other natural picturesque sceneries that only deserts can offer. Also, human-based attractions like historical monuments, type of architecture and materials used for construction purposes, the ways desert-dwellers produce and subsist or deal with drought are other striking views that can attract tourists.

Tabular data relating to the distribution of scenic ratings, and the indications of preference among observers, were generated using SPSS statistical software. After qualitative analysis, 7 main categories of cognitive aspects of natural landscapes were identified. Each landscape evoked each participant's memories and background, and altered through these influences, imagination/association, impression, aesthetic judgments, and meaning and attractiveness of nature.

All these played their roles in the evaluation of desert landscapes (Figure 1). Each question caused that the participants remembered individual memories from their life and memories acquired through media or education. Participant's background, hobbies and personal preference influenced the landscape cognition. Time of day and season were also associated with questions related to first impressions about the landscape. Imaginative activities and modifications concerning the landscapes as well as the feeling of greatness of nature influence the answers. Also, because the participants were related to planning and design of landscapes they judged the landscape aesthetically depending on particular elements of the scene and they were able to understand it as a photograph or as an actual scene.
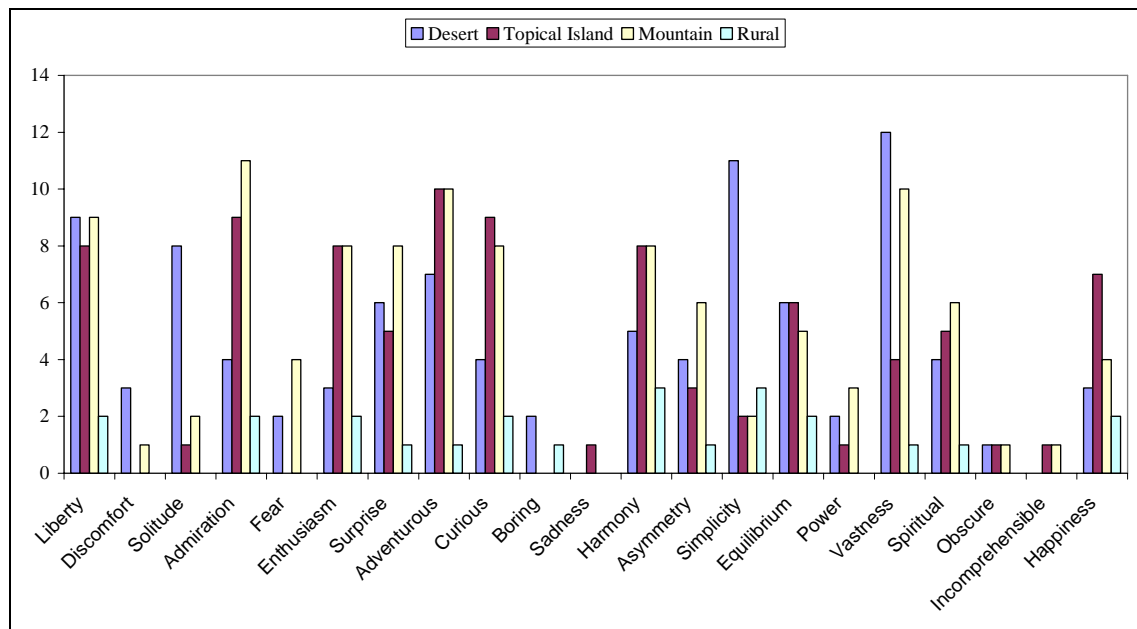
Figure 1. Feelings evoked by each participant when evaluating different types of landscapes.

Landscape cognition with photographs showed dynamic and complicated interactions of various mental aspects during the course of each session. Participants had sufficient time for various

inner responses to arise naturally during his/her interaction with the landscapes. However, most conventional quantitative studies of landscape evaluation allow viewing times of only approximately few seconds per landscape and with such a procedure researchers can deal only with participants' first impressions or fragmented memories (Ohta, 2001).

Desert landscapes show similar results of aesthetic value as a tropical island landscape, while they provoke more fear, sense of power, vastness, sense of more spiritual, obscure, and incomprehensible landscape than any other compared. In all characteristics of a sublime landscape, deserts and desert storms had the highest score. Also they had high scores in some attributes of the aesthetic variables for beautiful and picturesque landscape like: harmony, balance and simplicity for beautiful, or asymmetry and pictorial value.

A large majority of the individuals responded that whishes to buy a holiday house in desert landscape offering till 200.000 euros, but 25% responded that is not wishing to have house in this kind of landscape. 19% could spend more than 500 euros to travel in desert landscape and another 500 euros for subsistence.

From the field survey it was found that majority of participants (56%) consider that the cost of reclamation practice at decertified areas should be paid from the residents of those areas or neighborhood areas because they provoked the desertification. Although, a 38% consider that desertification is a universal problem and is responsibility of everybody to avoid landscape degradation.

Only 4 out of 16 participants consider that the Mediterranean garden could be the desirable solution for tourism development in decertified landscapes. Six prefer exotic species gardens (like oasis) 3 prefer Zen stile spaces (no vegetation) and two would rather prefer large loan areas with few trees. The large majority prefers to develop in those areas naturalistic landscapes or with minimum human intervention, while none would like to see dominant tourism development projects to overtake in those landscapes. A large number of participants (68%) requests that those areas to be preserved as of unique value as landscapes and ecosystems.

In Figure 2 can be seen the most preferable landscape aesthetic elements that the participants consider as most attractive for decertified landscapes. Human presence, luck of vegetation, geometric lines could be the less attractive elements in desert landscapes, while water presence, color contrast and texture variability, wildlife, panoramic views and organic natural lines were the most attractive. Cultural elements, activities, dense vegetation like oasis, natural sounds and silence could also be important to consider for tourism development sites and scenes.

The current study contributes to this endeavor by exploring tourists' perception of the desert landscapes of central Asia (Aral Sea and Silk Road area); a landscape that is suffering severe Aeolian erosion from dust storms and is undergoing various reclamation measures. Exploration of tourist's landscape meanings is informed by literature on the interpretation of space and place.

Barnes & Duncan, (1992) makes a distinction between three dialectical structures of space, namely, spatial practices, representations of space and spaces of representation. Spatial practices manifest into social landscapes over time. Representations of space are practices which organize and represent space, particularly through planning and design. Spaces of representation are spatialities ''space as directly lived through its associated images and symbols'' as understood by locals, tourists and tourism officials who compete for meanings, and uses.

The main objective of this study was to create a better understanding of how a person interprets desert landscapes, to examine public awareness and performance in the promotion of reclamation projects on decertified environment a to describe how to integrate landscape

aesthetics into landscape planning of the Central Asia Silk Road area. From the preliminary results of the first group of participants (planners and designers) it was found that the public have limited awareness and a poor understanding about sustainable development in global scale. Even that it was considered that desertification is a universal problem and is responsibility of everybody to avoid landscape degradation, preserve and promote the desert landscapes and ecosystems as of unique value. Also, it was found that ecological aesthetics pleasure could be derived from knowing on how part of the landscape relate to the whole.
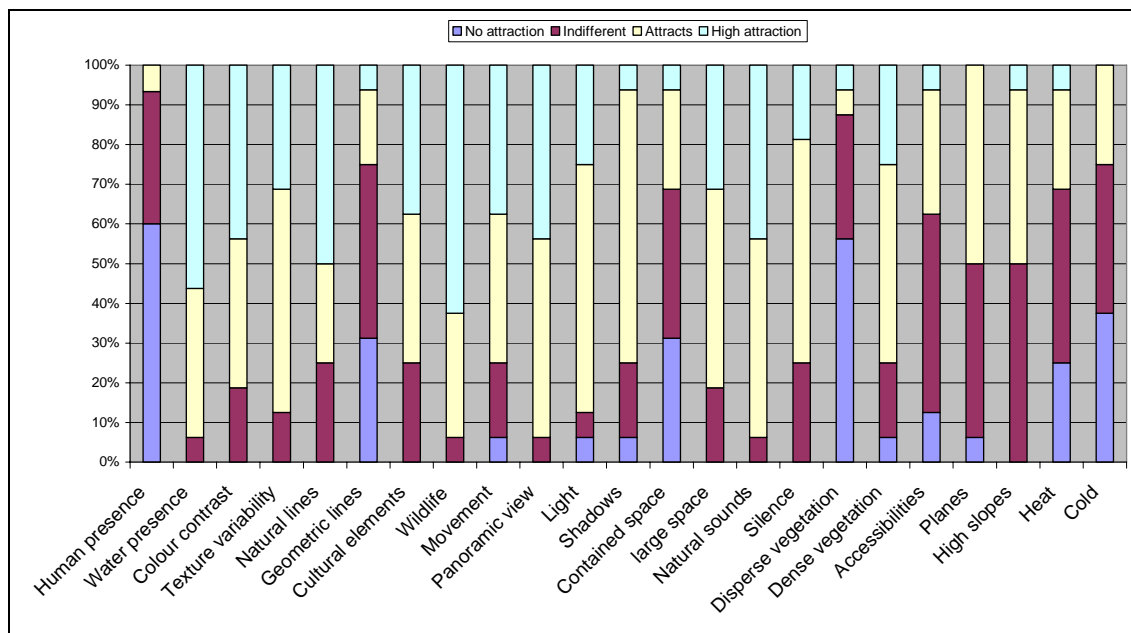
Figure 2. Landscape aesthetic elements that may attract to a decertified landscape.

Opinion of the authors is that in the wake of global climate change, society has to address the dynamic interactions between an increasingly changing environment and its politically and culturally contested spatial development in decertified landscapes.

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The impact of legislation on the dynamics of land use the River Basin Cará-Cará, Ponta Grossa-PR/Brazil, in period from 1980 to 2007

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Abstract

The human ownership of area causes transformations that can be accompanied and identified by means of land use, delineation of areas of environmental conflicts and categories of hemeroby. The objective of this work is examine the dynamics of occupation of the land use in Cará-Cará hydrographic basin located in municipal district of Ponta Grossa, in Parana State – Brazil, between the years 1980 and 2007, and the relation of laws in force with the land use. It was necessary to search and draw up maps of relevant legislation, of slope and land use that were overlay until they reach to maps synthesis of conflicts land use. As for land use, the urban class increased (121.83%) due to the increase in population. Areas that are in conflict regarding the use represent 21.05%. Classes of hemeroby showed that the landscapes more artificial than natural occupy 41.94%. It was concluded that the changes in Cará-Cará hydrographic basin were motivated by guidelines of the Municipal Master Plans.

Keywords: Hydrographic basin, Environmental conflicts, Land use, Hemeroby

1. Introduction

The changes caused by human activities in space can be monitored and verified through a survey of land use, the delimitation of areas of environmental conflicts and the identification of areas that suffered most changes in their natural characteristics.

When dealing with topics and themes used in environmental planning, Santos (2004, p. 97) states that land use is a basic theme, it "portrays the human activities that can create pressure on the natural elements" which describes "not only the current situation, but recent changes and history of occupation of the study area".

According to Clawson & Stewart (1965), land use refers to human activity on land, which is directly connected to earth. With the same thought Campbell (1997) states that land use are the human activities on land held as needed, and the results of these activities are physical changes that transform the environment.

There is need for strategies to maintain balance and dynamics of natural ecosystems present, for example in hydrographic basin. These strategies can be implemented and controlled by legislation, such as the Municipal Master Plan and the Forest Code to address the Permanent Preservation Areas. The occupation of these areas with other uses generates so-called environmental conflicts.

According to Rocha (1997) environmental conflicts in land use occur when agricultural

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activities are practiced in inappropriate areas, and these activities are most responsible for the erosion, siltation of rivers, floods and droughts.

The effects of the use and occupation of areas protected by law may cause the deterioration of the environment, emerging, so-called environmental conflicts in land use (FERNANDES NETO & ROBAIANA, 2005).

To study the effects caused by human action on the various biological systems, according to Dueñas (2004), it is necessary to develop a systematic method, comparative and qualitative, which permits the effect of human disturbance on the different elements of ecosystems.

Arise, thus concepts that serve as the basis for monitoring the developments and changes in land use caused. The concept of hemeroby is one. This term was suggested by Jalas (1953) which determines the degree of alteration of landscapes, in other words, the degree of naturalness and artificiality of the medium, considering the following classification: Ahemerobe - natural landscapes or small human interference, such as rainforest and gallery forest; Oligohemerobe - landscapes more natural than artificial, like dirty fields used for livestock; Mesohemerobe - landscapes more artificial than natural, such as reforestation, and Euhemerobe - artificial landscapes, such as cultivated areas and urban area.

The anthropogenic impact can be evaluated through studies that show where are the areas most degraded and modified, primarily through the analysis and temporal-spatial representation of land use.

Studies of this nature are part of environmental planning because they provide information needed to develop strategies and actions to mitigate the impacts caused by human interference. It is a study that could help in the delimitation of areas to be occupied or eventually recovered.

Therefore, the general aim of this study is to analyze the impact of the legislation in force in the dynamics of occupation of land use in the period 1980 to 2007. Thus, it was necessary to draw up maps of land use, raise the relevant legislation for the period studied and elaborate maps of environmental conflicts in land use.

2. Methodology

The input, storage, processing and output data was performed using the software SPRING, version 4.3.3, developed by the National Institute for Space Research/Division of Image Processing (INPE / DPI, 1999).

Based on the topographical maps, in digital media, prepared by the Directorate of Geographic Services (DSG) Army (1980), scale 1:50,000, sheet SG.22-XC-II/2 (Ponta Grossa), data were taken drainage, contour, perimeter of the basin, roads and highways.

After scanning the drainage network buffers were created to set the Permanent Preservation Areas (PPAs) along the rivers and springs, as provided by the Forestry Code (BRASIL, 1965).

For the preparation of maps of land use was used aerial photography from 1980 (Institute of Land and Cartography of Parana - ITC) in the scale of 1:25,000, and the image CBERS2, March 2007. The composition of bands adopted in the present work was the R (3) G (4) B (2). The method adopted for the classification of the images was the Supervised Classification by algorithm MaxVer.

Subclasses themes of land use were adapted from the Technical Manual of Land Use from the Brazilian Institute of Geography and Statistics - IBGE (IBGE, 2006). Subclasses were defined as follows: urbanized area, cultivation (including temporary and permanent crops), forest, grassland and water body. In addition to the subclasses suggested was adopted by the IBGE class industrial area and reforestation.

After completion of all maps was used superposition method (Santos, 2004) with the binary crossing until reach the intermediate maps that were in turn overlapped.

To identify the degree of naturalness/artificiality in the Cará-Cará basin used the scenarios focusing on land use from 1980 to 2007.

After preparation of scenarios of land use adopted the concept and classification of hemerobia of Jalas (1953) in the preparation of letters of artificiality in the Cará-Cará basin. The Categories adopted are: ahemerobe, oligohemerobe, mesohemerobe and euhemerobe.

3. Result

Two scenarios land use were constructed for Cará-Cará basin for the years 1980 and 2007 (Figure 1), where they were identified in the first scenario five classes of land use and seven classes in the second (Table 1).
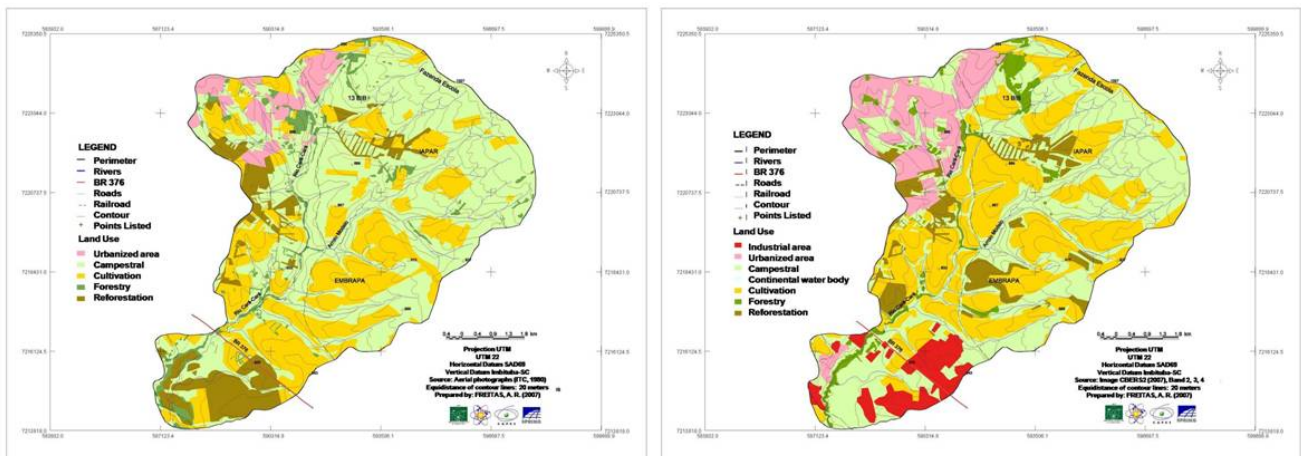
Figure 1. Maps of land use of Cará-Cará Hydrographic Basin of 1980 and 2007

Table 1. Quantification of land use classes

Classes	1980		2007	
	Area (ha)	%	Area (ha)	%
Industrial area	-	-	314.59	4.30
Urbanized area	343.72	4.70	762.48	10.42
Campestral Industrial area	3,802.30	51.96	3,069.06	41.94
Continental water body	-	-	2.64	0.04
Cultivation	2,126.42	29.06	2,423.79	33.12
Forestry	363.42	4.97	274.36	3.75
Reforestation	681.66	9.31	470.60	6.43
Total	7,317.52	100	7,317.52	100

To map the areas of environmental conflicts, we used the proposal to Beltrame (1994) represented by the classes corresponding use and areas over-used and under-utilized. In this study, the corresponding use areas are being used as the relevant legislation. The over-used areas are those where the activities are being carried out in permanent preservation areas or not provided for in the Zoning Plan. Underutilized areas in the Cará-Cará Hydrographic basin are represented by areas for urbanization and industry, not yet occupied by these activities (Figure 2) (Table 2).

Table 2. Environmental conflicts in the Cará-Cará hydrographic basin

Classes	1980		2007	
	Area (ha)	%	Area (ha)	%
Over-used	409.62	34.26	153.39	9.96
Underused	786.15	65.74	1,387.06	90.04
Total	1,195.77	100	1,540.45	100
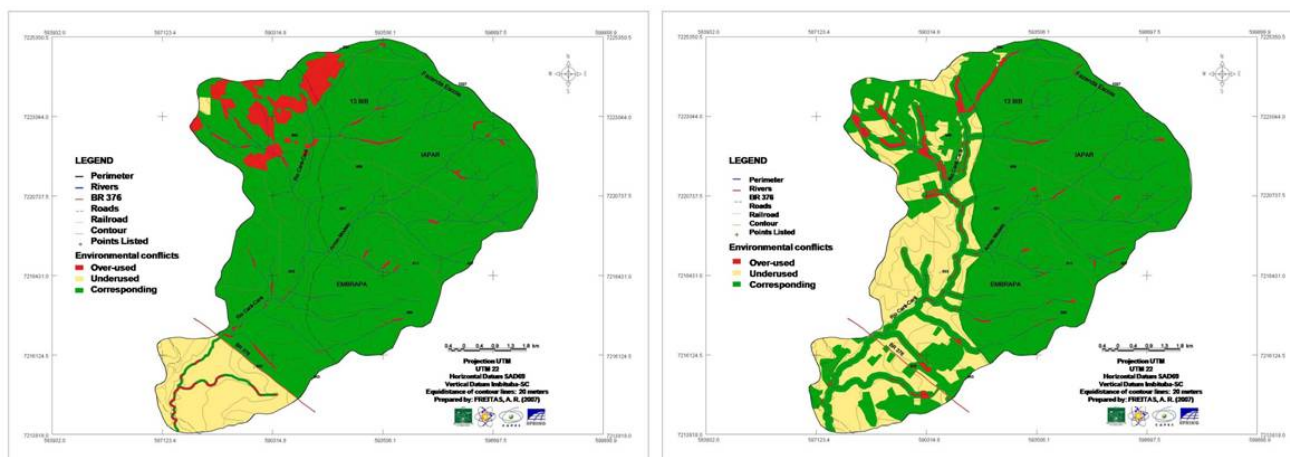
Figure 2. Maps of environmental conflicts of Cará-Cará Hydrographic Basin of 1980 and 2007.

As a result of the maps of artificiality of the medium we obtained two letters of hemerobia for Cará-Cará Hydrographic basin dated of 1980 and 2007 (Figure 3), which were analyzed according to the degree of anthropogenic interference existing.
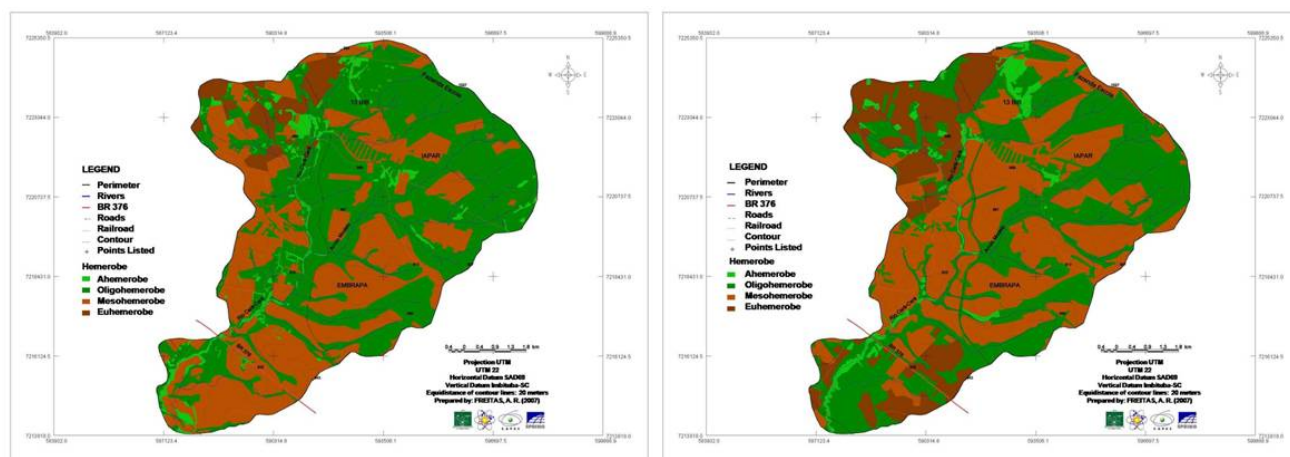
Figure 3. Maps of hemerobia of Cará-Cará Hydrographic Basin of 1980 and 2007.

Were identified and mapped four classes of hemerobia: ahemerobe, oligohemerobe, mesohemerobe and euhemerobe (Table 3).

Table 3. Quantification of hemerobe classes of Cará-Cará Hydrographic Basin

Classes	1980		2007	
	Area (ha)	%	Area (ha)	%
Ahemerobe	363.42	4.97	274.36	3.75
Oligohemerobe	3,802.30	51.96	3,069.06	41.94
Mesohemerobe	2,808.08	38.37	2,897.03	39.59
Euhemerobe	343.72	4.70	1,077.07	14.72
Total	7,315.52	100	7,315.52	100

4. Discussion

Between the years 1980 and 2007, three classes of land use had expanded, namely: industrial area, urbanized area and cultivation. In 1980 the industrial district was already defined in the Cará-Cará basin, however there were no industries located. The area dedicated to industrial activities at this time was occupied by reforestation (Pinus spp.) raw material for wood

industries located in the vicinity.

The urbanized area, was the class with the biggest increase during the study period (121.83%) and is located in the northwest portion of the Cará-Cará basin. These areas were employed due the implementation of subdivisions and areas intended for urban expansion planned in the city plan.

The cultivation class, represents areas occupied by temporary and perennial crops, mainly soybean planting, followed by corn and wheat. These areas are located mainly in central and have advanced to the northeast of the basin, using areas that were once occupied by the field and forests. For the period studied there was an increase of 13.98% in total area.

The areas occupied by native vegetation, represented by the forest and grassland were the most had a reduction in area, and the forest showed a decrease of 24.51% for the period analyzed, due to the expansion of urban activities, industry and farming . The forest areas are distributed on the banks of some rivers, especially in the southern portion near the mouth of the Cará-Cará River and north in the area belonging to the 13th BIB, where there was the recomposition of forest and the area is used in training the army. The campestral class was affected by the occupation of other activities, decreasing by 19.28% the area occupied between 1980 and 2007.

The reforestation class, representing the areas reforested with eucalyptus (Eucalyptus spp) and pine (Pinus spp), was unstable between the years 1980 and 2007. This occurred because in the 80, industrial output surpasses agriculture, and this transition the so-called traditional industries (textiles, wood, food, furniture, etc..) lose relative importance in the economy of the state of Parana. The wood and textile sectors were the most reduced their participation in the GDP of the state (Migliorini, 2006).

As can be observed during the study period, the class with the biggest increase was the urbanized area (121.83%) due to population increases and, consequently, the expansion of the town of Ponta Grossa, in the east of the Cará-Cará Hydrographic Basin. The increased area occupied by urban activities took place, not only by increasing the population of the city, but also by urban voids used for speculation.

In relation to environmental conflicts, over-used areas characterized by the illegal occupation in areas that should be protected or not built that were more varied. Between the years 1980 and 2001 the variation was 7.99% this is due to the establishment of areas of Funds Master Plan for the Vale of Ponta Grossa that were being occupied by urban and agricultural activities.

Areas of environmental conflict deemed over-use continues to increase, so even if incipient, on permanent preservation areas and not building land in the central portion of the basin.

The other conflicting class is regarded as underutilized, where the areas that should be being used by certain activities have not yet been occupied. In the period studied the class that this was more varied and increased (76.44%) due to changes in local laws, especially in residential zoning and industrial and extinction of Special Landscape Areas.

The maps of environmental conflicts assist in identifying areas where there is greater human interference in Cará-Cará Hydrographic Basin, making it more natural and less artificial. To facilitate the analysis of the anthropogenic impact were prepared letters of hemerobia.

The ahemerobe class corresponds to remnants of Araucaria forests in different successional stages. Ahemerobe areas are occupied by urban activities, industry and culture, representing a decrease of 24.51% of the basin area, being more significant in the northern (13 º BIB) and on the banks of rivers in the south.

The oligohemerobe class, represented by dirty fields used for grazing cattle, also showed decreased area occupied (19.28%) due to the advancement of industrial, urban and agricultural lands.

Unlike previous classes, the classes mesohemeorbe and euhemerobe had expanded between 1980 and 2007. The mesohemerobe class is characterized largely by corn, wheat and soybeans at EMBRAPA and reforestation of pine (Pinus spp) and eucalyptus (Eucalyptus spp) in IAPAR. It may be noted that this class has expanded only 3.17%.

The euhemerobe class represents the areas more artificial of Cará-Cará Hydrographic Basin, or those occupied by industrial and urban activities. The class has advanced over 200% compared to 1980.

The changes in the use of land, which formed the basis for determining the hemerobe classes were given due to changes in territorial planning of the city of Ponta Grossa.

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Quantitative assessment of temporal dynamics in altitudinal-driven ecotones in a section of Valtellina Italian Alps

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Abstract

Mountain ecotones are sensitive to climate and global change and their historical dynamics can be used as a record and indicator of such events. Nevertheless there are relatively few studies aiming at the quantification of their dynamics in a spatial explicit way at a detailed scale. In this work we quantified the altitudinal shifts and spatial pattern of mountain ecotones. We applied a novel procedure to delineate the current and former location of three characteristic mountain ecotones, formalised as forest, tree and tundra lines in a section of Valtellina (Italian Alps). We estimated the medians of overall decadal altitude increments in 25 m for forest line, 13 m for tree line and 11 m for tundra line. The method also allowed us to differentiate between ecotone advance and retreat events. We also conducted an analysis of vegetation patches morphology at the ecotone locations, which showed significant implications in their dynamics.

Keywords: Mountain ecotones, Alps, Global change, Spatially explicit model, Digital elevation model

1. Introduction

Mountain and boreal ecosystems are among the environments most susceptible to climate and land use changes (Theurillat and Guisan 2001; Didier 2001). Both phenomena have the general effect of raising of altitude driven ecotones (Didier 2001; Körner 1998; 1999). Despite the considerable number of works dealing with the definition and environmental implications of the upper limits of mountain vegetation, there are few works that focus on its spatially explicit delineation. Besides, the literature offers many examples of woodland upper limits while less attention has been paid to alpine treeless vegetation and its limits with non-vegetated rocky and nival habitats.

The main aim of this paper is to analyse the spatial and temporal dynamics of forest line, tree line and tundra line ecotones in alpine areas and to evaluate their fluctuations in the context of climatic and land use change.

We tested the method in the Val Masino catchment in the Central Alps (province of Sondrio, Lombardy region, Italy). The study area comprises two sub-catchments (Valle dei Bagni and Val di Mello) of the Masino creek basin, comprising 83.4 km^2 of surface and with a range of altitudes from 909 to 3432 m a.s.l. (Fig. 1). Vegetation types and patterns are closely related to altitudinal gradients. The uppermost sectors are occupied by glaciers, bare or sparse vegetated surfaces on rocky habitats such as screes, rocky slopes or cliffs. Below this belt different kinds

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of herbaceous formations, dwarf scrubs and thickets take place. Woodlands with variable density of scattered and often stunted individuals of pine (*Pinus sylvestris, P. mugo*), spruce (*Picea abies*) and larch (*Larix decidua*) occur between this treeless area and dense forest formations. These species also dominate the high altitude forests, while the lower parts are covered by different tree formations dominated by deciduous broadleaved species. Hay meadows are the most common agricultural land, occupying only a small surface at valley bottoms, while arable land is virtually absent in the area.

2. Methodology

We started with the stereoscopic analysis and visual interpretation of aerial photos from 1954 and 2003 to generate a raster map with the distribution of close forest, scattered trees and alpine tundra for each of the dates. We then used a spatial overlay technique to analyse the temporal change of the three classes. The overlay outputs were arranged in a 4×4 contingency matrix using as input the 1954 (columns) and 2003 (rows) raster maps, and considering 4 classes, namely: "Dense forest", "Scattered trees", "Tundra" and "Other". Overall Kappa and Kappa indices for each land cover class (Cohen 1960) were used as estimators of the rate of change, as suggested in other studies (Calvo-Iglesias et al. 2006).

We then applied an algorithm developed by Diaz Varela et al. (2010) to identify the uppermost pixel of targeted ecotones for each of these maps. The method used to delineate forest line, tree line and tundra line ecotones follows the general definition of tree line by Körner (1999) and aims at performing the automatic discrimination of elements (outpost) with an uppermost extreme position on a certain slope. Outposts corresponded to the uppermost pixels of each of the three land cover classes and they were used to represent and map the ecotones. That is, for the land cover class "forest", outposts define the forest line; the "dense forest" plus "scattered trees" class outposts define the tree line and the "tundra" class outposts define the tundra line. An outpost is herein defined according to this example regarding trees: an operator in the field will define a tree as belonging to the tree line if he encounters no other tree while walking upward in the direction of maximum slope for as long as possible (i.e. until a summit is reached). Therefore, the trajectory from a given point will move upward following a maximum slope path until it encounters another element of the same class or finishes at a summit large enough to define a slope or series of slopes with similar exposure at a certain scale (cf. fig 2). Extending this concept from single trees to a the maps of forests, trees and tundra, the algorithm was implemented in ITT-IDLTM V. 6.3 to label the cells of a binary land cover map (in this case tree – no tree) as belonging to the ecotone or not (see Diaz-Varela et al. 2010 for a more thorough description of the method).

The temporal evolution of the different ecotones was analysed by extending the algorithm to a diachronic map. For the identification of ecotone altitude advances we ran upward flow paths from any upslope outpost pixel for 1954 until a 2003 upslope outpost pixel or a summit was reached. Altitude retreats were computed with the same scheme but using 2003 and 1954 ecotone pixels as starting and end points, respectively. Therefore, where the ecotone location in 1954 appeared in a higher position than in 2003 along a given maximum slope line, it was possible to trace and quantify the retreat or negative altitudinal shift.

To characterise morphologically the spatial pattern of the outposts for the three ecotones in the period of reference and to assess changes in vegetation dispersion strategies, we used the GUIDOS software (Graphical User Interface for the Description of image Objects and their Shapes). This software was recently developed for morphological spatial pattern analysis (MSPA) of forest functional connectivity in the context of biodiversity studies (Vogt et al. 2008, Vogt et al., 2009). The output of the MSPA is a raster layer where patch cells are assigned to

seven morphological spatial pattern classes: edge, core, perforated, islets, bridge, loop and branch. We ran the software using the default parameters for the computation of MSPA, considering an edge width of 20 m.

3. Results

For the period analysed, tundra remained mostly stable while forest and scattered tree classes experienced more intense dynamics, as indicated by kappa values of Table 1. From the contingency matrix shown in this table, we observed that tundra also experienced some expansion colonising rocky areas and bare soils while in other areas it was colonised by scattered trees. The increase of dense forest occurred at the expenses of areas occupied by scattered trees in 1954.

The totals and altitudinal distribution of the outpost is shown in Fig. 3. The forest line was located between 1350 and 1950 m, rarely reaching more than 2000 m. The tree line showed a slightly elevated position (around 100-150 m higher) on the slopes, while the tundra line lay clearly much higher, with maxima up to 2600 m.

Figure 4 shows the altitude distribution, along with the horizontal and vertical increments of outpost altitudinal shifts, distinguishing positive (advance) and negative (retreats) altitude increments. A total of 225, 352 and 645 paths showing positive altitudinal shifts were recorded for forest line, tree line and tundra line respectively, with median values of 26, 17 and 15 m of decadal altitude increment respectively. Retreats were far less common than advances for the three ecotones under analysis. Putting together advances and retreats gives an overall view of the altitudinal shifts: the forest, tree and tundra lines showed a net advance, with medians of 25, 13 and 11 m of altitude shifts respectively. Altitude plays a major role in the occurrence and magnitude of the shifts. Advances of forest line took place mainly from 1300 to 1700 m. The altitude advance magnitude shows a clear trend to decrease with the rise in altitude. Thus, shifts that started from lower positions attained the most important advances, up to 600 m, while those starting near the top of the altitudinal limit for the class reached much lower values (e.g. less than 20 m on average in the interval 1900-2000). This tendency is less clear in the case of tree line, which showed more regular behaviour along its altitudinal range and altitudinal shifts which were generally lower than 200-300 m. The tundra line advance also shows the same trend to decrease its magnitude proportional to the altitude gradient, starting from large shifts (400-800 m) occurring at the lower locations (1600-1900 m) to small ones (less than 50 m) near its altitudinal limit (2700-2800 m). Retreat paths showed less clear patterns in terms of variation of magnitude along the altitudinal gradient.

Similarly to land cover dynamics, the spatial pattern of tundra experienced little variation (cf. Fig. 5, being characterised by a high amount of core and little proportion of edge and other morphological classes, though there is some increase of branches and islets reflecting the expansion and colonisation of new areas. Scattered trees and forest classes experienced an increase in core and decrease in edge and branches, as a result of their expansion they became more compact.

4. Discussion

The application of the method on multi-date land cover datasets (1954 and 2003) in a study area of the Southern Alps, allowed the monitoring of spatiotemporal dynamics of forest, woodland and tundra formations and pointed out significant upward shifts of their ecotones, formalised as forest, tree and tundra lines.

Analysis of land cover dynamics by spatial overlay of multi-temporal land cover maps showed that forest and scattered tree formations tend to expand their areas, while tundra was more stable in time. However, the application of analyses addressing ecotone dynamics more specifically proved that the uppermost location of these formations underwent significant changes and showed a general trend to advance in altitude.

Ecotone dynamics typically correspond to a balance between colonization and extinctions, which in the case of mountain altitude-driven ecotones can be formalised as advances or retreats on the slopes. Therefore, to identify unambiguously if the changes correspond to an effective advance or retreat in altitude, we performed a directional analysis of the altitudinal shifts of extreme outposts along the maximum slope path. Results showed that most of the ecotone dynamics corresponded to advances or overpasses of outposts. Forest line retreats were virtually absent, corresponding at almost all outpost changes to advances in altitude. Tree and tundra lines showed a certain amount of retreats concentrated at the top of their current altitudinal distribution, but had a much higher rate of advance than retreat. The median values for the forest, tree and tundra line advances corresponded to decadal upward shifts of 26, 17 and 15 m respectively. Absolute altitudinal shift (considering together advances as positive values and retreats as negatives in the same frequency distribution for each ecotone) had similar median values of 25, 13 and 11 m respectively.

Spatial pattern analysis at the ecotone locations provided complementary information for a better understanding of their dynamics. Thus forest and tree lines tended to show a more compact arrangement in 2003 than in 1954, with a significant decrease in islets, indicating a decrease in long-distance dispersion and suggesting a stabilisation of its advance in the form of massive colonisation along wide advance fronts. Alternatively, the tundra line increased the number of islets, pointing towards an increase in long-distance colonisation. This fact, along with the intense dynamics deduced from the results of advance and retreat paths, points out this ecotone as prone to undergo significant future changes in the case of the continuing of present trends in environmental dynamics.

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Table 1. Change matrix between 1954 and 2003. Cell values are per-class areas (ha) resulting from the spatial overlay of 1954 and 2003 land cover maps. Main diagonals correspond to stable areas while marginals correspond to changes. Per class Kappa indices are shown in the last column

		1954				
		Dense forest	Scattered trees	Tundra	Other	Kappa
	Dense forest	259.84	101.04	19.12	203.04	0.43
2003	Scattered trees	0.96	87.76	89.72	26.20	0.42
	Tundra	1.08	17.16	1563.40	198.64	0.86
	Other	1.88	1.80	30.44	8979.28	0.98
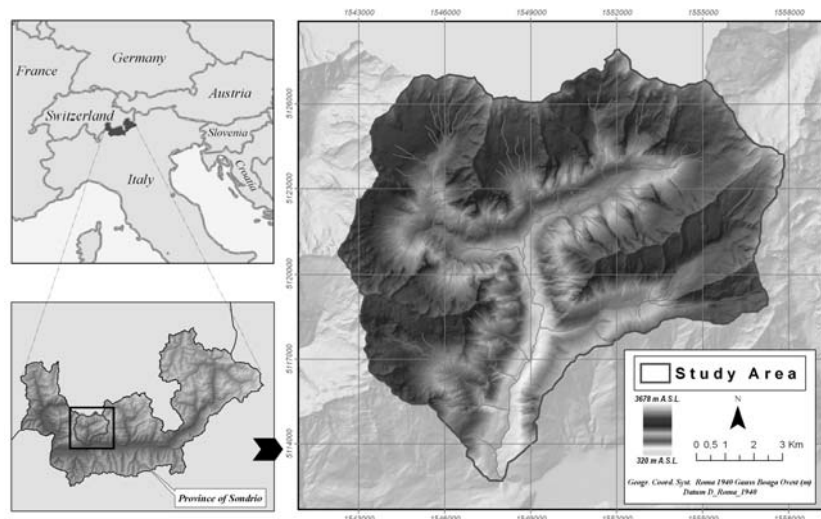
Figure 1: Study area
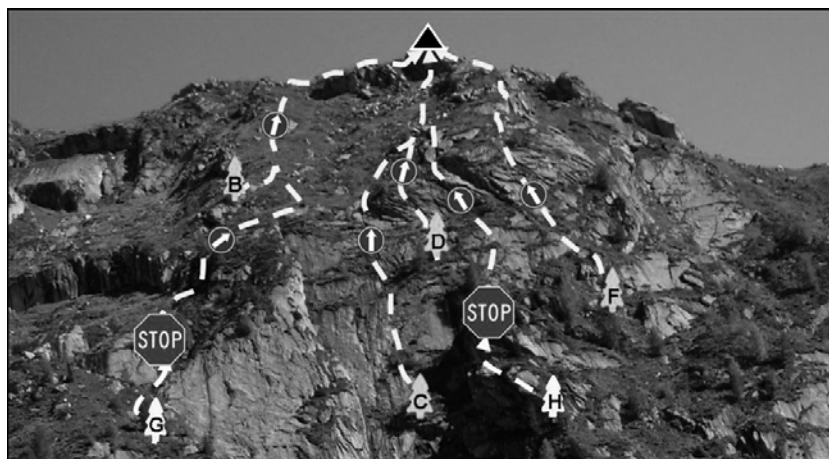
Figure 2: Simplified representation of the conceptual approach for the definition of extreme outposts for a slope section
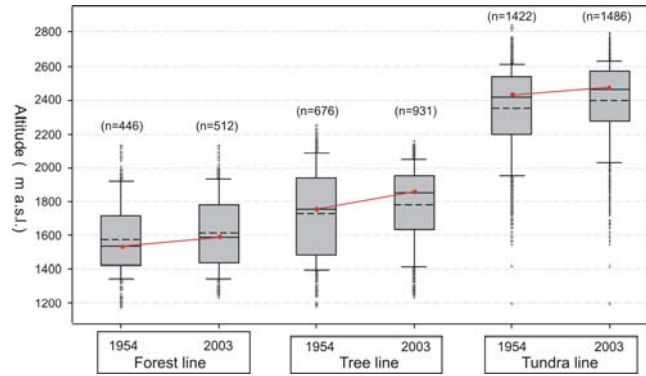
Figure 3: Altitudinal distribution of the extreme outpost (forest line, tree line and tundra line ecotones) for the 1954 and 2003. Between brackets overall frequencies of raster map cells labelled as ecotones

Forest line advance   **Tree line advance**   **Tundra line advance**

Forest line retreat   **Tree line retreat**   **Tundra line retreat**
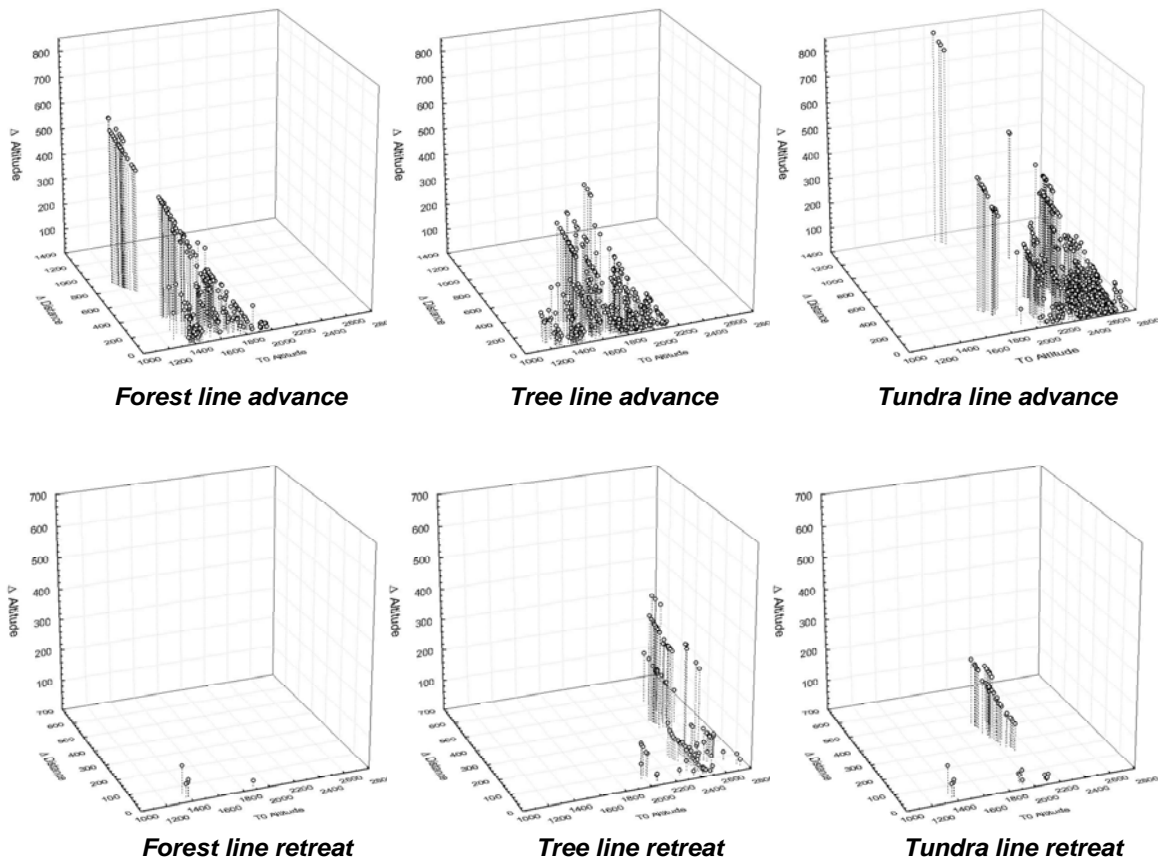
Figure 4: Advances and retreats of the three ecotones in the period 1957-2003. In each graphic the X axis represents the initial altitude, Y axis the increment in horizontal distance and Z the increment in altitude (positive in advances and negative in retreats) for each of the events of altitudinal shifting
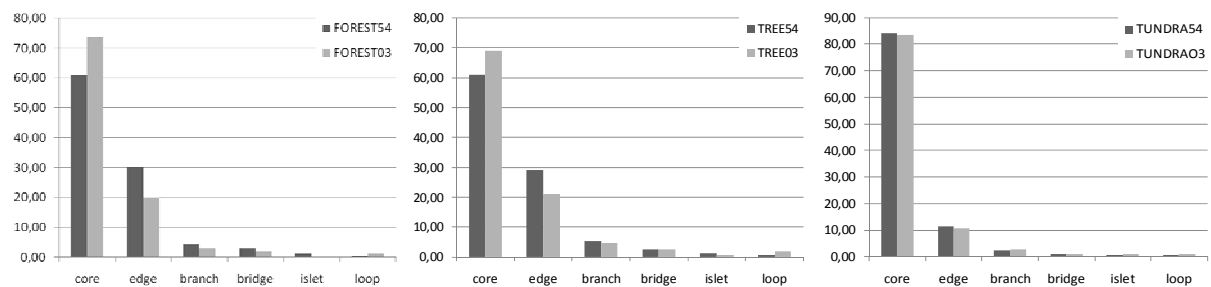
Figure 5: Percentages of the different spatial pattern morphology classes for the targeted ecotone types

Land use changes in Portugal between 1990 and 2005

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Abstract

In the last decades, changes occurred in all Mediterranean territory. Social and economical trends changed and the related land use accompanied this alteration. We used different Portuguese cartography (1990 and 2005), made them comparable and identified the changes on the territory. Despites all the incentives for forestation in the last decades, results showed that shrublands advanced on the territory. *Eucalyptus* forests and irrigated agriculture increased too with less significance. The general trends verified were for shrublands increase and lost of traditional uses.

Keywords: Portugal, Land use changes, Land use types, Forests, Agriculture, Shrublands, Oaks, Transition

1. Introduction

The landscape is a reflection of the aims of the society. Neolithic man began changing the landscape through the invention of agriculture (Pasquale et al, 2004). In XIX century he made long railways and enlarged constructed surfaces. Portugal, like all Mediterranean countries, have a landscape with centuries of history from intervention, cutting, grazing, fire, and the socio-economical trends always were related with agriculture, forestry and livestock (Duarte et al, 2009; Acácio, 2009; Lloret, 2003). The traditional land use has last for centuries, or millennia, but recently major changes have been occurring (Paqualle et al, 2004). Many agricultural lands were abandoned, due to migration of people to urban areas in search of better socio-economic conditions. The silvicultural practices, related with the traditional economie, as also decreased largely. Grazing became negligible. All these events determined the increase in shrubland areas and forest cover, continue, reducing the fragmentation of the landscape (Paqualle et al, 2004; Hill et al, 2004; Regato-Pajares et al, 2004).

In the first half of the XX century, in Portugal, the agriculture expands with the campaign of wheat (Duarte et al, 2009). Then, in the second half of the century, the forests take a lot of his place and shrublands increased because of the abandonment of the land (Ferreira el al, 2004). More recently, agricultural land increased again with the irrigation possibilities and diversification of productions (Pinto Correia et al, 2006; Ferreira et al, 2004). But forests still the more representative land use types (Ferreira et al, 2004).

There has been some studies about changes in land use in the Portuguese territory (Ferreira at all, 2004; Pinto Correia et al, 2006) that shows this occurrences in the portuguese context.

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However, with the XXI century arrival, it matters to understand if the trends are maintaining or, if something changed in the land-cover relation with society.

With this study, we pretend to identify (1) the main changes in land use in Portugal between 1990 and 2005, (2) the general trends and (3) the dynamic relationship between the land use types.

2. Methodology

We used as a basis for study two cartografic elements: Carta de Ocupação de Solo -1990 (COS90) from the responsibility of the Portuguese Geographic Institute (IGP) and the National Forest Inventory 2005 (IFN05) of the National Forest Authority (Ministry of Agriculture and Fisheries). However, these mappings have been developed with different objectives. The first, inspired in the nomenclature of CORINE landcover, aims to give greater accuracy and detail to the Corine coverage, in Portugal (Caetano et al, 2007), assumed at the time as a tool to support planning studies, and decision making. IFN05 was conceived for supporting policies and forest management (DGRF, 2007).

Thus, COS90 is presented on the form of polygons and is based on a alphanumeric information legend as type of occupation, first and second dominant species and a reference to density. In this map we obtain the total of 638 different land use type combinations. The IFN05, is presented on the form of 334390 points, in a grid of 2km for 2km, covering all continental Portuguese territory. This legend, also alphanumeric, but with a different nomenclature, was established for purposes of identification of type of use, dominant species, second and third dominant species, vertical structure, density and presence of other uses. Overall, we obtain 2163 land use type combinations.

Methodology begins on data transformation in order to compare both cartografic elements. We used ArcGis 9.3 program package, to join tables, getting a grid of points with the information contained in each of the mappings in accordance with their original captions. Then we reclassified all the 334390 points, covering the whole territory, for the year 1990 and for the year 2005, with a general common nomenclature. This new classification was based, on the first level, on the type of land use: Forest, agriculture, shrublands, other (artificial) and wetlands. On the second level, considered the dominant specie (forest) or type of agriculture. In the class shrublands were included also clear cut, burnt, sown and young plantation areas as well as recently soil mobilized. We removed wetlands and remaining 328029 points**.**

The comparability has made possible, such as the construction of the transition matrix, using the Microsoft Office Excel 2007.

3. Results

To identify the land use changes between 1990 and 2005, we produced a transition matrix that explains the alterations between classes, showed in table 1. With this matrix, and figure 1 support, we can clearly verify the (1) significant increasing of shrublands, (2) the visible increase of *Eucalyptus*, irrigated agriculture and artificial occupancy, and (3) the losses of Pine, Cork & Holm oaks and unirrigated and other agricultures.

The persistence index calculated was only 51%. This means that 49% of Portuguese territory suffered a transition for one other class, during the 15 years in analysis.

Table 1: Transition matrix between 1990 and 2005

	Shrub	Artificial	Cork & Holm oaks	Other forest sp	*Eucalyptus*	Pine	Oaks	Irrigated agriculture	Unirrigated agriculture	Other agriculture	Total 2005
Shrublands	31052	3544	7112	2497	2561	16540	2501	728	9876	9597	86008
Artificial	1097	7502	251	240	428	1273	67	481	1860	2172	15371
Cork & Holm oaks	846	45	26247	775	465	1892	289	85	2045	1671	34360
Other forest sp	968	133	1179	2313	278	1323	436	257	1284	1214	9385
Eucalyptus	2296	346	645	524	15144	7874	118	265	1353	1012	29577
Pine	3708	278	514	1482	2014	19927	478	254	1376	1151	31182
Oaks	986	54	551	655	48	1042	1563	104	703	493	6199
Irrigated agriculture	315	359	1228	163	130	273	21	5850	10486	2807	21632
Unirrigated agriculture	2692	864	5759	548	359	1108	347	4171	32302	9938	58088
Other agriculture	1827	1055	1234	393	229	1161	230	1298	9441	19359	36227
Total 1990	45787	14180	44720	9590	21656	52413	6050	13493	70726	49414	328029

Analyzing the data, in figure 2, it is perceptible the gains and losses from each land use type from and to each other. So, shrublands, including clear cut, burnt, sown and young plantation areas, were the most significant transition report. The gains came mostly from Pine, unirrigated and other agricultures. The losses, with low proportions, were curiously with the same classes and with *Eucalyptus*. The exchanges with Cork & Holm were significant too, with just one way to shrublands and no return.
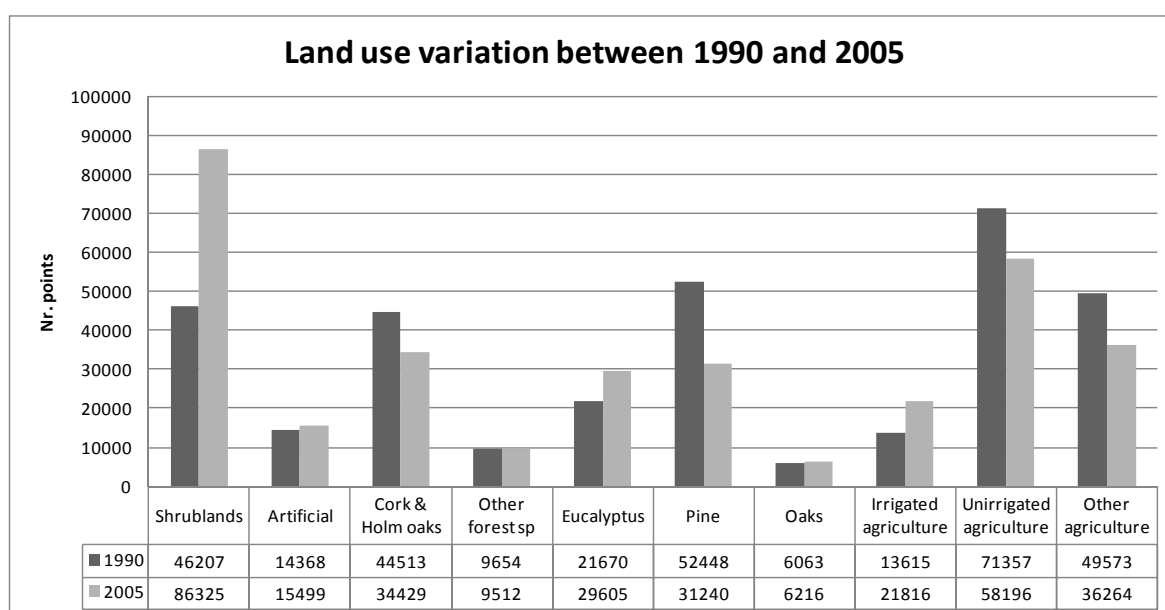
Figure 1: Comparison, for each land use type, between 1990 and 2005

Also in figure 2, despite Artificial land cover, mostly urban areas, had a slightly increase, the transitions with it were significant. The transitions from this one to shrublands were notable. This is probably a sign of abandonment. In the other way, a lot of agricultural and Pine forests switches to artificial areas.

Cork & Holm oak forests decreased, turning into shrublands or unirrigated agriculture. The first one, due to abandonment, the second, probably correlated with the mortality of Cork & Holm, leaving only the agricultural part of the system.
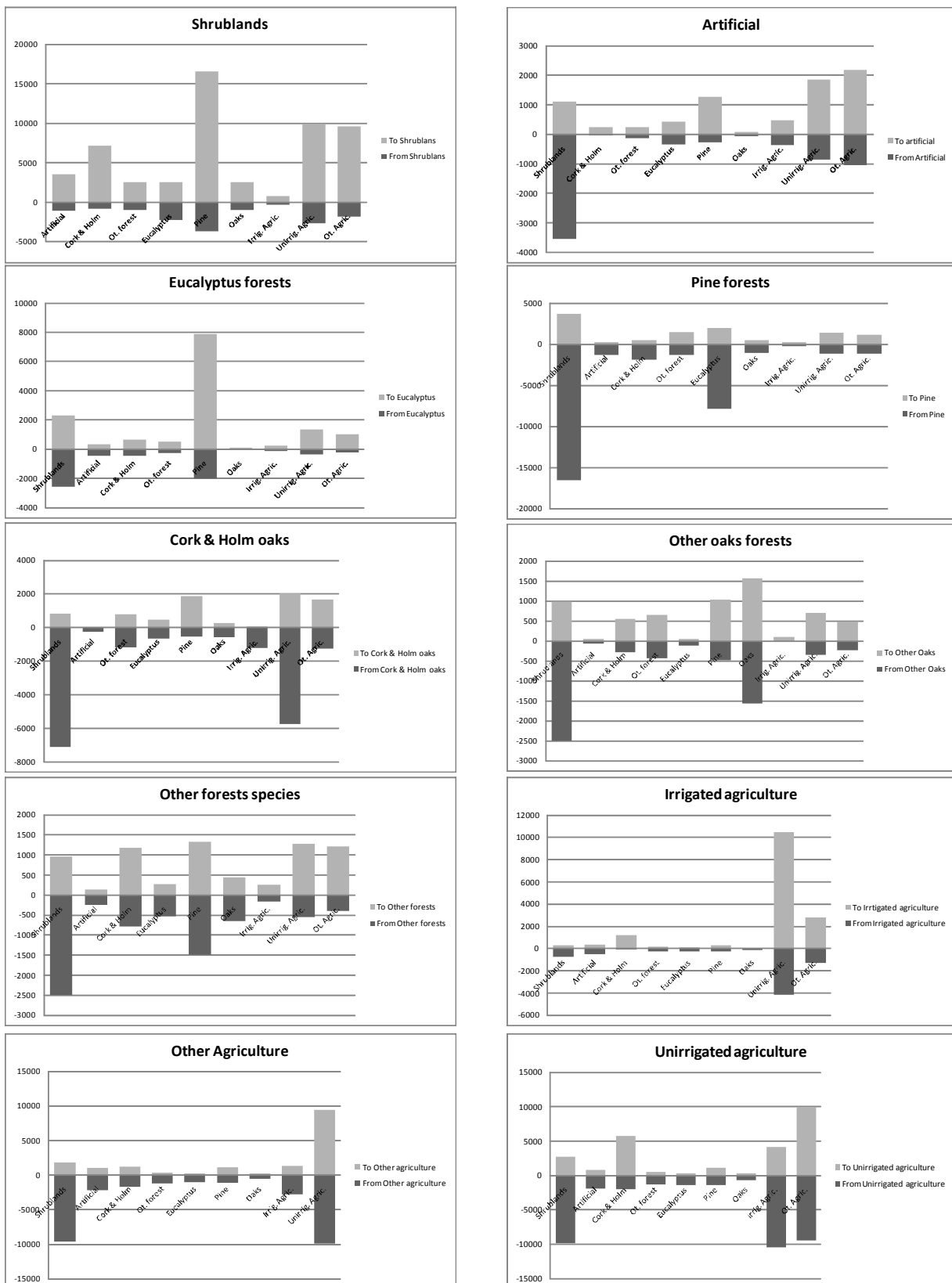
Figure 2: Representative graphs of gains and losses in each land use type, related with each one other

Many *Eucalyptus* areas turned over into Pine forests. Furthermore, areas of Pine forests were converted into *Eucalyptus*, or degraded forests (shrublands). This can be justified by the forest fires that had been occur frequently over Pine forest in Portugal during this years (Acácio, 2009).

Has showed in figure 2 other oak forests are being turned into shrublands (abandonment or fire) or into Pine forests. The last case can be justified with the introduction of Pine into oak systems, gettin dominance over the years.

Between the agricultural types of land uses, switches occured, with irrigated agriculture areas growing, and a part of the others loosing areas to shrublans once again.

Figure 3 represents the dinamic changes between the studied land uses. On this figure were considered only transitions with more meaningful values, i.e. greater than 10% of each class or higher than 3000 points. The only exceptions considered were the transitions from shrublands to Pine forest or *Eucalyptus* forest because they are significant on these forest systems dynamics.

It is clear to identify a group of agricultural uses and one other of forest uses. Cork & Holm had caracters from both, staying undistiguished from them. On this representation it is notable the magnetic effect of Shulands, that justifies the values obtained on table 1 and figure 1.

On the agricultural part of studied land uses, many changes occured, maybe related with rotational land programs, between irrigated, unirrigated and other types of agriculture. The last two, with frequent losses for the class of shrublands.
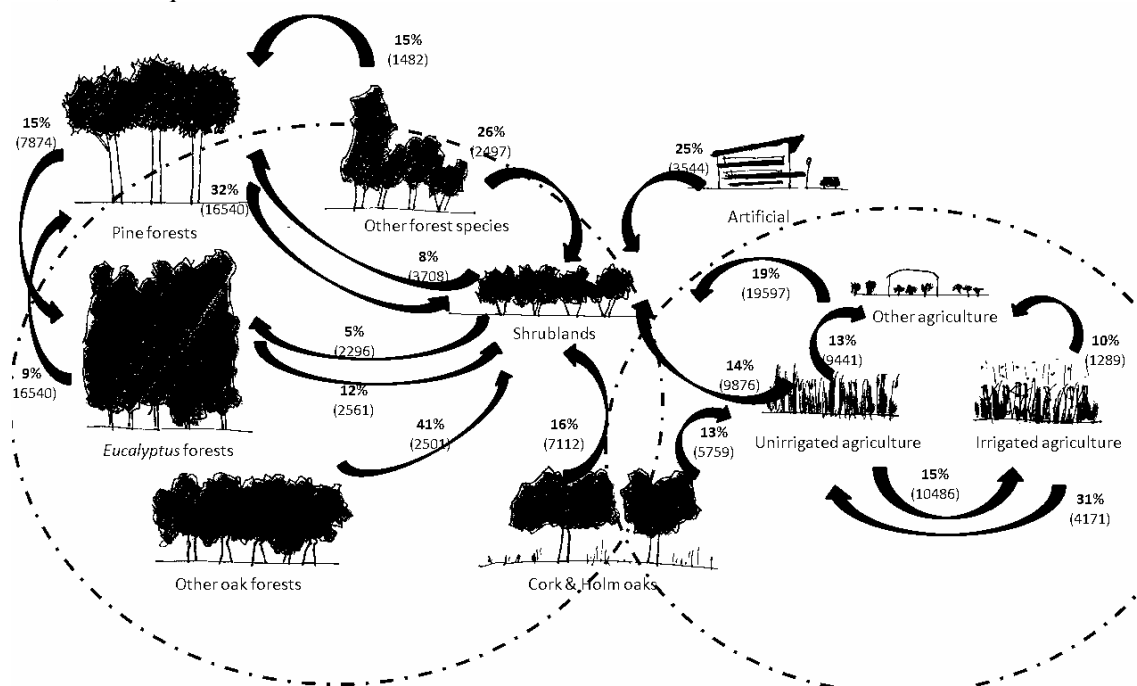
Figure 3: Representation of the dynamic changes of land use

Artificial areas losses were significant to shrublands, however, as shown in figures 1 and 2, less significant gains of other land uses justified an increase in the total value of artificial areas.

4. Discussion

On this study, we analyze the changes on soil occupancy in continental Portugal. The index of persistence obtained was 51%. Pinto Correia et al (2006), calculated between 1990 and 2000, for the same territory, a persistence index of 86,7 %. It means that in the last five years, changes were accelerated.

The general trends, despite all the incentives for forestation in recent decades, were for the decrease of forest area and increase of shrublands areas. *Eucalyptus* and irrigated agriculture also increased. Also occurred one slight increase in artificial areas, such as in other agriculture.

The dynamical model identified let us concerned about the trends in portuguese and all mediterranean territory, because of the forest degradation and losses of natural values as corks forests and unirrigated agriculture. On the other hand, perhaps this is a time of change, of reflection, similar to the socio-economic reflexion of the day.

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Simulation of climate scenarios for the region of Campos Gerais, State of Parana, Brazil

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Abstract

This study aimed to simulate climate scenarios based on possible change to the region of Campos Gerais, state of Parana, Brazil. Originally defined as a phytogeographical region, the Campos Gerais understand the grasslands and savanna parks situated on the edge of the Second Paraná Plateau. In the forests of Campos Gerais, the *Araucaria angustifolia* is the main tree species, occupying portions of the plateau state of Parana whose floristic composition is strongly influenced by low temperatures and frost occurrence. Thus, using daily weather series, stochastic climate models were parameterized to simulate the climate scenarios, based on projections of the IPCC. The results achieved through analysis of graphs, presenting essential elements for a systematic reflection on the future of the floristic diversity of Campos Gerais, showed that an environment in the near future may be unfavorable to the development of species that today fully supplies the forests in this region.

Keywords: simulation, climate scenarios, temperature, precipitation, Araucaria angustifolia.

1. Introduction

The Earth has been undergoing continuous natural oscillations along its evolution, creating new organizations and changing ecosystems. Among the components that operate in this dynamic system in itself, the weather is a factor that interferes directly or indirectly in these transformations, causing instability in the natural land surface and oceans. Thus, as recommended by Claussen in 2004, it is expected that an important aspect of global climate change, is their likely impact on natural ecosystems considering that climate influences soil and biota in the same way that it can also be strongly modulated by biological processes of vegetation, phytoplankton and other characteristics of the biosphere. Within a bioclimatological perspective, according to Worbes 2002, in tropical forests, seasonal precipitation regimes or flooding is described as the major determinants of the seasonality of growth. However, in subtropical forests, the annual variation of air temperature may have great influence on the regulation of cambial activity. Originally defined as a phytogeographical region, the Campos Gerais of Parana understand grasslands and forests galleries or geldings isolates, mixed in a temperate rainforest, located on the edge of the Second Parana Plateau (Maack 1948). This forest type can be defined as a mixing of floras from different sources, with typical phytophysiognomic patterns in a characteristically rainy climatic zone, without direct influence of the ocean, but with well distributed precipitation throughout the year. According to Roderjan et al. 2002, forests in Campos Gerais, the Araucaria or Pinheiro-do-Paraná (*Araucaria angustifolia* (Bertol.) Kuntze) is the main tree species, occupying portions of the State of Parana Plateau whose floristic composition is strongly influenced by low temperatures and the

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occurrence of regular frosts in winter. The Araucaria occurs in regions with annual average temperatures ranging from 12°C to 18°C, supporting frost until -10°C, characterized therefore as a species of temperate climate. The climate of the region of Campos Gerais, Parana, according to Köppen may occur variably in some places, from subtropical (Cfa) to temperate (Cfb), with an average temperature of the coldest month below 18°C and average temperature in warmest month above 22°C, with frequent frosts in winter and trend of concentration of precipitation during the summer months, but without a dry season (IAPAR 2000). According to Salazar et. al 2007, the geographic distribution of vegetation and its relationship to climate, has been object of analysis through models of biomes or biogeographic models, which in turn use it as the central paradigm assumption that climate has a dominant control on distribution of vegetation, simulating potential vegetation, based on some climatic parameters like temperature and precipitation. In this context, on the premise that the crops may be considered relevant probabilistic variables and depend on climatic factors during the growing season, it becomes important to the development of simulation models that generate synthetic data of climate, in order to reproduce, probabilistically, the occurrence of climatic components. Several climatic data generators are cited in the literature, in order to simulate sets of climate data, and create climate scenarios in order to provide alternative methods for measuring the risk of climate uncertainty that is related to alternative managements of enterprises conducted in agroecosystems (Virgens Filho 2001). Given the climatic transition projected by the Intergovernmental Panel on Climate Change (IPCC) that will affect natural resources, economics and societies around the world, actually unknown in magnitude, this study aimed to simulate climate scenarios based on possible climate change in the Region of Campos Gerais, Parana State, Brazil.

2. Methodology

This research was conducted at the State University of Ponta Grossa (UEPG), Parana State, Southern Brazil, where there were used historical series of climatic data of temperature and precipitation, obtained from the Instituto Agronômico do Paraná (IAPAR) and the Instituto Nacional de Meteorologia (INMET) as shown in Table 1 for four cities in the region of Campos Gerais, Parana State (Figure 1). For the simulation of climate scenarios, it was used a beta version of the Stochastic Generator of Climatic Scenarios PGECLIMA_R, developed by the Computational and Applied Statistics Laboratory, in UEPG. The scenarios generated for the air temperature were based on climate projections for 2100, published in 2001 in the Third Assessment Report of the IPCC, in which its worst scenario is estimated to increase average global temperature of 5.8ºC and at its best scenario, an average increase of 1.4°C (IPCC 2001). The scenarios for the simulation of precipitation, were created from the variation of 10% for each degree Celsius in 2100, as suggested by Pike in 2005. Therefore, as the scenarios of air temperature were simulated for an increase of 1.4°C and 5.8°C, the average increase in precipitation was 14% and 58% in the total annual in 2100, for the worst and best climatic scenario, respectively. The analysis and discussion of the results were based on graphics, which projected the trend of the next 99 years (2002-2100), for simulated scenarios for temperature and precipitation.

3. Result

Figure 2 shows the graphics with the trends of annual mean air temperature for the four cities located in the Campos Gerais region of Parana, and for each site are presented separately, the worst and best simulated scenarios. It is observed by the simulated trends (gray line), that for the city of Telêmaco Borba, which has an average annual temperature of 19.5°C in the worst scenario, the projected average temperature for 2052 was approximately 21.5°C, while close to year 2100 it is projected to be around 25.6°C. In the best scenario, the temperature values in

2052 and 2100 were approximately 20.1°C and 21°C, respectively. For the city of Castro, with an average annual temperature of 18°C, in the worst scenario for 2052, simulated temperature was 20°C, while close to year 2100, it was around 23.9°C. In the best scenario, the approached temperature for the years 2052 and 2100 were 18.5°C and 19.5°C, respectively. Note by the simulated trends, that for the city of Ponta Grossa, with an average annual temperature of 18.7°C , in the worst scenario, the average temperature expected for 2052 was approximately 20.5°C, while close to the year 2100 to it was projected to be around 24.6°C. In its best scenario the temperature in 2052 and 2100 will be close of 19.1°C and 20°C, respectively.

Table 1 - Geographical coordinates of the cities and information related to the climatological series.

Municipal District	Latitude	Longitude	Elevation (m)	Period	Data Source
Telêmaco Borba	- 24°20'	- 50°37'	768.0	1972-2001	IAPAR
Castro	- 24°47'	- 50°00'	1008.8	1972-	INMET
Ponta Grossa	- 25°13'	- 50°01'	880.0	1972-	IAPAR
Lapa	- 25°47'	- 49°46'	910.0	1972-	IAPAR
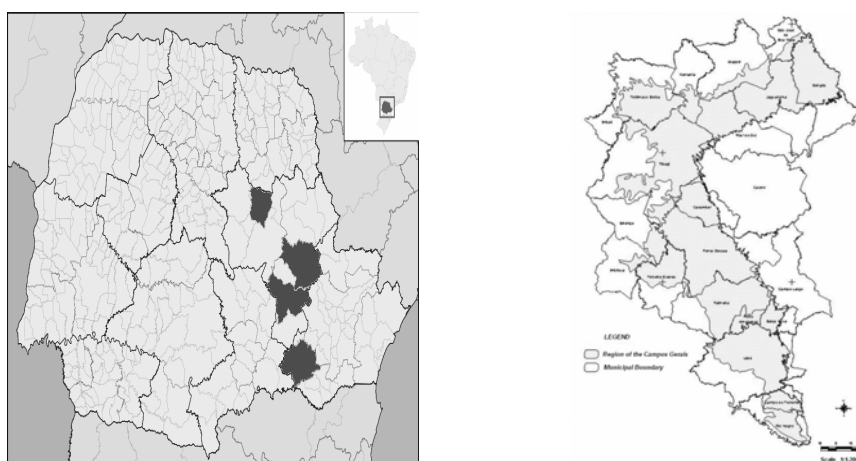
Figure 1 - Location of the cities in the Region of Campos Gerais, Parana State, Brazil.

For the city of Lapa, which average annual temperature is 17.9°C, in the worst scenario the average temperature generated for 2052 was 19.8°C, while in the year 2100 it was around 23.8°C. In the best scenario, the temperature approached 18.3°C and 19.2°C for the years 2052 and 2100, respectively. Figure 3 shows the graphics with the trends of annual totals of precipitation for the four cities in the region of Campos Gerais, Parana, and for each site are presented separately, the worst and best simulated scenarios. It was found by the simulated trends (gray line), that for the city of Telêmaco Borba, which has a historical average annual total precipitation of 1630 mm, that for the worst scenario, the projected annual total for 2052, was approximately 2049 mm, while next to the year 2100 it was projected to be around 2541 mm. In its best scenario, the annual total in 2052 and 2100 was around 1571 mm and 1880 mm, respectively. For the city of Castro, with a historical average annual total precipitation of 1414 mm, in the worst scenario, the annual total raised to 1922 mm in 2052, while in the year of 2100 it was around 2273 mm. In the best scenario, annual total in 2052 and 2100 approached to 1602 mm and 1710 mm, respectively. Note by the simulated trends, that for the city of Ponta Grossa, which has an annual historical average total of 1613 mm, in the worst scenario, the expected annual total for 2052 was approximately 2002 mm, while next to the year 2100, it was

around 2493 mm. In its best scenario, the annual total in 2052 and 2100 was around 1776 mm and 1882 mm, respectively. For the city of Lapa, where the annual historical average total was 1651 mm, in the worst simulated scenario, the annual total for 2052 was 1932 mm, while in the year of 2100, it approached 2246 mm. In the best scenario, the annual total in 2052 and 2100 approached, 1911 mm and 1955 mm, respectively.
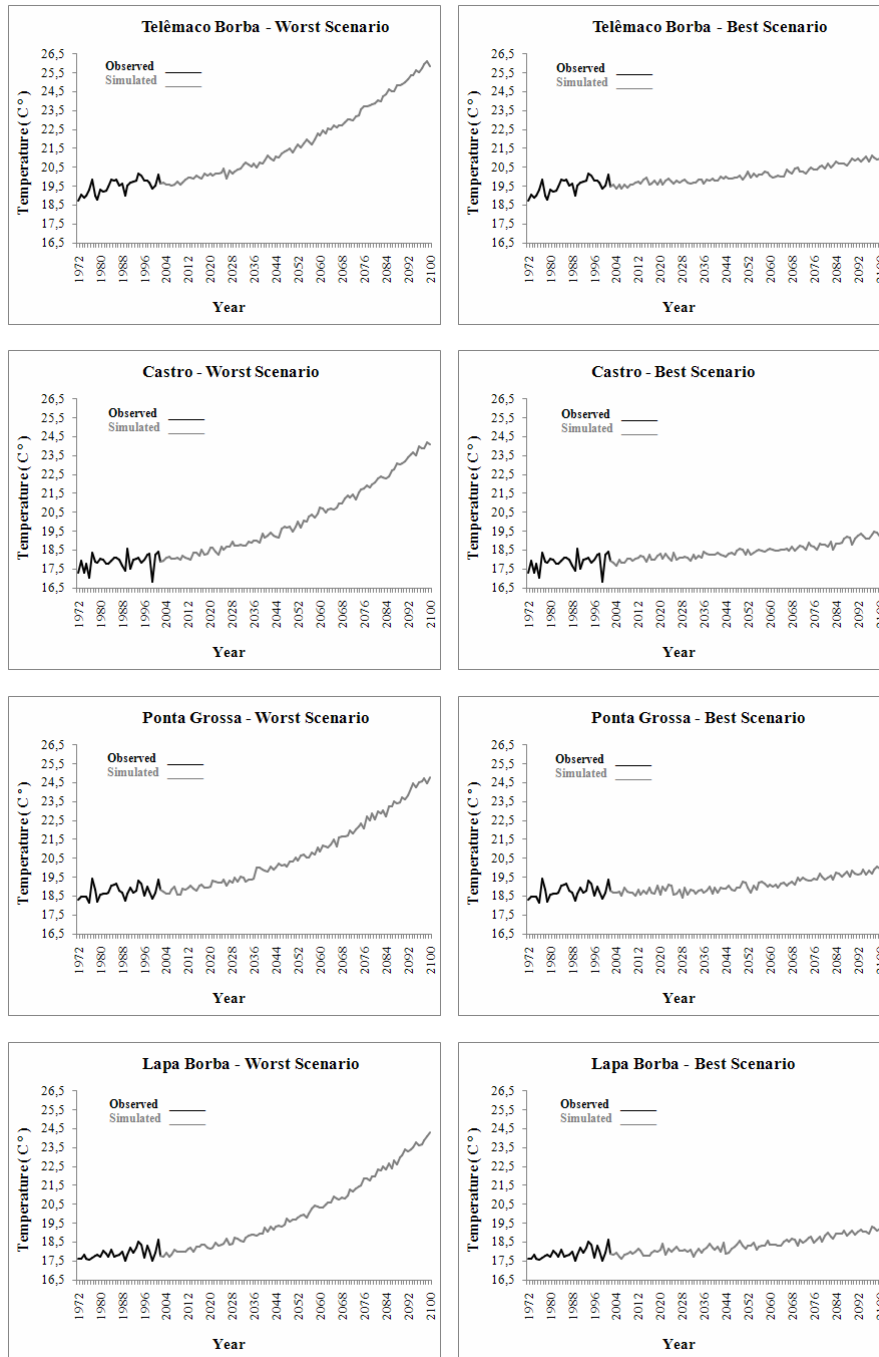
Figure 2 - Mean air temperature scenarios simulated by PGECLIMA_R for the year 2100, considering the best and worst outlook projected by the IPCC.

4. Discussion

Given the fact that the region of Campos Gerais of Parana is located in a climatic zone, dominated in some places by the subtropical climate (Cfa) and others by temperate climate

(Cfb), with precipitation concentrated during summer months, without dry season and with regular occurrences of frost in winter, it is expected that from a perspective of regional climate change, the increase in temperature causes significant changes in the landscape since the floristic composition of the forest and grassland are strongly influenced by temperature and precipitation.
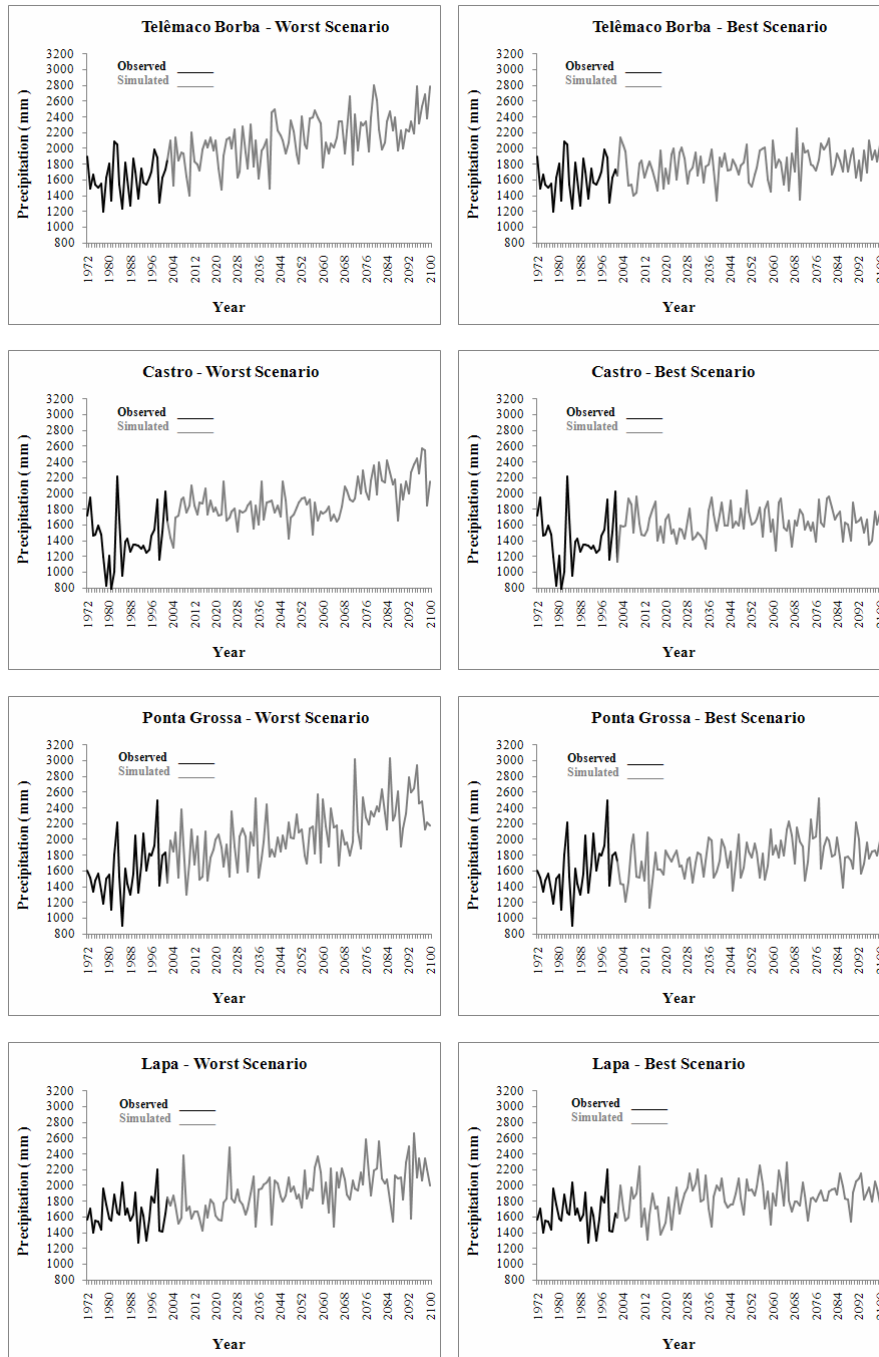
Figure 3 - Precipitation scenarios simulated by PGECLIMA_R for the year 2100, considering the best and worst outlook projected by the IPCC.

In the case of Araucaria Forest, which is a forest formation adapted to conditions of humid altitude, its main plant species, the Araucaria, have their reproductive phenology affected mainly by abiotic factors such as temperature and photoperiod (Liebsch and Mikich 2009). According to Zanon 2007, the increase in temperature and precipitation have a positive

influence on the annual growth rings, but the occurrence of precipitation coupled with low temperatures reduces the growth of them. With the simulated climate scenarios, presented in this research, for the four cities of Campos Gerais, Parana State, one can deduce that at best, which projected an average increase of 1.4°C in the average temperature and 14% increase in precipitation, future changes will be possibly positive as regards the development of Araucaria Forest. However, for a scenario with an increase of 5.8°C in the average temperature and 58% increase in the amount of precipitation, extreme events may occur daily for these climatic elements which, according to Kramer and Kozlowski 1960, influence negatively the hydration and dehydration of the trees, which may result in variations in the diameter growth during the twenty-four hours a day.

Acknowlegments

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Land use changes and mixed forest dynamics. The case of Montiferru Mountains (Sardinia, Italy) (1955-2006)

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Abstract

Land cover dynamics in forest landscapes are altered by the role of human-induced processes linked to global change, especially to land use changes as a driving force and primary sector activities as key factors. This study was conducted at oak (*Quercus pubescens* Mill.) and holm oak (*Quercus ilex* L.) mixed forest patches located at Montiferru mountains (Sardinia, Italy). The aim was to analyze land use & land cover changes during the last five decades, especially reforestation due to forestland use decrease and abandonment circumstances linked to traditional rural economies' crisis. Changes observed have become apparent at different biodiversity levels. Firstly, at ecological level mixed forestland surface has grown by mean 13% and reforestation reached upper levels (ca. 25-30%) in areas characterized by low use recurrence. Secondly, at species level despite the increase of deciduous oaks population in contrast to previous decades, evergreen oaks tends to dominate mixed forest composition and regeneration dynamics.

Keywords: Land use & cover changes, reforestation, mixed forest, Sardinia

1. Introduction

1.1 The role of land use changes into landscape dynamics

Classically land cover dynamics had been exclusively considered under biologist criteria but nowadays this order is altered by human-induced processes in terms of global change (Turner et al. 1995), especially by land use and its changes as key factors due to contemporaneous human transformation capacity oversize (Vitousek et al. 1997; Folke et al. 2004). Recent Mediterranean mountain landscape dynamics are highly determined by two basic premises related to land use & cover changes. Firstly, the evolution of socioeconomic driving forces merge into strong land use changes during the last half of XXth century, the most important is the decrease, and in most cases, abandonment of primary sector activities. Secondly, the main response of these landscapes is the increase of forestland surface. Some authors (Rudel et al. 2005) explain this pattern as the last part of the *forest transition*; in that paradigm forestland surface becomes historically reduced until a *no-return point* when trend reverses and forestland cover begins to increases due to remove land use from disturbance regime (Perry 1998; Folke et al. 2004). One of the principal phenomena derived from forest transition is reforestation defined as the reestablishment of forest cover either naturally (by natural seedling, coppice, or root suckers) or artificially (by direct seedling or planting) (IUFRO Silva Term database). In that sense, natural reforestation is the most habitual land cover change related to land use change in some Mediterranean mountain socioecosystems like the Montiferru mountains at Sardinia (Italy) (Longitude 8º 33' a 8º 39' E; Latitude 40º 08' a 40º 11' N) where this study was conducted.

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1.2 Brief Montiferru's environmental history

The Montiferru Mountains are an archetypical Mediterranean mountain socioecosystem due to its biodiversity and environmental history. Its contemporaneous development starts at XIXth century when early signs of non domestic land uses increase become apparent, mainly due to navy and pre-industrial activities (glass, leather workshops, etc.) (Beccu 2000). During this period, characterized by organic economy strong dependent of wood for construction and firewood and charcoal for fuel, forest raw material consumption grows drove by the expansion of iron and steel industries, railway and sea transport and due to population growth and its demand. Linked to these and other factors like the increase of land plough derived from agricultural and subsistence crisis, forestland covers become highly reduced in all Italy and especially in mountain systems like Sardinian ones at latest XIXth and the beginning of XXth century.

First signs of land use shift scenario, based on industrial and inorganic-based model, arrived in the decade of 1930-40 when firewood and charcoal consumption drops while fossil fuels increases (Agnoletti 2003), this trend arrives to mountain socioecosystems later meaning the beginning of rural economies crisis. It was then when changes in primary sector activities become apparent, showed in forestry in two general ways; models specialized in fast-growth wood and dedicated to paper and pulp emergent industry rise and the most extended traditional uses linked to slow-growth wood, firewood and charcoal decrease and in most cases become abandoned few decades later. Other indicators, like rural exodus processes, reinforce this socioeconomic scenario shift characterized by traditional rural economies' crisis; at Montiferru population decreased ca. 24% since 1960s (Mura 1995).

In the last decades of XXth century the massif shows incipient signs of another socioeconomic scenario shift like the increase of biodiversity management and protection measures and the rise of third economic activities. As a result, nowadays the Montiferru still conserves aspects of its traditional Mediterranean mountain area character but post-industrial socioeconomic scenario tends to be predominant.

2. Methodology

2.1 Object of study

In the massif of Montiferru oak (*Quercus pubescens* Mill.) and holm oak (*Quercus ilex* L.) mixed forest patches occurs in the geographic transition from the upper mesomediterranean to submediterranean wet-temperate climate conditions, in the altitudinal range comprised between 750 and 950 meters a.s.l. In the context of Mediterranean basin, these forestland covers begin its actual dynamics after Youger Dryas (11.000 B.C.) and undergo different fluctuations in its composition until the frontier between Subboreal and Subatlantic (aprox. 3.000 B.C.), when palinological records show an evident decline of *Q.pubescens* and a increase of *Q.ilex* (Suc 1984). Two hypotheses try to explain this event; biotic arguments related to the capacity of holm oak to compete with other trees, and the consideration of human-induced effects (Pons and Quézel 1985; Barbero et al 1990). At this point, centuries of human intervention on Mediterranean forestland upsets the balance between oak and holm oak populations, favoring *Q.ilex* mainly due to its fuel value and its food value for cattle in detriment of *Q.pubescens,* taxon that in the case of Sardinia and Corsica becomes very reduced (Gamisans 1977). In that sense, more or less isolated character of mixed forest areas contributes to assume the role of these entities as indicators of global change manifestations, especially of land use changes processes derived from socioenomic scenario shifts (Lomolino, 2000).

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2.2 Material and methods

The analysis of land use and land cover change processes requires the ecological and social criteria integration, linking socioeconomical and biophysical driving forces, so as to unravel landscape dynamics complexity; in this aim hybrid methodologies based on holistic approaches are basic tools to interpret them (Naveh 2000). In our case, there has been posed a diachronic model and a synchronic model to analyze land use & cover changes.

Diachronic analysis comprises historical records related to land use and cartography for the period 1965-2006. Information about forest use was taken from the review of *Corpo Forestale Regionale* of Sardinia archive. Historical series was, in general, vague and unsystematic; for this reason data was treated to homogenize records and to set (i) year and type of intervention (familiar or commercial thinning) (ii) species and quantity of wood or firewood removed (using dendrometric rates for Sardinian *Quercus* sp. and normalizing non explicit records into habitual oak and holm oak cutting shift documented for the Montiferru). Besides, oral sources of information were consulted to improve environmental history of the studied sites. Several interviews were made to social actors related to Montiferru forestland sphere, especially primary sector workers (woodcutters, shepherds, etc.) and forest owners and traders; a wide majority of people interviewed were elderly men, owners of non written and usually non enough considered information, but very valuable, regarding to relations between human and environment. Four sampling stations were selected attending to differences on land use patterns and classified in terms of intensity, considered high when commercial thinning is predominant and low when are related to domestic use (up to 5 m³ per year); and recurrence, considered high when there were more than 20 interventions during recorded period (1965-2006) and low in the other cases (Table 1). Besides, diachronic model comprises the analysis of aerial photographs of 1955, 1977 and 2006. Spatial characteristics of mixed forestland patches corresponding to sampling stations and its dynamics have been analyzed by GIS during this period.

Synchronic model comprises the analysis about mixed forestland mass' ecological dynamics. For this objective, 20 experimental 10x10 meters plots were randomly distributed into each sampling station. In each plot, number and diameter at breast height (dbh) of oak and holm oak (live and dead trees) were measured and classified into thee size class: saplings (dbh<7cm), poles (7<dbh<30cm) and adults (dbh>30 cm); also, seedlings of both species were measured.

Table 1: Sampling stations and land use regime

Sampling station	Code	Altitude range (meters a.s.l.)	Slope	Orientation	Intensity	Recurrence
La Madonnina	MA	700-800	30%	WSW	High	Low
Bau de Mela	BM	800-900	43%	ESE	High	High
Sa Pattada	SP	800-950	33%	SSE	Low	Low
S'Abba Sutterrada	AS	700-900	15%	WSW	Low	High

3. Results

During the period 1955-2006 oak and holm oak mixed forest areas have increased its surface by mean ca. 13%, mainly at the second part of the period (1977-2006). Main changes in forestland covers are related to edges where reforestation has taken place preferably in areas orientated from WSW to NNW (ca.71%) and slopes upper than 40%. Related to forest gaps, reforestation has taken place almost only in north faced areas during the first study period (1955-1977) and in a major quantity in south oriented areas during the second study period (1977-2006); slope was similar during all the period and mainly comprised between the values 30-35%. In terms of casual factors, low use recurrence is the most significant condition in the reforestation process; areas with that regime (SP and MA) show upper forest growth, ca. 25-30% and outstanding decrease of forest gaps, ca. 30-50% (Table 2).

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Table 2: Changes in mixed forestland area 1955-2006

	Forest patches				Forest gaps	
Sampling station	1955-1977 (hectares)	1977-2006 (hectares)	balance (ha)	% of change (1955-2006)	1955-2006 (hectares)	% of change (1955-2006)
MA	6,70	7,18	13,88	28,2	-2,28	-52,0
BM	-19,50	0,18	-19,32	-25,3	4,36	69,8
SP	-0,17	12,66	12,49	26,2	-1,91	-30,4
AS	-3,92	8,25	4,33	7,1	-1,23	-16,4

At species level, 299 oaks and 1.673 holm oaks live trees were counted and measured (per 45 and 430 death, respectively). Widespread, holm oak presents higher observed tree densities and upper values of basal area (BA) in all the sampling stations than oak that are by mean older; also, another trend in species composition, documented by the oral sources of information, sets that nowadays oak density is higher than in previous decades. For land use regimes, the largest BA and average diameter of trees (and consequently age) are related to high use intensity. However, certain values of density and basal area take remarkable records in low use recurrence and abandoned areas (SP & MA) where reforestation is higher (Table 3).

Table 3: Estimated mean values for *Q.pubescens* (Qp) and *Q.ilex* (Qi) density, BA, dbh and age

	specie	MA	BM	SP	AS
Density	Qp	485 (330)	270 (211)	295 (216)	445 (349)
(ind/ha)	Qi	2.140 (850)	1.580 (494)	2.065 (980)	2.580 (886)
BA	Qp	7,23 (8,66)	8,78 (8,75)	5,50 (4,52)	8,22 (5,64)
(m²/ha)	Qi	22,33 (8,96)	33,74 (12,71)	28,82 (13,55)	26,36 (10,87)
Mean dbh	Qp	7,86 (11,34)	15,2 (12,08)	9,88 (11,56)	12,92 (8,56)
(cm)	Qi	7,26 (8,98)	12,5 (10,48)	7,68 (10,22)	8,16 (6,88)
Mean age	Qp	18,8	28,7	21,1	24,7
(yr)	Qi	17,4	24,6	18,3	18,5

In terms of age structure, significant differences become apparent between use recurrence for both species (Mann Whitney test for Qp, $Z=-2,824$ $p=0,0047$; and Qi, $Z=-2,786$, $p=0,0053$) due to younger age size class: low use recurrence areas presents higher sapling frequencies than pole ones in contrast to high use recurrence regimes where this pattern reverses (Figure 1). Also, as proposed indicator of mature forest structure (Barbour et al. 1987) areas of high use recurrence have better adjustments to reverse J-shaped curves than low use ones where reforestation is higher. The Differences observed in tree-mortality related to land use regime were statistically non-significant in both species (Kruskal-Wallis test for Qp, $H=1,378$, $df=3$, $p=0,7106$; and Qi, $H=7,804$, $df=3$, $p=0,0502$)

Related to regeneration dynamics 139 oak and 1.706 holm oak total ramets were counted (12 and 115 death ones, respectively), and 666 *Q.pubescens* and 1.298 *Q.ilex* seedlings too.

As a rule, holm oak presents more resprouting capacity than oak (Mann Whitney test, $Z=-7,399$, $p<0,0001$) in terms of ramets/genet (by mean 1,12 ramets/genet in the case of *Q.ilex* and 0,41 in the case of *Q.pubescens*) and in terms of ramet's size resprouts are very similar (by mean diameter 3,77 cm for oaks and 3,68 for holm oaks). For land use regimes, differences between areas in terms of ramets/genet ratios are only significant in the case of holm oaks; low use recurrence areas show high resprouting ratios than high use recurrence ones (Mann Whitney test, $Z=-4,253$, $p<0,0001$). Also, mortality of resprouting doesn't present significant differences between sampling stations in both species.

Recruitment values for holm oak are by mean, significantly higher than oak number of seedlings (13,35 seedlings/plot per 7,82, respectively; Mann Whitney test, $Z=5,223$, $p<0,0001$) and the spatial pattern has been observed as clumped (Barbour et al. 1987) but is not significantly

related to adult trees presence (Mann Whitney test for Qp Z=-0,775, p= 0,4385; and for Qi Z=-1,587, p=0,1124). For land use regimes, differences between areas in terms of seedlings/plot ratios are significant (Kruskal-Wallis test for Qp, H=4,476, df=3, p<0,0001; and for Qi, H=38,834, df=3, p<0,0001) and recurrence is observed as a key factor: low use recurrence regimes favor high recruitment ratios in both species (Mann Whitney test for Qp Z=-6,182, p<0,0001; and for Qi Z=-6,057, p<0,0001); However, mortality rates of low use recurrence areas are observed higher than the others (by mean 0,76 per 0,95 in the case of oaks and 0,58 per 0,86 in the case of holm oak)
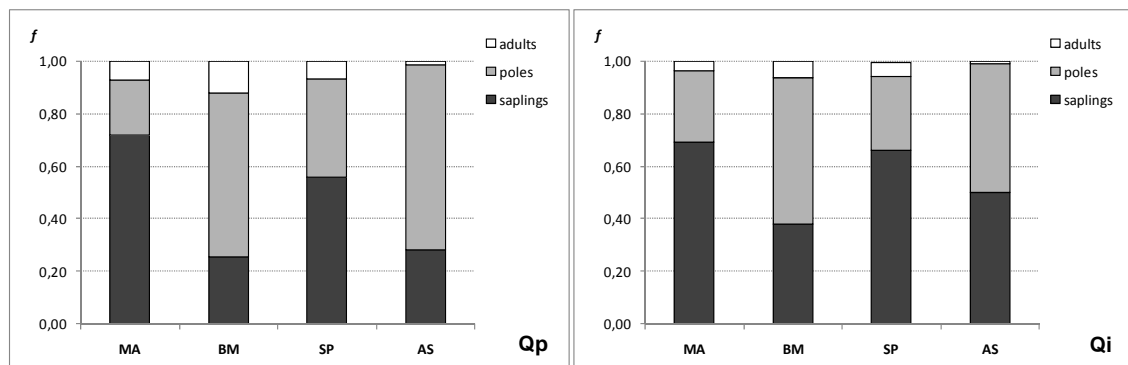
Figure 1: Differences between age size frequency for *Q.pubescens* (Qp) and *Q.ilex* populations (Qi)

4. Discussion

Reforestation is one of the most habitual land cover changes observed at Mediterranean mountain socioecosystems. This process is highly determined by socioeconomic driving forces, mainly by the decrease of forestland uses and abandonment circumstances. These land cover changes tend to be evident in areas where traditional land use become unprofitable in economical terms, either due to high costs (extraction, transport, etc.) or to low benefits (low demand, low value of products, excess of offer). In the case of Montiferru, oak and holm oak mixed forest areas of the Massif fulfill the majority of these premises; their potential products are devalued due to lack of demand and they are located in places that increase costs (high altitude ranges relative far off villages and in high sloped surfaces) in contrast to other more accessible forest areas in basal ranges. In that land use scenario the decrease of interventions is the habitual trend during last five decades and especially since early 1980s and in particular the fall of use recurrence becomes the key factor to explain the increase of land cover extension and biomass.

Far away from a biased interpretation of the forestland growth area, reforestation determines biodiversity dynamics at different levels and due to contemporaneous repercussion of this human-induced process its effects requires of an outstanding attention to avoid environmental risks. The main limiting factors observed in the case of Montiferru mixed forests are related to the tree population structure and to *Quercus* dynamics. Recent land use trends based on low recurrence determine the strong predominance of resprouting in contrast to recruitment mechanism; this scenario obviously favors at species level to *Quercus ilex*, more adapted to resprout, in detriment of *Q.pubescens*. As a result, reforested areas related to land use reduction or abandonment tends to present an ecological impoverishment in contrast to moderate disturbed areas in terms of unbalanced population structures (excess of young trees), less productivity, poor vertical development and low rates of sexual regeneration. Besides, the increase of saplings and resprouts of reforested areas as understory biomass usually becomes a risk factor on fire occurrence, a critical biodiversity conservation topic on Mediterranean basin in general and particularly in Sardinia. Also, at species level, *Quercus ilex* success means, in part, an impoverishment of species composition into mixed forest areas despite the documented

increase of deciduous oaks populations regarding decades ago. In terms of global change (Peñuelas et al 2007) and assuming the uncertainty linked to the complexity of the phenomenon, it could indicate competitive exclusion episodes of deciduous oaks as shift biome processes.

In conclusion, the analysis of driving forces of land use & cover process highlights limiting factors and conservation risks and make it clear the need to integrate land use as an active management tool to maintain Mediterranean mountain landscapes and its biodiversity. However, in actual global change scenario more future researches are necessary to improve our knowledge about biodiversity responses, especially to land use and climate change components, as a way to guarantee its conservation.

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Analysis of rainfall in the Vila Velha State Park, State of Parana, Southern Brazil, in the period between 1954 and 2001

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Abstract

The aim of this study was to perform a temporal analysis involving frequency, intensity and variability of rainfall for the city of Ponta Grossa, between 1954 and 2001. Data of daily rainfall (mm) were analyzed and obtained from the Meteorological Station, situated in the area of the State Park of Vila Velha, Paraná State, Southern Brazil. The Park constitutes a Conservation Unit with a total area of 3122.11 hectares and presents vegetation of open grassland and scattered clumps of forest, with the focus on the Paraná Pine (*Araucaria angustifolia*). The annual average rainfall observed for the series was 1546.2 mm, revealing a growing trend over the years. The month with the highest average rainfall was January and the lowest average was observed in August. Summer was the most rainy season, including the highest number of days with rain. The range of "drizzle" showed the highest frequency in all months.

Keywords: temporal analysis, intensity, variability, rainfall.

1. Introduction

Rainfall is one of the meteorological elements that most influence on environmental conditions and has a great importance because it is directly related to many sectors of the society, since the rainfall affects the economy, the environment and the society as a whole (Silva et al., 2007). The spatial-temporal distribution of rainfall is a very important regional characteristic, both for society and for the economy. Knowledge of this feature can guide decisions on the measures necessary to minimize the damage from irregular rainfall (Piccinini, 1993 apud Minuzzi et al., 2007). According to Nery et al. (2002 apud Nery et al., 2004), information about the number of days with rainfall are useful both in agricultural planning in a short-term (which agronomic practices for soil and/or air moisture are conditioning factors), as a long-term conditions (definitions of regions and times most suitable for the sowing of crops and/or for maintenance of perennial species). To Assis (1991 apud Ribeiro and Lunardi, 1997), the frequency, i.e. the number of days within a month or season in which rainfall occurs, perhaps is the most important aspect in relation to rain for vegetation in general, besides quantity and variability. The objective of this study was to evaluate the frequency and intensity of rainfall from the Meteorological Station located in the Vila Velha State Park, near the city of Ponta Grossa, State of Parana, Southern Brazil, over the period of 1954 to 2001.

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2. Methodology

Daily rainfall data (mm) were obtained from the Meteorological Station, belonging to the Instituto Agronômico do Paraná (IAPAR), located in the State Park of Vila Velha, on the geographical coordinates of 25°13'S, 50°01' W and 880 m of altitude. The data were collected from January 1954 to December 2001, constituting a series of 48 years. The State Park of Vila Velha, has an area of 3,122.11 hectares and is situated in the city of Ponta Grossa, State of Paraná, Southern Brazil (see Figure 1). The main access is the BR-376, an important road junction that connects the shores, Curitiba (the State capital) and the North of the Paraná State. Ponta Grossa is located in the Second Parana Plateau and is situated in an area of grassland (short grass steppe) with clumps of forest of Araucaria. Because of this phytogeographical feature, the region where Ponta Grossa is located is called the Campos Gerais Region of Paraná State (Maack, 1981). Initially, the daily rainfall data were subjected to screening and assessment of consistency of time series. To assess whether there was any particular trend related to the annual totals of rainfall, there was used the concept of moving average, calculated by cycles of five years. After that, it was proceeded the frequency analisys of the days with rain in each month of the series. The days with climatological drought (Leaves & Fisch, 2006) were excluded and the remaining data were divided into class intervals of rainfall. From there, they were classified in relation to the intensity of cumulative daily rainfall as: drizzle (0.1 to 2.5 mm), light rain (2.5 to 10.0 mm), moderate rain (10.0 to 25.0 mm), heavy rain (from 25.0 to 50.0 mm) and extreme rain (above 50 mm) (Calvetti et. al., 2006). It was also evaluated the annual totals of rainfall and annual totals of days with rain and climatological drought.
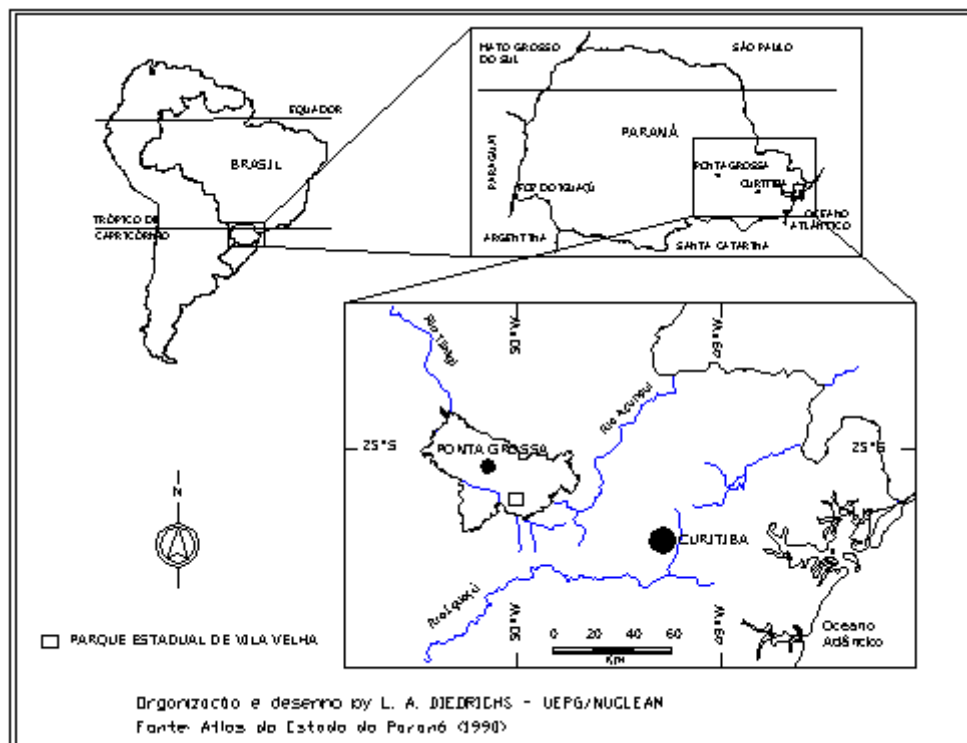
Figure 1: Location of Vila Velha State Park

3. Result

Figure 2 shows the annual totals of rainfall (mm) for the city of Ponta Grossa (PR) from 1954 to 2001. It is observed that the year with the higher total of rainfall was 1998 with 2494 mm, and the year with the lowest total was 1985, with 910.3 mm. For the series studied, it was obtained an annual average total of rainfall of 1546.2 mm. The estimate of the moving average for the total annual rainfall, considering cycles of five years throughout the series, evidenced the existence of a positive trend over the annual totals of rainfall, as explained by the regression line with the time variable ($r^2 = 0.5264$). The graph in Figure 1 also shows the alternation between high and low annual totals of rainfall, which can partly be explained by the occurence of El Niño and La Niña. Analyzing the data in a monthly scale, it can be observed that the month with the highest average rainfall was January (185.4 mm) and the month with the lowest average was August (78.9 mm). Considering the occurrence of rain, the year 1983 was the year with more rainy days (168 days), while 1968 was the year that had the lowest total of days with rain (only 73 days). The average for the studied period was 126 days with rain per year, showing also a tendency to increase this number of days in the course of time.
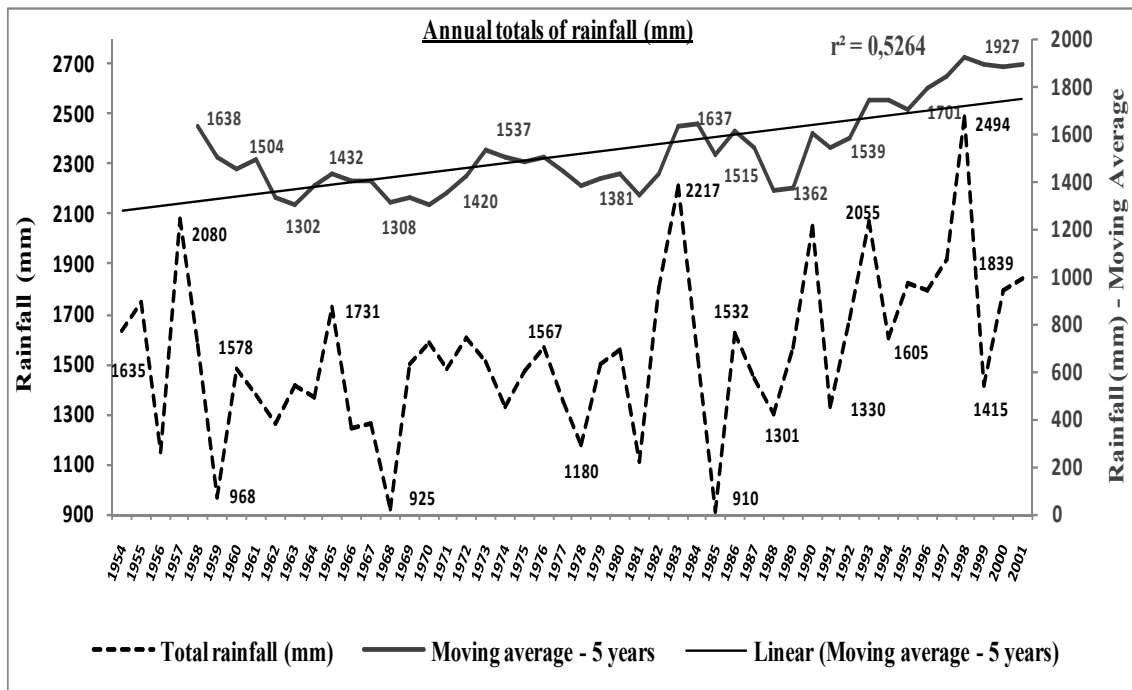
Figure 2. Annual totals and moving averages of rainfall (mm) over the period of 1954 to 2001.

On Table 1, which classifies the rainfall intensity, it can be seen the percentage that each class interval represents, over the total number of days with rainfall, for each month of the year. The predominant class interval throughout the year is light rain (2.5 - 10.0 mm accumulated in a day), being the most frequent during nine months of the year, ranging from 29.46% attendance in June to 33.66 % in March. The range of drizzle (0.1 - 2.5 mm) was more frequent in April (30.08%) and the range of moderate rainfall (10 - 25 mm) was the most frequent in October (29.76%). In May, drizzle and light rain had the same percentage (29.11%). The range of heavy rain (25 - 50 mm) ranged from 8.73% of frequency in November to 14.79% in April. With respect to the rain considered extreme (over 50 mm a day), it was observed that this range was

less frequent in all months, exceeding 5% frequency only in May (5.57%) and with the lowest frequency in February (1.18%).

Table 1. Percentage corresponding to the class intervals of rainfall over the total number of days with rainfall for each month analyzed. CRI = Classification of Rainfall Intensity; RI = Rainfall Intensity.

CRI	RI (mm)		J (%)	F (%)	M (%)	A (%)	M (%)	J (%)
Drizzle	0,1 ⊢ 2,5		28,47	28,11	31,23	30,08	29,11	26,73
Light rain	2,5 ⊢ 10,0		31,11	32,25	33,66	27,57	29,11	29,46
Moderate rain	10,0 ⊢ 25,0		25,42	26,18	23,14	25,81	24,05	25,50
Heavy rain	25,0 ⊢ 50,0		11,94	12,28	9,55	14,79	12,15	13,37
Extreme rain	> 50,0		3,06	1,18	2,43	1,75	5,57	4,95
TOTAL			100,00	100,00	100,00	100,00	100,00	100,00

CRI	RI (mm)		J (%)	A (%)	S (%)	O (%)	N (%)	D (%)
Drizzle	0,1 ⊢ 2,5		25,78	27,11	22,45	24,86	26,79	28,34
Light rain	2,5 ⊢ 10,0		33,14	32,23	33,06	28,49	32,14	31,76
Moderate rain	10,0 ⊢ 25,0		24,65	26,51	26,94	29,76	30,16	26,87
Heavy rain	25,0 ⊢ 50,0		12,46	12,35	14,29	13,97	8,73	9,77
Extreme rain	> 50,0		3,97	1,81	3,27	2,90	2,18	3,26
TOTAL			100,00	100,00	100,00	100,00	100,00	100,00

4. Discussion

The phenomenon called El Niño Southern Oscillation (ENSO), considered as the main cause of climate variability in various regions of the globe is a phenomenon of ocean-atmosphere interaction that occurs in the tropical Pacific Ocean and has two extreme phases: a warm phase known as El Niño and a cold phase called La Niña (Berlato & Fontana, 2003). Among the consequences of El Niño, is the increase in rainfall in southern South America, reaching catastrophic proportions, as occurred in 1983 and 1998. In those years, there were registered the two largest annual totals of rainfall in the series studied in Ponta Grossa (2494 mm in 1998 and 2217 mm in 1983). The other three largest totals of rainfall (2080.1 mm in 1957, 2071.1 mm in 1993 and 2054.7 mm in 1990) also occurred in El Niño years, although that the event was not as strong as in 1983 and 1998. Furthermore, the La Niña phenomenon, opposite to El Niño, which corresponds to the anomalous cooling of surface waters in the equatorial Pacific, Central and Eastern, may explain the lowest rainfall observed in the series studied (910.3 mm in 1985). From the standpoint of hydrology, rainfall up to 10 mm have little impact, except to moisten the soil to the point of reaching its field capacity, increasing the efficiency of runoff into rivers. Despite of the reduced frequency observed, the "very heavy" rains can cause further damage such as landslides, floods, etc.. as a result of the use and occupation of land. It is very important to make a suitable plan for land use, paying particular attention to areas of risk, as close to river banks or slopes, which are greatly affected sites when it rains heavily. The uncertainty related to global changes connected to precipitation, originated from natural phenomenas and/or anthropogenic activities, makes it currently impossible to establish categorically the effects of climate change on ecosystems and on agricultural activities more broadly. Nevertheless, studies on various scales, including regional scale, will enable the understanding of how natural ecosystems can respond and adapt to these climatic variability, becoming an increasingly urgent need. Identified potential vulnerabilities, one should start the search for strategies and technologies for adaptation, including taking advantage of possible climate changes that may be considered beneficial.

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Identification of climatic trends for some localities in the Southern Region of Campos Gerais and surroundings, State of Parana, Brazil, through the analysis of historical data of rainfall and temperature

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Abstract

This study aimed to assess possible changes in climate localities in the southern region of Campos Gerais (Fernandes Pinheiro, Lapa, Ponta Grossa), Parana, Brazil. The forest vegetation occupies 22% of the area of Campos Gerais, including different types and successional stages. These forests are naturally fragmented, forming isolated groves of various sizes and extensions, located on the slopes, small depressions or tracks that come in rivers, streams and springs. To investigate possible changes in climate, daily temperature and precipitation data were analyzed, by the use of Mann-Kendall test. Data analysis revealed an increase in average and minimum temperatures in the three localities. For the maximum temperature, the city of Ponta Grossa showed negative trend, a fact explained by the increase in cloudiness in the region. For the rainfall data, the city of Ponta Grossa and Fernandes Pinheiro showed a positive trend, while for the city of Lapa, it was negative.

Keywords :precipitation, temperature, climatic trends

1. Introduction

The climate is characterized by the interaction between various climatic variables, especially among precipitation and temperature. Both are closely related and these changes may cause major changes in regional climate. There are few studies on long-term variability of extreme weather and climate in Brazil and South America. In addition, studies in some regions of Brazil, or in the rest of South America, have used different methodologies, which does not allows intercomparisons or geographical integration. The lack of meteorological information of good quality related to daily series in large areas of Brazil, and the very restricted access to daily weather information stored in databases of meteorological services, have not allowed identification of climatic extremes and their variability, especially in tropical South America. To the South of Brazil and Northern Argentina, the works of Marengo and Camargo (2006) and Rusticucci and Barrucand (2004) showed negative trends in diurnal temperature range due to positive trends registered in minimum temperature. They also observed an increased frequency of hot days in winter. Compared to the air temperature, a larger number of studies of trends in precipitation have been developed due to the greater availability of data on rainfall than temperature. Groisman et al. (2005) found positive trends of systematic increases of rainfall and extremes of rainfall in the subtropical region, in the South and Northeast of Brazil. The authors considered that the Southeast, since 1940, has shown systematic increases in the frequency of heavy rainfall, up almost 58% in recent years. This study aimed to examine the climatological

variables, temperature and precipitation and check for possible changes and climate trends observed in the cities of Fernandes Pinheiro, Lapa and Ponta Grossa, Southern of the Campos Gerais Region and surroundings, State of Parana, Brazil.

2. Methodology

The cities of Ponta Grossa and Lapa are located in the phytogeographical region known as Campos Gerais of Paraná, while Fernandes Pinheiro is located in a surrounding area, Paraná State, Southern Brazil. These cities are represented on the map in Figure 1.
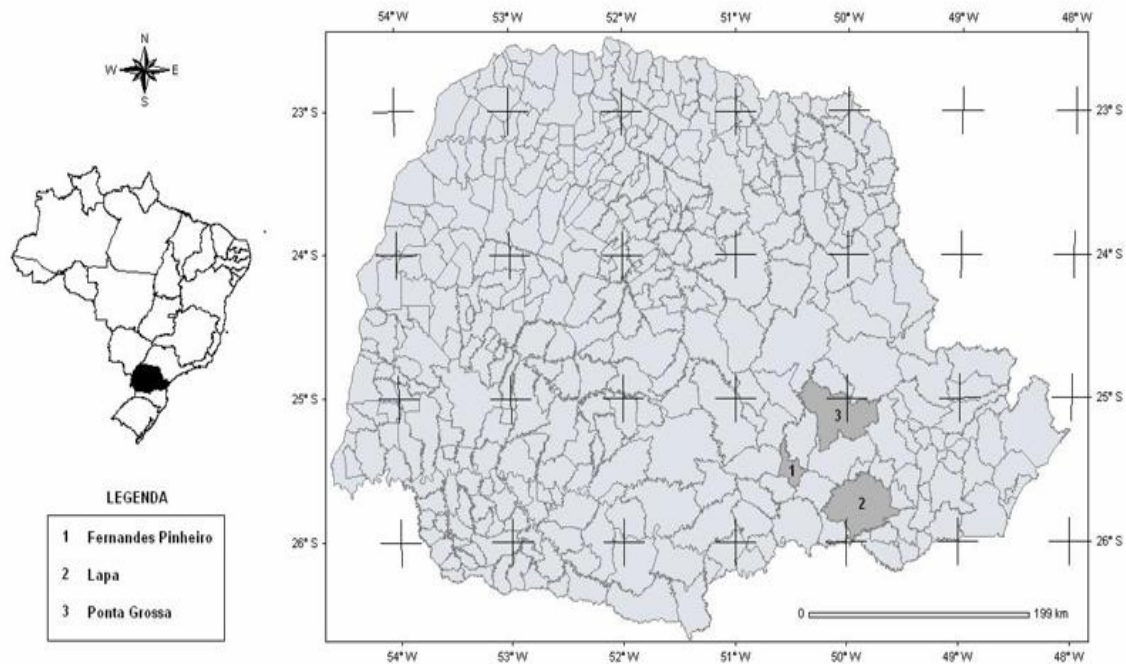
Figure 1 – Location of the cities: Fernandes Pinheiro, Lapa and Ponta Grossa, State of Parana, Southern Brazil.

The region of Campos Gerais holds unique landscapes such as escarpments, caves, canyons, rivers with rocky beds, waterfalls, ruiniform reliefs, remarkable displays of rocks and fossils and diverse floral species. The forest vegetation occupies about 22% of the area of Campos Gerais, including different types and successional stages. Such forests have been naturally fragmented, forming isolated copses of various sizes and extensions, located on the slopes, small depressions or in bands accompanying rivers, creeks and springs. However, the occupation of areas previously considered unproductive, the rise of mechanized agriculture and the use areas for the production of wood, have become factors that could cause preoccupation, and cause, over time, major changes in the regional ecosystem, requiring studies of diverse natures. The data used in this study were provided by the Instituto Agronômico do Paraná (IAPAR) and consisted of records of the climatological variables temperature (maximum, minimum and average) (ºC) and precipitation (mm). Initially, the daily data were subjected to screening and assessment of consistency of time series and then arranged in annual, quarterly and monthly series. The nonparametric test of Mann-Kendall, initially proposed by Sneyers (1975), was applied in a significance level of 0.05 and 0.01%, in order to identify possible climate changes over time, which could be presented as positive or negative trends within the period analyzed. The data series have different durations for each city and location details can be found in Table 1.

Table 1 . Length of series and location of the municipalities of Fernandes Pinheiro, Lapa and Ponta Grossa – State of Parana, Brazil.

City	*Latitude*	*Longitude*	*Altitude (m)*	*Series*	*Number of years*
Fernandes Pinheiro	-25°27'	-50°35'	893	1963-2007	45
Lapa	-25°47'	-49°46'	910	1989-2007	19
Ponta Grossa	-25°13'	-50°01'	880	1954-2001	48

3. Result

The climatological data were analyzed with the nonparametric Mann-Kendall test, producing the results shown in Table 2.

Table 2 . Results of the Mann-Kendall Test applied on the climatological data of rainfall and temperature in the cities of Fernandes Pinheiro, Lapa and Ponta Grossa, State of Parana, Brazil.

Localidade	Variável	Teste de Mann-Kendall (U calculado)	0,05% de significância	0,01% de significância
Fernandes Pinheiro	Precipitação	0,35	NS	NS
Fernandes Pinheiro	Temperatura Máxima	3,30	**S**	**S**
Fernandes Pinheiro	Temperatura Média	5,81	**S**	**S**
Fernandes Pinheiro	Temperatura Mínima	5,38	**S**	**S**
Lapa	Precipitação	-1,92	NS	NS
Lapa	Temperatura Máxima	2,41	**S**	NS
Lapa	Temperatura Média	2,27	**S**	NS
Lapa	Temperatura Mínima	2,27	**S**	NS
Ponta Grossa	Precipitação	2,06	**S**	NS
Ponta Grossa	Temperatura Máxima	-3,18	**S**	**S**
Ponta Grossa	Temperatura Média	1,88	NS	NS
Ponta Grossa	Temperatura Mínima	4,85	**S**	**S**

With respect to the rainfall data, a positive trend was observed for the city of Ponta Grossa, while for the other two cities, the results were not estatistically significant. For temperatures (maximum, average and minimum), significant trends were detected for all the cities, at least with 0.05% of significance. For the maximum temperature there was a positive trend for the

cities of Lapa and Fernandes Pinheiro, the latter being significant at 0.01%, while for the city of Ponta Grossa, the maximum temperature had a significant negative trend of 0.01%. For minimum temperature, all the cities had significant positive trends, showing a rise in the minimum temperature in the region. These results of a temperature rise in the southern region of Campos Gerais, in the State of Parana, is reinforced by analyzing the average temperature in the three localities, which showed positive trends. Finally, for the city of Ponta Grossa, in despite of having observed an average temperature rise, this was not significant for the studied period.

4. Discussion

According to Silva (2004) the rainfall in southern Brazil are distributed regularly throughout the year, compared to other regions of the country, but in recent years the phenomenon El Nino has served continuously in this region. This climatic phenomenon, when actuates, significantly alters the levels of rainfall, which are increased during the year. Whereas this phenomenon has been acting steadily in the region, the increase in the totals of annual rainfall and the positive trend observed for the city of Ponta Grossa may be correlated with the performance of such a frequent phenomenon in the region. Back (2001) also found elevated totals of annual rainfall for the city of Urussanga, State of Santa Catarina, identifying a significant positive trend. The decrease of the maximum temperature in Ponta Grossa, along with higher minimum temperature, can be partially explained as a consequence of increased cloudiness in the region. Due to this rise in the levels of cloudiness during the day, a smaller amount of sunlight can reach the earth's surface, occurring a decrease in maximum temperature. During the night, with lots of clouds, there is greater retention of radiation, complicating its loss to space, thereby increasing the minimum temperature at location (Silva & Guetter, 2003). In a previous study, Silveira & Gam (2006), analyzing changes in minimum temperatures in southern Brazil, found that the minimum temperature in the state of Rio Grande do Sul also showed a positive trend over the study period under review. The same increases were verified by Obregon & Marengo (2007), which developed a major study on climate throughout the Brazilian territory, in order to determine possible changes in climate variables. In this study the annual minimum temperatures in the city of Curitiba, Brazil, showed a significant positive trend at 0.05%, reinforcing the findings of elevated temperatures in the State of Parana. One reason for this increase in temperatures can also be correlated to the increase in the totals of areas destined to urbanization in the last years (Sansigolo et al., 1992). In some regions, deforestation and changes in land use, as a result of human activities have increased rapidly in recent decades, and there are evidences that these actions can modify the thermodynamic characteristics of the lower atmosphere. These changes are the result of complex interactions between climate, hydrology, vegetation and management of water resources and land.

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Monitoring vulnerability of the Spanish forest landscapes: the SISPARES approach

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Abstract

SISPARES is a system devoted to study the ecological evolution of the Spanish Rural Landscapes including their characterisation, classification, and recent past and future changes. It is based on a sampling network of 215 permanent 4x4 km plots surveyed by using aerial photographs of three dates: 1956, 1984 and 1998. Currently, a new survey is going on. The network design was based on an environmental stratification of Spain well linked to the European Environmental Stratification.

Forest Landscape Vulnerability (FLV) is defined as the risk of human disturbance, especially forest fires. We assessed FLV using an index based on Forest Landscape Fragility (FLF) weighted by Road Accessibility. FLF is defined as the risk of landscape disturbance caused by a high degree of interspersion and juxtaposition between patches of forest and non forest land uses: The non forest land uses, such urban, crop and managed grassland, are considered as potential sources of human disturbances, for the forest land use patches, including woodland, "matorral", "dehesa", tree plantation and riparian woodland.

From 1956 till 1998, a significant increase of FLV has been observed in SISPARES landscape plots. This increase is related to the increment of forest fires in Spain during the last 40 years.

Keywords: Landscape, monitoring, vulnerability, SISPARES system, Spain

1. Introduction

Landscape vulnerability is defined as the risk of severe disturbances and could be consider as a character of landscape patterns (composition and configuration). In recent years, landscape character assessment in Europe has become central to sustainable development and the management of land. It is recognised as an important tool for policy stakeholders, which provides them with quantitative and qualitative evidence to reach a dynamic management, adjustable to new demands of regional identity (Washer 2005). But only, Denmark (Nordic Council of Ministers 1987), Austria (Wrbka et al. 1999) and Spain (Elena-Rosselló *et al*. 2005) have developed national approaches for delimitation and mapping local spatial units on the basis of a range of landscape features (geophysical, cultural and historic, perception and aesthetics and natural value) as a basis for vulnerability assessment. However, in many other countries all over the world, local approaches exist and some of them have been specifically designed to evaluate landscape vulnerability to forest fire (e.g. Preston et al. 2009, Sorrensen 2009). They are important tools for preventing the risk of forest fire.

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In Spain, the SISPARES national approach is an ongoing project designed to study the ecological value and dynamics of rural landscapes in Spain, including their characterisation and classification (Elena-Rosselló *et al*. 2005). Forest Landscape Vulnerability (FLV) is among of the ecological landscape characteristics assessed and then monitored. FLV has been defined as the "risk of human disturbance" and measured as "the interspersion among forested and non forested patches weighted by road accessibility". According to its definition, we might hypothesize that FLV is a good indicator of forest fire risk. Therefore, it is necessary to prove that hypothesis by studying its relationship with forest fire incidence.

This paper compares the FLV values in Spain among 1956 to 1998 with the annual national burnt area and forest fire frequency (Spanish Environmental Ministry 2005) trying to find out their relationship type. An increase of FLV could be determining a higher number of forest fires and/or an increase of burnt areas.

2. Material and methods

The vulnerability of Spanish forest landscapes has been monitored by using the SISPARES approach which has a stratified simple sampling design based on the Biogeoclimatic Land Classification of Spain, known by its acronym CLATERES (Elena-Rosello *et al.* 1997). This stratification was constructed using a divisive multivariate classification approach adapted from the Country Survey land classification system (Bunce *et al*. 1996a, 1996b, 1996c), applied to climatic, physiographic and geological data. The initial stage was the establishment of a representative Spanish Rural Landscape Network (*REDPARES)* that has 206 4x4 km squares in Iberian Peninsula and Balearic Islands. All the squares were surveyed using aerial photographs at three dates: 1956, 1984 and 1998 to derive measurements of 11 major land cover (Table 1). A new survey is currently in progress to updating the samples by interpretation of air photos from 2007, but the data are not let ready to be presented in this work.

Each square of SISPARES represents the landscape of one geoclimatic class and was analysed by delimiting patches of land cover and linear elements of road network from aerial photo interpretation and field surveys during the nineties. The scale of photos is 1:30.000 and the minimum patch size that it has been interpreted is 1 ha. The patches are relatively homogeneous portions of land that represent different land covers that are adjacent and make up the landscape.

Table 1**:** Types of land cover detected by interpretation of aerial photographs and their correspondence with land cover CORINE classification (EEA 1995)

Type of land cover	CORINE/level
Forest	Forest/3.1
Matorral	Shrub and/or herbaceous vegetation associations/3.2
Dehesa	Agro-forestry areas/2.4.4
Forest plantation	Young Broad-leave forests/3.1.1. and Young Coniferous forests/3.1.2
Pastures	Pastures/2.3.1
Crops	Arable land/2.1 and permanent crops/2.2
Riparian woodland	Riparian woodland/3.1.1.5
Rock	Bare rock/3.3.2
Water body	Water bodies/5.1.2
Urban and industrial use	Artificial surfaces/1

2.1 Data analysis

In each square FLV has been calculated as:

FLV=FLF*RD/100   (1)

Where RD is road density in the square and FLF is an index of forest landscape fragility, which has been calculated as:

FLF=IJI*WFN   (2)

Where IJI is an index of interspersion and juxtaposition that considers the neighbourhood relations between patches. Each patch is analysed for adjacency with all other patch types and measures the extent to which patch types are interspersed i.e. equally bordering other patch types. The IJI is a relative index that represents the observed level of interspersion as a percentage of the maximum possible given the total number of patch types (McGarigal et al. 1995).

$$IJI = \frac{-\sum\limits_{i=1}^{m}\sum\limits_{k=i+1}^{m}[(E_{ik})*\ln(E_{ik})]}{\ln\left(\frac{m(m-1)}{2}\right)}$$

(3)

m = number of patch types,

E_{ik} *= length of edge between patch type i and patch type k.*

IJI approaches 0 when the distribution of adjacencies among unique patch types becomes increasingly uneven. IJI = 100 when all patch types are equally adjacent to all other patch types (i.e., maximum interspersion and juxtaposition.

WFN in equation 2 is the contrast between forest and non forest areas in the square and is measured as:

 (1-| Forest area – Non Forest area|)/100   (4)

A landscape square will be more fragile when a higher WFN and a higher IJI have. Besides if the square has a higher road density it will be a high value of vulnerability.

Fragstat software was used to calculate the IJI index. Repeated measures ANOVA was used to analyse FLV, FLF, IJI, WFN and RD of 206 squares of SISPARES in three dates: 1956, 1984 and 1998 by means of Statistica softhware.

3. Results and discussion

FLV index showed a significant increase in Spain along the study period (F=3.36; p=0.04) as it is observed in the figure 1. The increase between 1956 and 1984 was 2% and during the last 24 years of this study period the mean number of forest fires was 3,940 per year (Table 2). Between 1984 and 1998 data, the increase of FLV was 12% more and only during these 14 years the mean number of forest fires was 15,844 per year. In the same way the burnt areas were

near twice over in the second period, mainly caused by the increase in the mean of burnt non forest areas per year (Table 2).

Per zones, FLV has been higher in northwest of Spain because to a typical complex landscape structure that provides higher levels of landscape fragility, interspersion of patch types and contrast between forest and non forest areas (Fig 1a). Lower FLV has been observed in aridity
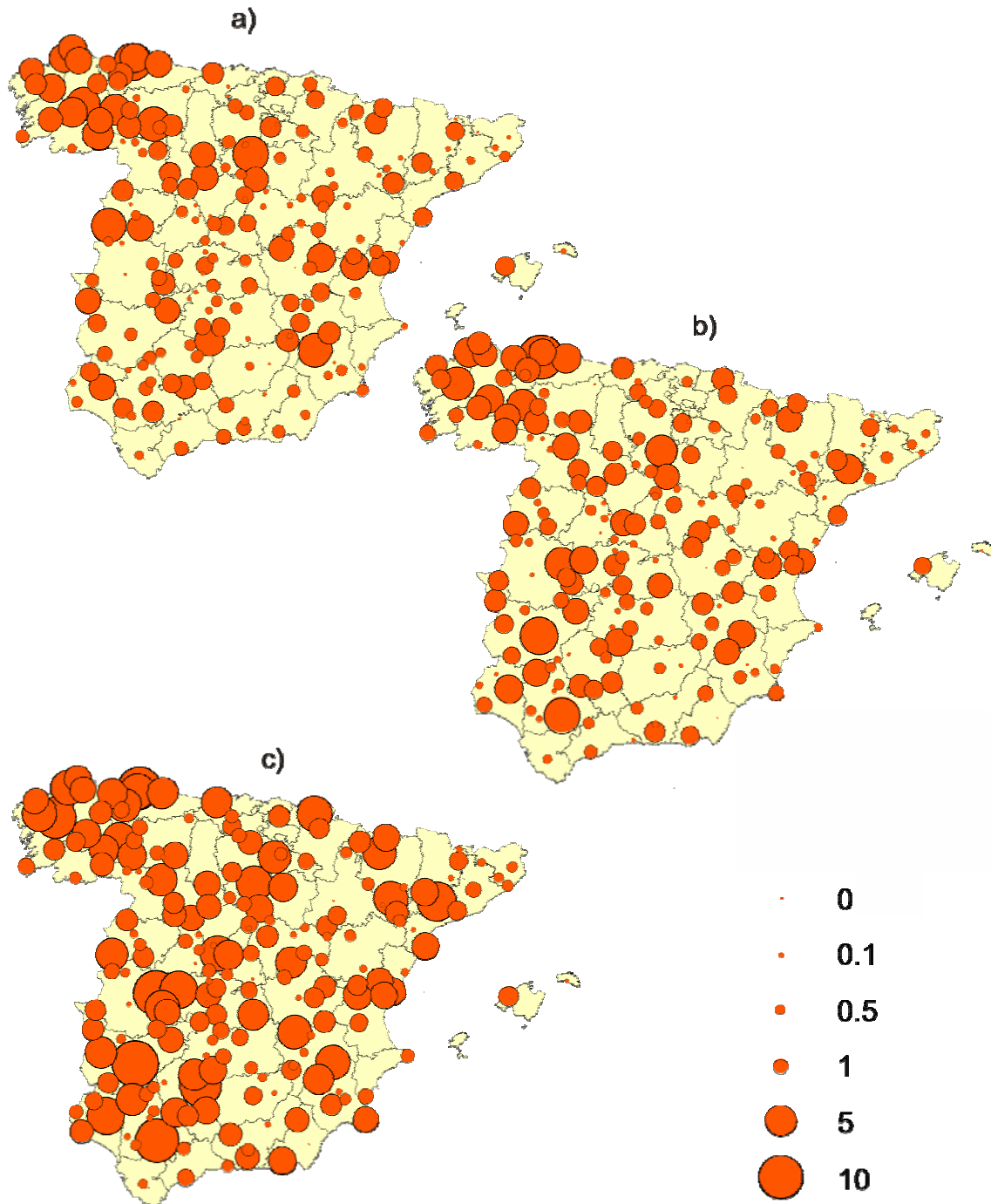
Figure 1: Monitoring of Forest Landscape Vulnerability (FLV) in 206 squares of SISPARES approach along three dates: (a) 1956, (b) 1984 and (c) 1998. The point size indicates the value of FLV.

zones because to a typical agricultural landscape that determines low fragility, interspersion of patch types and contrasts.

But this framework of 1956 changed with the abandon of crops productions and the increase of forest plantation between 1956 and 1984 mainly (Ortega et al., 2008). These changes of land use has produced a decrease of FLF along the study period ($F=17.55$; $p<0.01$) because a decrease in contrast between forest and non forest areas. However, the road density had a significant increase along the study period ($F=73.3$; $p<0.01$) that has determined the increase of FLV in the all Spain that could be associated to the increment of forest fires and burnt areas.

Table 2: Forest landscape vulnerability (FLV) increases along study period and mean data of forest fires and burnt areas per year (Spanish Environmental Ministry 2005).

	1956-1984	1984-1998
FLV increase	2%	12%
Mean number of forest fires per year	3,940	15,844
Mean area of burnt forest (ha)	52,452	85,162
Mean area of burnt non forest (ha)	69,875	128,516

These results are a global comparison between the dynamic of FLV and forest fire incidence in Spain. A detailed assessment per zones would be necessary and will be made with the new data of 2007 survey of SISPARES system.

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Landscape transformations seen through the historical cartography: Sardinia as case study

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Abstract

Land Cover Changes are directly linked to landscape transformations due to human activities. In the last century land changes dynamics have increased just like the attention towards the need of landscape conservation. Landscape, as a collector of "environmental objects and relations existing between them", can be considered a privileged point of view in order to understand the territorial dynamics. Forestry systems, as biodiversity collectors, have suffered the biggest changes in terms of loss/increase of surface. This work regarding Sardinian island, can be considered the first one, at this scale, about changes analysis focused on forestry landscape. Recovering historical cartography, and integrating the obtained data with different data-sources, a new frame is designed to underline the increase of forestry surface. The obtained results could be a reliable and useful tool to direct new studies on forestry landscape, especially for Mediterranean and Apennine regions and to manage new scenarios on biodiversity conservation.

Keywords: Sardinia, Land Use & Land Cover Change, Forestry landscape, Historical maps, Deforestation,

1. Introduction

Sardinia is the second largest island in the Mediterranean (after Sicily) with a total area of roughly 24,000 km^2. With a resident population of more than 1,600,000 inhabitants (43% of which concentrated in two main urban areas), Sardinia is one of the Italian regions with the lowest demographic density. The island has a complex topography, with more than 80% of the region occupied by hilly and mountainous areas (>300 m a.s.l.), and with a maximum elevation of 1,834 m a.s.l. The highest human population densities occur in the main plains where large agricultural areas are also located. In Sardinia, forests had always played a key role with an essential importance for local community to strengthen the island culture and identity and to reflect and spread the "idea" of Sardinia as a flourishing land in people coming from foreign lands. Forests have been seen as a refuge and, on the opposite side, as also a precious natural resource, as "wood", leading to a conflict between the different interests in forest floor exploitation since the first travels through the Mediterranean Sea by navigators such as the Phoenician people. The presence of woodland has always been considered as an obstacle to extensive and subsistence farming but also to the intensive one that ran over plains and hills on the island arousing the need to reduce and destroy forests where lands could be managed, with a more or less income, for agriculture. In the meantime, forest mantles were the appropriate space to support the presence of herds during the dry summer periods that island climate usually shows as, and often, lead to the cut of lower branches to get green forage until rare and

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umbrella-shaped formations took place and became a typical character of Sardinia inland as they are many times cited to represent the old residue of primordial formations or ancient Mediterranean forests in the Island. According to Le Lannou (1941) "There are few regions, in Europe, where natural green landscapes- if with this term we refer to landscapes that had not changed under land cultivation- have a so important role as in Sardinia." All different observers writing on Sardinia, describe the nineteenth century as a century that deeply altered the "complex landscape" in the Island, changing it from a land covered by woods with a mosaic of surfaces dedicated to sheep farming, passing through management models characterized by a dichotomy between agriculture and forestry, to much more sophisticated agro-silvo-pastoral systems. Even if it's not clearly delineated in landscaping, this issue has been quite focused in terms of landscape, if this word refers to a "wide container of objects and systemic relationships", since woods and forest have always been complex territorial objects, with a multitasking character covering private and "public heritage" concerns even if under a private property. Land governing coming from legislation (with dichotomies right/wrong in the question statement and in the imposed solutions, and applied/not-applied for what regarding the proper realization of laws expectations on territory), is the actual source of observed reality, giving evidence of social movements and economical drivers replying to legal acts.

2. Methodology

To understand the actual landscape it's then necessary to ensure a diachronic interpretation of it through time because only with the comprehension of territorial motivations of the past, the dynamics and the identity of the present can be really realized and acquired. This historical lecture of the presence and distribution in forests on the island, turns to fix a new attempt of analysis in comparison to the what have been done and is archived in literature, and sets the aim of this work. In Sardinia, Landscape Issues (Conservation and Management) had often assumed the distinguishing feature of "Identity Definition" in community talks and social living during the end of nineteenth century and he beginning of the twentieth, leading to a contrast between two different economic scenarios for forest management:

1. Forest cut was configured as a generalized deforestation, with an undue removing of woods and a disfigurement of Sardinia
2. Forest cut was configured a san economical operation needed to increase the government income and to let modernity come in the Island updating its services to the rest of the island

2.1.1 The "Forest Map" made by National Forest Militia

To analyze the effects of forest management at regional scale along a time period of more than a century (1850-2010), it's necessary to integrate and complete different sources of data so that to delineate a trend of areas covered by woods as fully as possible. In particular, historical maps, never analyzed before, have been recovered; these maps have been realized in the period 1930-35 and, called as "Forest Map", reports location and composition of woodlands at 1:100000 scale. This cartography is one the first forest inventory, elaborated at a national scale (where Italy is represented in 267 sheets and Sardinia in 26 sheets with an extension of 30 degrees in longitude and 20 degrees in latitude). To restore all the thematic information through digitalization, single sheets have been georeferenced by "rubber sheeting" with three layers (coats of the island, administrative boundaries and roads) so that to obtain a great number of control points (at least 100 points per sheets) and produce a direct georeferentiation in WGS84 (Geri et al. 2008). This method, even if it's not so correct from a formal point of view, allows a large computational time saving in comparison to the georeferentiation in the native system (not so clear because of geographical metadata lack) and re-projection in other systems and, in

particular, (due to the great number of points) has introduced errors that have been estimated lower than map scale precision.

2.1.2 Map of land utilization made by National Research Counsil, Italian Cadastre, and Italian Touring Club.

The second map used in this work, is called "Map of land utilization" realized by a cooperation between National Research Council (CNR), Italian Cadastre (Catasto) and the Italian Touring Club (TCI) and it has been released in 1952-1960. This map can be assimilated to a land use and land cover map, even if the legend, made by 21 items, cannot be completely compared with that one of the European CORINE Project (Falcucci et al. 2007). Different opinions exist about its original setting and, actually, the real thematic aggregation criteria, that led to the final map (1:200000 scale) starting from all he information contained in the single sheets of the Italian Cadastre (1:1000; 1:2000; 1: 4000 scales), are not known

2.1.3 The CORINE Land Cover map

The third map used for comparisons, is derived from CORINE Project, that, for Italy, produced a digital map at the nominal scale of 1:100000 with 44 legend items.

2.2 Model development

To develop a model for a diachronic comparison between different cartographic maps, it's necessary to obtain the best compatibility between them, even heterogeneous in legend and elaboration methods (topographic survey vs aerial and satellite photos analysis) that can be realized according to the procedures of map generalization (Weibel and Jones 1998) summarized in three consequential phases (Petit and Lambin 2002; Pelorosso et al. 2009). Due to the different structure of legends in the maps used, thematic generalization could be obtained only reducing all the items into two classes: wood vs non-woods. Spatial resolution generalization was derived by a rasterization on the same DTM at a 20x20 m of resolution. For every map, consequential aggregations were achieved starting from 40 m cells with a step of 20 m until 500 m cells were reached using the majority rule and giving rise to 24 maps for each of the national cartographies. Using five landscape indexes (Riitters 1995) every aggregated map can be analyzed and a distance can be elaborated in 5-dimensional space of landscape metrics between the generalized and the target map. In this way, the best resolution can be identified to make a comparison between target map (CLC, 1990) and generalized maps (Forest Map 1930-1935; Map of Land Utilization 1952-1960). See Table 1:

Table 1. Comparison framework between maps.

Forest Map (1930-35) *vs* Map of Land Utilization (1952-60)	$MIL_{040} \div MIL_{500} \rightarrow CNR\text{-}TCI_{040}$
Forest Map (1930-35) *vs* CORINE (1990)	$MIL_{040} \div MIL_{500} \rightarrow CORINE\ 1990_{040}$
Map of Land Utilization (1952-60) *vs* CORINE (1990)	$CNR_{040} \div CNR_{500} \rightarrow CORINE\ 1990_{040}$

3. Results

The first obtained results, show a great reduction of forest extensions after the Second World War, in a quite justifiable way. This collapse could be coherent with the extinction risk found for different animal species linked to forestal ecosystems (e.g. Corsican Red Deer, Fallow Deer,

Golden Eagle). Table 2 shows the results from the analysis, giving evidence to the consistent decrease occurred between '30ies and '60ies, according to Falcucci et al. 2007 for Sardinia.

Table 2. First results from map comparisons.

Cartographic data	Forest extensions	%
Milizia (1930-35)	2,473.9 km^2	
CNR-TCI (1952-60)	1,911.9 km^2	- 22,7
Corine Land Cover IT (1990)	3,853.5 km^2	101,6
Corine Land Cover IT (2000)	3,879.2 km^2	0,7
Corine Land Cover Sar (2008)	5,034 km^2	29,8
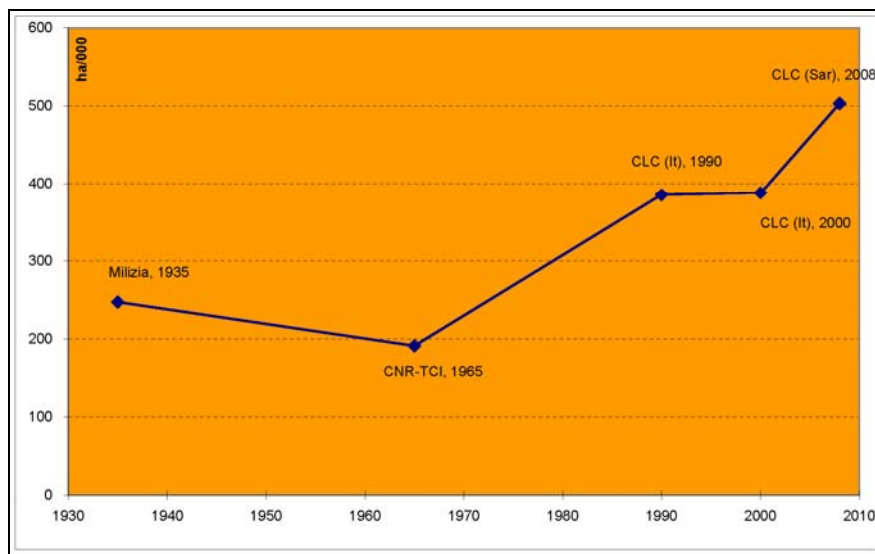
Figure 1. Forest contraction/expansion trend in Sardinia during the twentieth century.

Analyzing maps, two by two, with crosstab operation, Forest Map 1930-35 had much more similarities with CLC-1990 map than with CNR-TCI-Catasto map 1952-1960, in spite of the less elapsed time (for crosstabulation results, see Figure 2).

Figure 2. Results of crosstabulation between map

Recurring to other sources of information analysis, with a particular reference to National statistics and forest studies about Italian southern regions (D'Autilia et al. 1967; Merendi 1954; Quattrocchi 1950; IFN 1985) an alternative scenario can be delineated, in which the extensions have not decreased (Table 3), but, on the contrary, they show a slow and constant increase as Figure 3 shows.

Table 2. Other results from comparison between historical maps and inventory and statistical data.

Cartographic data	Forest extensions	%
Forest Map (1930-35)	2,473.9 km^2	
Merendi (1954)	2,956.4	19,5
1° National Inventory Forest	2,925 km^2	-1,1
Corine Land Cover IT (1990)	3,853.5 km^2	101,6
Corine Land Cover IT (2000)	3,879.2 km^2	0,7
Corine Land Cover Sar (2008)	5,034 km^2	29,8
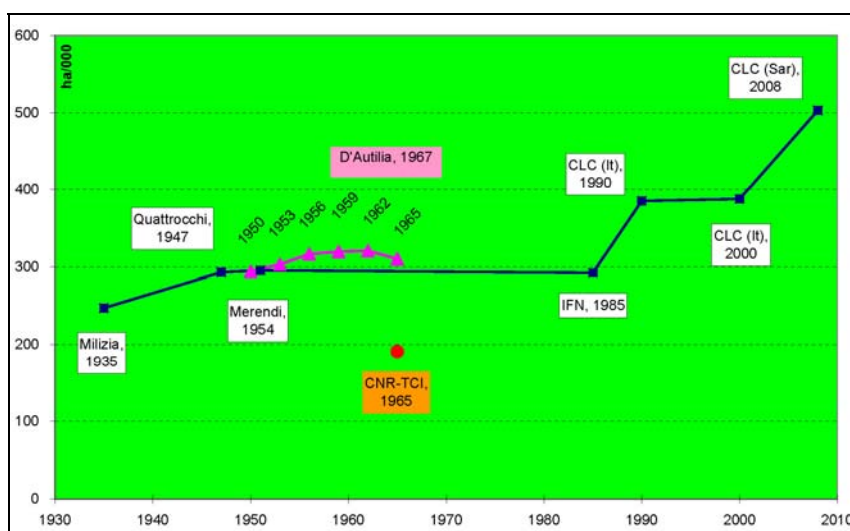
Figure 3.Forest expansion trend in Sardinia during the twentieth century.

4. Discussion

If these interpretation analysis is correct, forests in Sardinia remained constant or increased along twentieth century, because of the main law on Forests (Law 3267, 1923) that imposed an accurate direct management of forests. According to what is reported in Beccu, 2000, Sardinia, before 1877 (when a permissive law on woods-cut was delivered) had more than 4,000 km^2 of woodland that actually seem to be fully restored.

Table 3. Comparison between forests datasets in Sardinia

Beccu, 2000 (woodland at '800)		Forest Map, 1930-35		CLC Sardinia, 2008	
Forest	4,2566 km^2	Forest	2,473.9 km^2	Forest	5,034 km^2

The most known picture of Sardinia in terms of landscape, is linked to pastoral customs and habits, in which the aesthetic component is the diffusion of pasture land, and the increase of forests implies a strong environmental change that have to be taken into account in territorial planning strategies, since it'll lead to the new ("old") forest issue of relation between pasture and wood. Given that, in less than a century, the biological and ecological drives led forest systems to occupy spaces and territories (when these would be able to support forest growth), then a remark on "Habitat Directive" model in Sardinia (but also in Mediterranean basin) is due since a wide protection is reserved to semi-natural open areas, derived from (continuous) anthropic rehashing, even to the detriment of woods. If the dreaded destruction of forest habitat seems not to be occurred in 60's, as several Authors identified as the main cause of extinction and/or reducing in animal biodiversity on the Island, then the reasons of this extinction should be better analyzed and understood (e.g. trespassing, agriculture industrialization, urban expansion, industrial development).

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Multi-scale analysis of carbon stocks and deforestation monitoring – Case of the Eastern tropical humid forest of Madagascar

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Abstract

Carbon accounting and deforestation monitoring constitute the most important instruments in implementing the Reducing Emission from Deforestation and Degradation (REDD) mechanism in developing countries like Madagascar. Furthermore, most of the researches and calculations have been established at different scales. The present research develops a methodology to assess the aboveground biomass at a large scale through vegetation indices. Thus, biomass inventory in the field provides data for calibration and classification of the Normalized Difference Vegetation Index (NDVI) combined with the Enhanced Vegetation Index (EVI) on Moderate Resolution Imaging Spectroradiometer Image. The results demonstrate that NDVI and EVI provide an accurate classification of forest carbon at a large scale. Moreover, the use of vegetation indices enables the replication of the classification over time, useful for the detection of changes and the establishment of a deforestation baseline.

Keywords: vegetation indices, tropical humid forest, deforestation monitoring, carbon accounting, Madagascar.

1. Introduction

The estimation of this last decade shows that tropical forests represent 25% of the terrestrial biosphere's carbon (Bonan, 2008). This forest ecosystem plays a very important role in the global carbon cycle by storing about 80% of all above-ground terrestrial organic carbon (IPCC, 2001). For this reason, the United Nations Framework Convention on Climate Change (1998) and its Kyoto Protocol (2003) recognized the role of forests in carbon sequestration. In this way, the deforestation and degradation processes in tropical regions become more and more important: land conversion is the main reason for 93.4% of the annual net forest loss (FAO, 2001). The Bali Action Plan, adopted by UNFCCC at the thirteenth session of its Conference of the Parties (COP 13 – 2007), mandates Parties to negotiate a post 2012 tool, including possible incentives for forest-based climate change mitigation actions. This COP 13 has adopted a decision on "Reducing emissions from deforestation and degradation in developing countries" and encourages Parties to explore a range of actions, identify options and undertake efforts to address the drivers of deforestation and forest degradation. Moreover, it points out the need of methodologies related to REDD emissions reporting.

Satellite remote sensing technologies are currently widely tested and suggested as a tool in REDD monitoring, reporting and verification. However, there is a debate as to the overall feasibility and cost-benefit ratio of remote sensing approaches, depending on the wide range of

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ecosystem and land use conditions as well as the range of approaches to carbon credit accounting (Holmgren *et al.*, 2008).

This study is carried out in the tropical humid forest of Madagascar which is located in the eastern part of the island. The objective is to propose a methodology of upscaling process in deforestation and degradation assessment through satellite images (different resolutions) analysis and biomass inventory in the field. A spatial modelling approach is applied to search specific factors correlated to biomass stock, to identify vegetation indices in order to simulate the forest area across large regions, and to estimate the deforestation trend.

2. Methodology

2.1. Study area

Madagascar should be considered among the highest conservation priorities (Myers, 1988; McNeely *et al.,* 1990; Mittermeier *et al.,* 1992). However, the poverty remains one of the main causes of deforestation and degradation. The average income is around $200 per year (Population Reference Bureau, 1992). Moreover, more than 70 % are from the rural regions which are facing low agricultural productivity (CIA, 2009). These situations have led to a continuous deforestation and degradation process in the whole country.

The eastern part of Madagascar is characterized by a tropical humid climate with over 2000 mm mean rainfall per year and about 26°C annual mean temperature. The vegetation of this region is divided into three primary categories corresponding to elevation bands: "lowland rain forest" (0 to 800 m), "moist montane forest" (800 to 1,300 m), and "sclerophyllous montane forest" (1,300 to 2,300 m) (White, 1983). The third category is not considered in this study due to its limited repartition (the patches are to small to be evaluated in a 232 m * 232 m pixel of MODIS).

There are some general trends in forest characteristics with increasing elevation: decreasing stature, fewer straight unbranched and boled trees, less stratification, more epiphytes, more bryophytes and lichens, a better developed and more diverse herb layer, and floristic changes (Lewis *et al.* 1996). Dense evergreen trees characterize the lowland forest up to 800 m, with a canopy exceeding 30 m. The mid-altitude moist forest is as rich in species as the lowland forest, but tends to have a shorter canopy of 20 to 25 m.

The main threat is from subsistence agriculture through slash and burn activities ("tavy") and illegal logging which are the main causes of deforestation and degradation (Humbert, 1927; Rauh, 1979; Jolly and Jolly, 1984; Sussman *et al.,* 1985; Jenkins, 1987).

All of these aspects make REDD monitoring, reporting and verification very important for the country by creating clear and simple methods and tools to evaluate deforestation threat across a landscape especially for policy makers and forest managers.

2.2. Biomass and forest carbon accounting

Biomass is defined as "*organic material both above-ground and below-ground, and both living and dead, e.g., trees, crops, grass, tree litter, roots etc.*" (Samalca *et al.,* 2007). The IPCC (Intergovernmental Panel on Climate Change, 2003, 2006), has defined five different carbon pools for Greenhouse Gas (GHG) inventory : (1) living above-ground biomass (AGB), (2) living below-ground biomass (BGB), (3) dead organic matter in wood (DOM), (4) dead organic matter in litter (DOM), and (5) soil organic matter (SOM). Biomass is converted into carbon by multiplying its weight with a carbon fraction of dry matter which is usually 0.5 (IPCC, 2006).

Many biomass estimation researches are focused on above-ground forest biomass (Aboal *et al.*, 2005; Kraenzel *et al.,* 2003; Laclau, 2003; Losi *et al.,* 2003; Rakoto Ratsimba *et al.,* 2010) because it represents the majority of the total biomass.

This study focuses on the link between the assessment of above-ground forest biomass based on Rakoto Ratsimba *et al.* methods (2010) and recorded vegetation indices on satellite images.

2.3. Stratification and randomized plot based sampling

Rakoto Ratsimba et *al.* (2010) in their study on deforestation and degradation show that the differentiation between "low degraded forest" and "degraded forest" is possible in tropical

humid forest with SPOT 5 image. Their remote sensing analysis was combined with biomass inventory relating the difference between the carbon stocks between the two classes. It also demonstrates that this situation was possible at small scale analysis (SPOT images cover about 60 km * 60 km area). However, it is not always possible to cover the whole country with SPOT image (problem of cost) for the change monitoring. In this way, this research is dealing with lower resolution image in the South East part of Madagascar as test region (see Figure 1):
- a preclassification is realized on a Landast-7 ETM+ 2005 image to have the different forest type according an *a priori* classification : "low degraded forest" and "degraded forest". The other land use is only put in a "non forest" class including the different secondary formations,
- a biomass inventory through Rakoto Ratsimba et *al.* (2010) methods is realized with a local allometric equation establishment (through tree based sampling and wood density analysis) and a randomized plot sampling (see Figure 1),
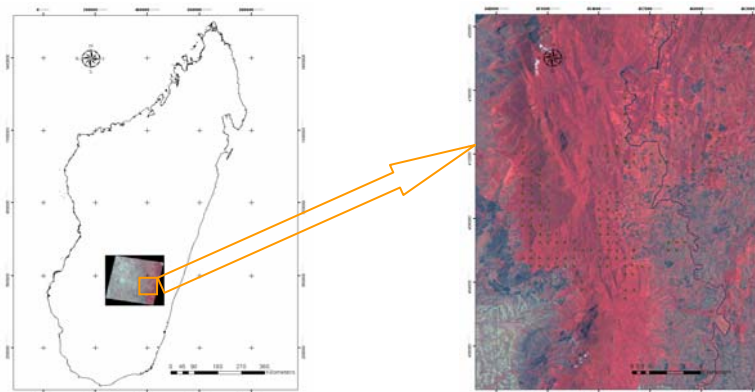
Figure 1: Test site (left) and distribution of the biomass inventory plots (right)
Landsat 7 ETM+ 2005, composite image RGB: 4 – 2 – 1
Projection: Laborde (Hotine Mercator Oblique) – Ellipsoïde International 1924

- a correlation between the biomass plot stock and value of vegetation indices is set up. In fact, this correlation is not possible with Landsat image because of sensor problems (black pixels throughout the image). Thus, Normalized Difference Vegetation Index (NDVI) combined with the Enhanced Vegetation Index (EVI) of Moderate Resolution Imaging Spectroradiometer (MODIS) Image (see Figure 2) are derived from the same period of the biomass inventory (2009). The Figure 2 summarizes the research approach.

3. Result

3.1. Forest biomass stock variation

The assessment of carbon stocks in the field shows that due to the accuracy of the stratification, the biomass stock is very low (4 t/ha) but can reach over 500 t/ha (at plot scale). It shows that the above-ground biomass estimate uncertainty is attributed to stratification error in this phase of the methodology. It is related to the spatial resolution of Landsat and the time period difference between the image (2005) and the biomass inventory (2009). In fact, the distribution of the points in the Figure 4 illustrates that the vegetation indices have not significant variations and gives the default value for the classification of NDVI and or EVI image.
Thus, assessing above-ground biomass using vegetation indices derived from MODIS image proved that monitoring carbon at large scale is possible. The Figure 5 shows the map derived from the combined classification from EVI and NDVI. Data from the fields indicate that this map is corresponding to forest that has 126 ± 12 t/ha stocks of carbon.
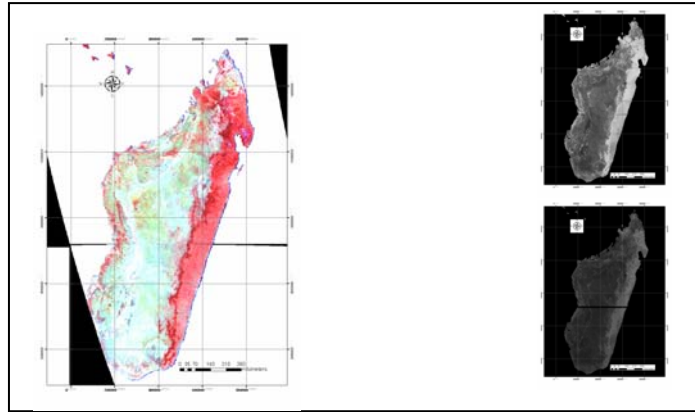
Figure 2: (1) MODIS (left) mosaic composite image RGB 2009: 3 – 2 – 1 (2)
derived EVI image (up right) and (3) derived NDVI image (down right)
Projection: Laborde (Hotine Mercator Oblique) – Ellipsoïde International 1924
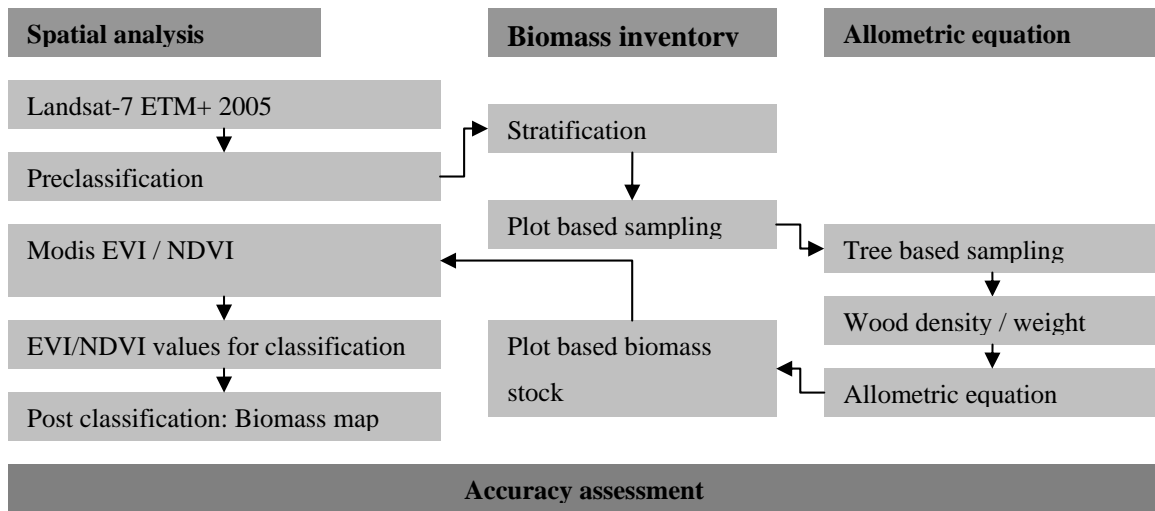
Figure 3: Research Approach
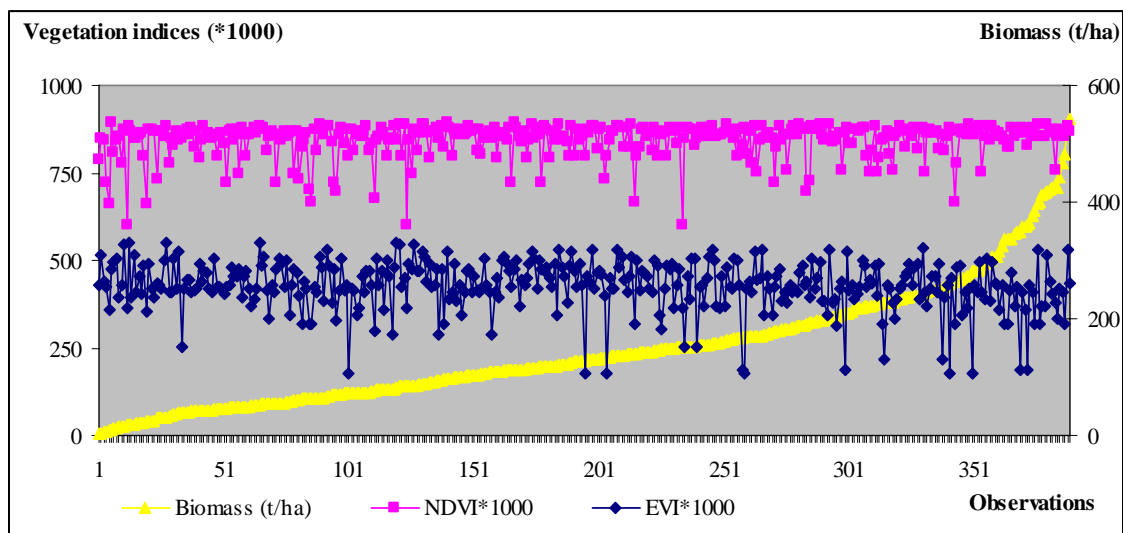
Figure 4: Repartition of NDVI and EVI with plot biomass stock

4. Discussion

Although deforestation occurs in practically all developing countries (FAO, 2006), the actual rate of deforestation makes REDD initiatives more and more important to maximize reductions of greenhouse gases. In this way, it is important to create methodologies to assess and to monitor the deforestation and the carbon stock together. The REDD initiatives suppose that countries has to be able to assess both degradation and deforestation processes. However, the degradation analysis seems to have some limitations regarding the cost effectiveness of the methodology. Rakoto Ratsimba *et al.* (2010) have shown that this kind of assessment is possible at a small scale (local level) while the upscaling process demonstrates that only deforestation monitoring is possible over large areas. It is due to loss of spatial accuracy (the diversity of value of 23 * 23 pixels of SPOT image are included in a single pixel of MODIS image).

This study reports that it is possible to report a forest map through biomass stock assessment. It gives the opportunity for policy makers to have not only the total area of the forest (2 754 905 ha for the humid forest of the Eastern of Madagascar), but also the mean carbon stock per area (126 ± 12 t/ha) (see Figure 5). If we refer to other studies done in the region, Sussman *et al.* (1994) estimated the forest area of the region at 3 800 000 ha in 1985. Moreover, the same assessment can be done in other images (2000 for example) in order to model the deforestation process. The accuracy assessment gives a total value of 28,85 % which is an acceptable value regarding other carbon assessment (Samalca et *al.,* 2007 – 41,27 % ; Rakoto Ratsimba *et al.,* 2010 – 31,35 %). Thus, depending on REDD objective in Madagascar and the country priority, a small scale or larger scale initiative could be implemented.
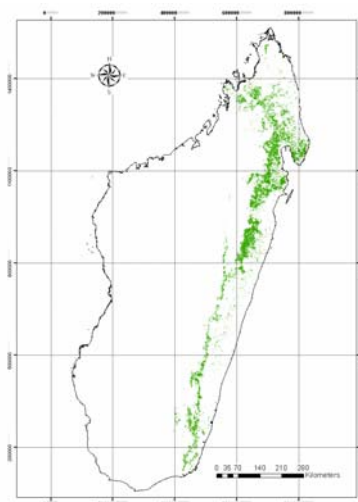
Figure 5: Forest map of the Eastern Humid Forest of Madagascar (biomass stock 126 ± 12 t/ha) Projection: Laborde (Hotine Mercator Oblique) – Ellipsoïde International 1924

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Characterization of a *Maculinea alcon* population in the Alvão Natural Park (Portugal) by a mark-recapture method

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Abstract

The blue alcon, *Maculinea alcon* located at the Alvão Natural Park was studied by mark-recapture methods in order to estimate population size and flight range of the butterflies. Sampling was made between 2007 and 2009. The results showed that maculinea population size has increased along the studied period with an estimated density at the peak of the flight period of 190 butterflies in 2007, 392 in 2008 and 1653 in 2009. The number of captured males was higher at the beginning of the flight period while females increase gradually over the flight period. The average value of the sex ratio was 0.9 in 2007, 1.4 in 2008 and 1.2 in 2009. The flight range of the butterflies did not show significant differences between sexes and an average value of about 12 m were recorded. Thus the results indicate that this population is in expansion and not threatened by extinction.

Keywords: Maculinea alcon L, population estimate, mark-recapture method

1. Introduction

As a result of their extraordinary life cycle, Maculinea butterflies are typical representatives of the most threatened species in Europe (Wynhoff 1998; Mungira and Martin 1999; Van Swaay and Warren 1999). Like most other Lepidoptera species, *Maculinea alcon* lays the eggs on a selected host plant, the *Gentiana pneumonanthe*. However, caterpillars do not complete development on the plant. Instead they are voluntarily carried by Myrmica ants to their nests. Once in the nest, caterpillars are fed by the ants until complete larval development (Thomas 1995). Thus, protecting the butterfly is protecting the whole complex systems because, both the host plant and the ant nests are essential for the successful development of *Maculinea alcon*. In Portugal, the Alvão Natural Park is the only known place where is it possible to see *Maculinea alcon* flying. In the past, several populations of the blue alcon were reported by local people but with the habitat fragmentation and abandonment of extensive management many of those populations disappeared. However, there still exist some small populations that need to be studied. Therefore, the population density, the probability of survival and the dispersal ability are important study population features that can lead to programmes of conservation. In this study we examined population size, sex ratio and movements that characterize a *Maculinea alcon* population located at the Alvão Natural Park, which is a part of a Site of Community Importance (SCI) for the Mediterranean biogeographical region, listed in 2006 by the European Commission.

2. Methodology

The method of repeated marking-release-recapture was used during June, July and August between 2007 and 2009 in order to estimate the parameters characterizing the maculinea population. This method consists in the capture of as many individuals as possible. Each captured adult was sexed and market with a number on the underside of the right hind wing, using a black permanent pen. Immediately after that, the butterfly was released at the same point of capture. After three days, sampling was repeated and the basic parameters of population dynamics were estimated on the basis of the rate marked *vs* unmarked *M. alcon* captured. Number of sampling days varied along the studied years. Jolly-Seber method was used to estimate population size and survival probability on those years. In 2009, at each point of capture and recapture, GPS coordinates were recorded and used to calculate the flight range of the butterflies.

3. Results

In 2007, the capture took place between 11 to 31 July and a total of 265 butterflies were marked, 154 males and 111 females. Of the market butterflies, 70 (26.4%) were recaptured only once and 8 (3.0%) were recaptured twice during the sampling period. The recapture rate was 29.4%. In 2008, a total of 263 were marked between 14 July and 7 August, 141 males and 122 females. Only 17 of the total market butterflies were recaptured (6.5%). In 2009, 566 butterflies were marked between 13 July and 10 August with 318 males and 248 females. Of the market butterflies, 43 (7.6%) butterflies were recaptured only once and 2 butterflies were recaptured twice. Sex ratio was calculated for each sampling day (see Figure 1). Results showed differences in the way males and females behave during the study years. The total number of captured males was higher than females during the studied years. However, the sex ratio varied across the sampling days. Although in 2007 the sex ratio was always higher than 1, favourable to males, the rate of females increased gradually which could be registered on the last two years with an inversion of the sex ratio at the middle of the flight period with more females after 24 July. The result of the population size indicates that *Maculinea alcon* population has gradually increased along the study period (see Figure 2). In 2009, at the peak of the flight period, the estimated number of the butterflies was four times higher than in 2008 and even higher than in 2007. The flight range of the butterflies measured by using capture and recapture GPS coordinates (see Figure 3) showed that from the 43 recaptured butterflies in 2009 only 14 moved more than 0,05m (5 males and 9 females). On average, distances of about 11.7±3.2 m were recorded with maximum values of about 80 m with no significant differences between males and females flight range (F=0.13; gl=43; Sig=0.911).

4. Discussion

Results showed differences in population characteristics across the studied years. Although the beginning of the flight period were almost the same (second week of July), the end differed between years with a shorter flight period in 2007. This could be due to weather conditions which was very rainy in the beginning of August 2007. Also, differences were obtained for sex ratio and behaviour characteristics of males and females. In the last two years, the rate of females increased gradually and the approximately 1:1 sex ratio was observed in the last third of the flight period. This is important in the balance of the population because at the beginning of the flight period the host plant used by females to lay the eggs is not flowering yet and that can compromise the success of larvae development. Identical results were obtained by Árnyas *et al* (2005) in a *Maculinea rebeli* population in Hungary. The mobility results of the butterflies indicate that their dispersal ability is very low. According to Thomas (1991) this could be a serious problem for their survival in the modern European landscape. The ability of dispersion

is very important in the successional habitats that this species inhabits (Johnson 2000). When the habitat becomes unsuitable it is necessary migration movements and available suitable sites within very short distances are desirable

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Acknowledgement

Figure 1: Sex ratio for each sampling day in 2007, 2008 and 2009
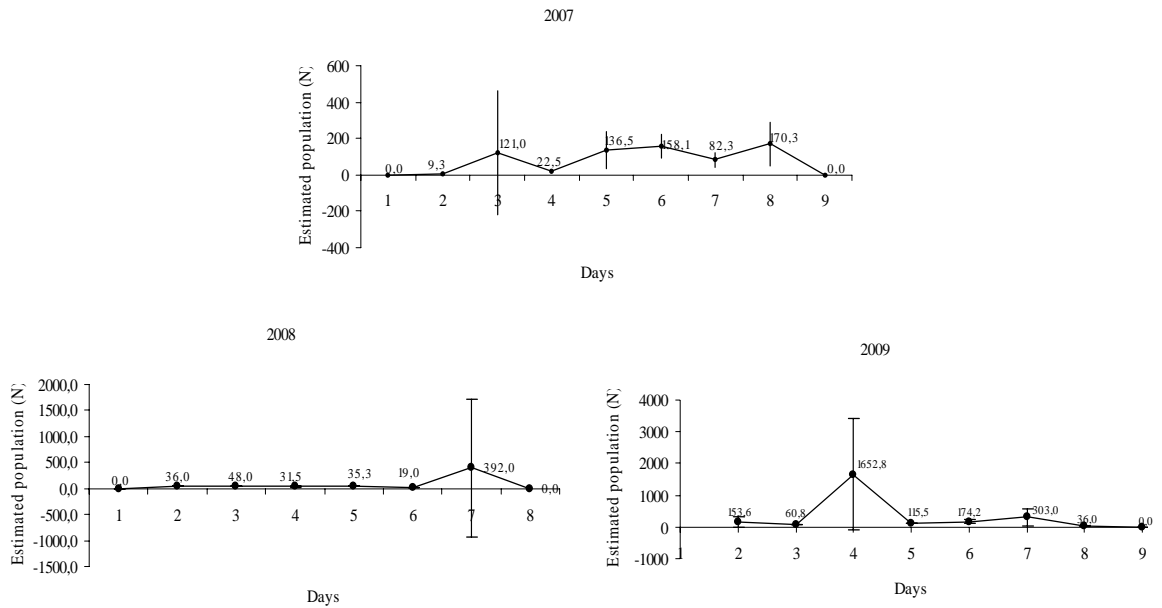
Figure 2: Estimates of the number of individuals and standard error of estimation in 2007, 2008 and 2009 by the Jolly-Seber method.
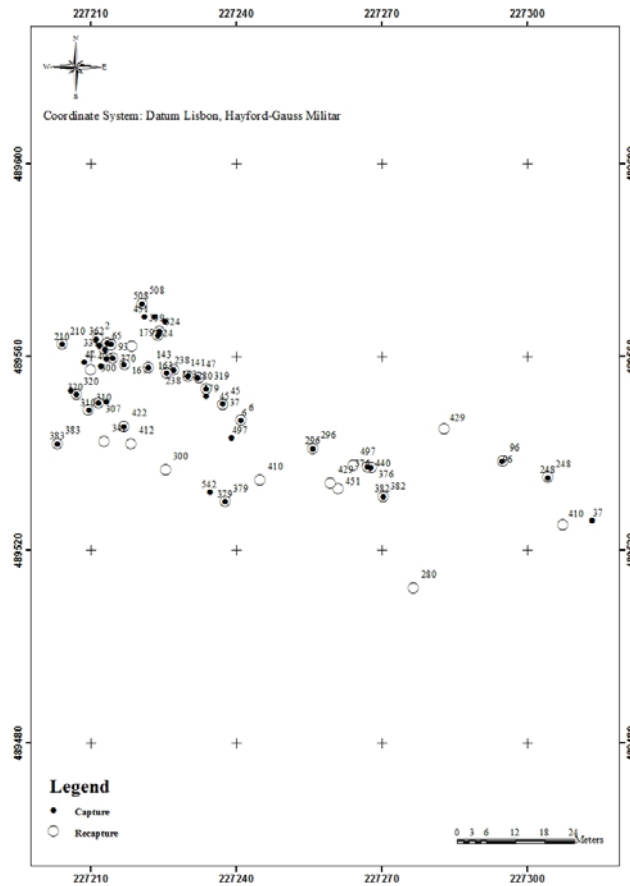
Figure 3: Capture and recapture coordinates used to calculate dispersal ability of *Maculinea alcon* butterflies.

Landscape changes in a watershed in the southwest of Portugal

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Abstract

Over the centuries human intervention has altered the landscape of the south of Portugal, the most dramatic changes having taken place during the last one hundred and fifty years: the dominant component of the landscape has changed first from natural/semi-natural shrubby communities to cereal crops and later to oak tree montados through processes of farmland abandonment, reforestation, change in the type of crops and trees grown, cutting or burning. All of these changes affected landscape composition and configuration and thus the functioning of natural systems.

The objective of this paper is to study landscape dynamics of a watershed in the southwest of Portugal over a century, using data from different time periods and the consequences of changes. Within the context of a GIS land-use changes were quantified through the analysis of land use maps and ortophotomaps.

Keyword: Land cover change, landscape

1.Introduction

Human intervention significantly altered the landscape of southern Portugal, the primitive forests having disappeared long ago. The landscape of the South of the country suffered major changes in its structure and composition over the past 150 years. In the late nineteenth century the landscape matrix essentially consisted of shrublands (Feio 1998). From that date on significant modifications that contributed decisively to soil degradation occurred. Successive campaigns to promote the production of cereals in the first half of the twentieth century led to a sharp increase of the cultivated area at the expense of farming on unsuitable land: steep slopes, rocky soils, shallow and of low infiltration capacity. As Feio (1998) points out, within a time period of about 50 years the shrublands almost disappeared from the landscape of southern Portugal while at the same time the plowed area with grain duplicated.

However, crop cultivation on unsuitable land led to intense erosion which in short time conditioned new sowings and consequently led to the abandonment of the sites less apt for agriculture or its replacement by other forms of soil use. Thus, "Carta Agrícola e Florestal" for the decade 50-60, shows that in areas of steeper slopes, agriculture had been replaced by forests (montados) or left abandoned, leading to a progressive recovery of the natural vegetation. In the 70s there was a strong expansion of the eucalyptus culture. In most cases, the deployment of plantations was not well conducted, which once again led to soil degradation. From the 90s on a tendency for the abandonment of cultivation of eucalyptus began to occur, or at least a lack of significant new investments due to the low economic profitability.

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2. Methodology

2.1 Study area

The area selected for this study corresponds to the watershed of Ribeiro do Canas, a sub-basin of the Sado River Basin (Fig. 1). It is small a watershed (5335 ha) that corresponds to about 0.8% of the Sado Basin. The climate is mediterranean with average annual temperature being approximately 16.3 °C and annual precipitation around 575 mm.

According to the biogeographic map of Costa *et al*. (2002) the territory in analysis is included in the Mediterranean West Iberian Province (Lusitan-Extremadurean Subprovince, Marianic-Monchiquensean Sector and Baixo Alentejano-Monchiquense Subsector). The head of the natural potential climatophillous vegetation series consists of the association *Pyro bourgaeanae-Quercetum rotundifoliae* that is, sclerophyllous forests dominated by Holm Oak (*Quercus rotundifolia*). The regressive succession consists of three stages. The first substitution stage of the forests (*Hyacinthoido hispanicae-Quercetum cocciferae*) is dominated by Kermes Oak (*Quercus coccifera*); the next regression stage consists of shrublands *Retameto sphaerocarpae-Cytisetum bourgaei*; a scrub community dominated by Gum Rockrose (*Cistus ladanifer*), the association *Genisto hirsutae-Cistetum ladaniferi*, represents the maximum degradation stage (Costa *et al*. 1998).

The changes that occurred in part of the study area, namely alongside Ribeiro do Canas, can be observed on aerial photographs from 1947 (Fig. 2A) and 2004/05 (Fig. 2B). In 1947 even the most steep terrain was then cultivated with cereals. Only some scattered ork oak treas were left. It can also be observed that at that time riparian vegetation had been largely destroyed. In 2004/05 a remarkable recovery not only of riparian vegetation but also of vegetation occupying the slopes can be noticed. An increase in biomass and structural diversity of plant communities is clearly evident. Nowadays the progressive succession has led to the appearance of tall shrub communites dominated by Kermes Oak, that is to say, the vegetation has almost reached the climax stage.

2.2 Methods

Land cover of the study area was characterized for four time periods: 1895, 1963, 1990 and 2004/05. Land cover was obtained by digitizing existing maps in analogical format for 1895 (Carta Agrícola) and 1963 (Carta Agrícola e Florestal) and color orthophotomaps for 2004/05. Land cover for 1990 already existed in the form of a polygon shapefile (Carta de Ocupação do Solo). Eight Land Cover classes were considered: Agriculture, Forest, Semi-natural vegetation, Bare soil, Water, Urban, Eucalypt plantations and Olive stands and Orchards. However, the last five classes had areal percentage values always fewer than 4% during the time period of analysis and will not be presented in this paper.

A Digital Elevation Model was produced which allowed the determination of slope, solar radiation and topographic wetness index (Beven and Kirby 1979). The information from these biophysical parameters was intersected with the information of land cover. All the analysis were performed in ArcGis 9.2 (ESRI) except the computation of solar radiation which was performed in ArcView 3.2 (ESRI) using the extension Solar Analyst (Fu and Rich 2002).

3. Results

The changes in land cover of the study area, over time, referring to the three most representative classes are presented in Figure 3. It can be observed that the study area witnessed the most important alterations between 1895 and 1963 while it changed less markedly from 1963 to 2004/05. It may also be noticed that the "matrix" of the landscape, which consisted of the class Semi-natural vegetation in 1895, changed to Forest thereafter.

The Semi-natural vegetation in 1895 occupied most of the watershed (65%), having suffered a dramatic decline between 1895 and 1963. Henceforth this land cover class did not undergo considerable changes, constituting about 5% of the study area. As regards Agriculture, this class occupied then a very low percentage of the area (about 2%) and, within 68 years, it increased substantially, reaching 29%. From 1963 to 2004/05 this class knew a decrease in its representativeness, more significant between 1990 and 2004/05. In the latter date the agricultural areas made up about 17% of the total area. The class Forest had a marked increase between 1895 and 1963, an insignificant decrease from 1963 to 1990 and a considerable increase between 1990 and 2004/05.

In Figures 4, 5 and 6 an analysis of land cover by biophysical parameters is presented. Agriculture in general was practiced in less steep terrain. By contrast, semi-natural vegetation, except in 1895, occupied areas with more pronounced slope. The Forests were always located in all slope classes. In 1990 and 2004/05 semi-natural vegetation occupies, to a large extent, areas with high soil moisture content. Overall, agriculture is not practiced in areas with high soil moisture. In general semi-natural vegetation occurs in areas receiving low radiation.

4. Discussion

The landscape transformations described in the present study are consistent with those that occurred in the south of the country, portrayed in various studies by other authors. After agriculture abandonment in the less suitable areas shrub cover increased. Semi-natural vegetation at present occupies areas that receive a smaller amount of solar radiation and to a considerable extent areas of high moisture availability. That is to say, vegetation has mainly recovered along the steep slopes of the rivers. These communities are structurally compex and consist of tall shrubs typical of the potential vegetation. This aspect has important consequences at the landscape level as these communities may constitute ecological corridors and thus allow the increase of diversity.

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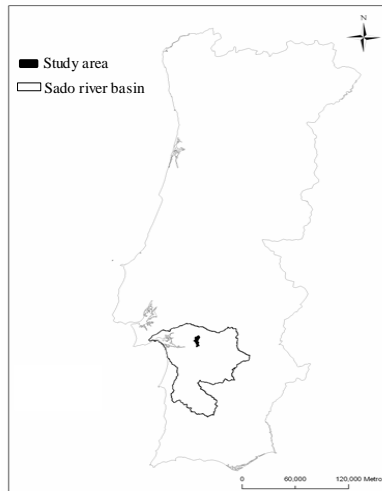
Figure 1: Location of the study area
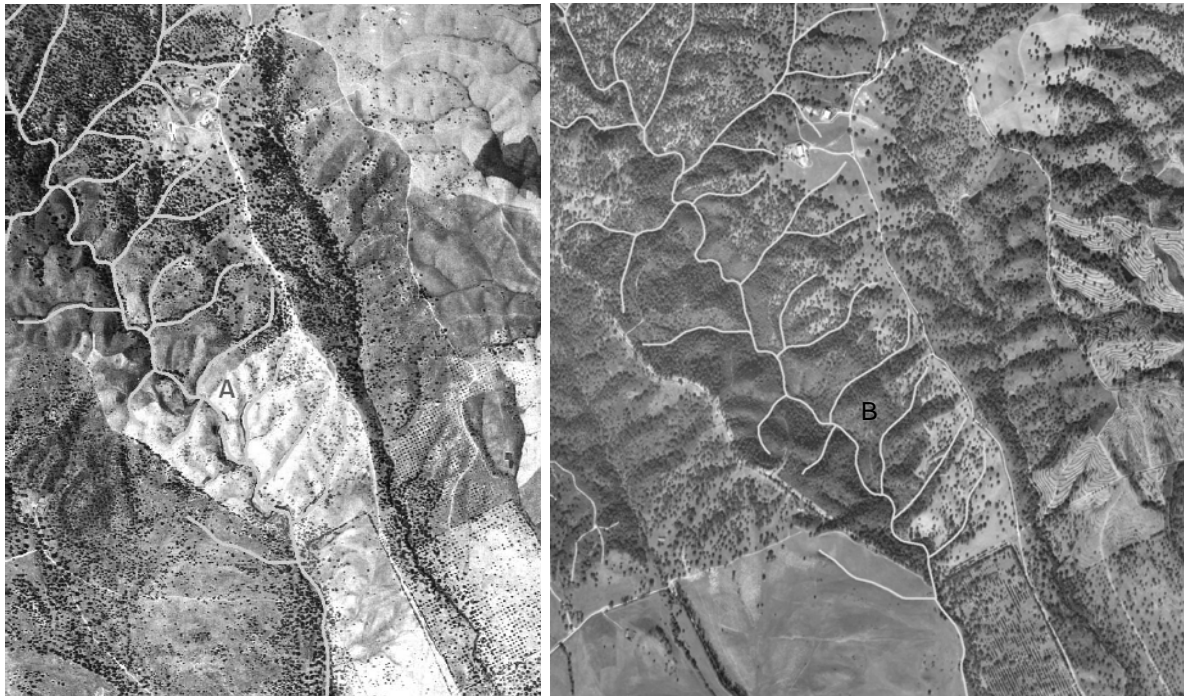
Figure 2: Part of the study area in 1947 (A) and in 2004/05 (B)
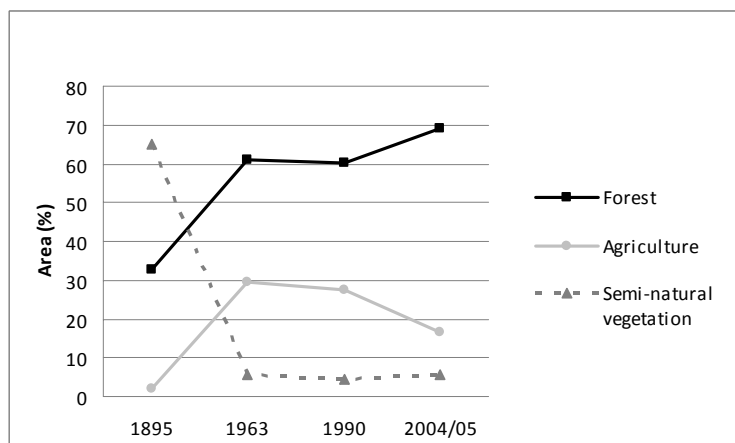
Figure 3: Land cover changes of the three most representative land use cover classes.
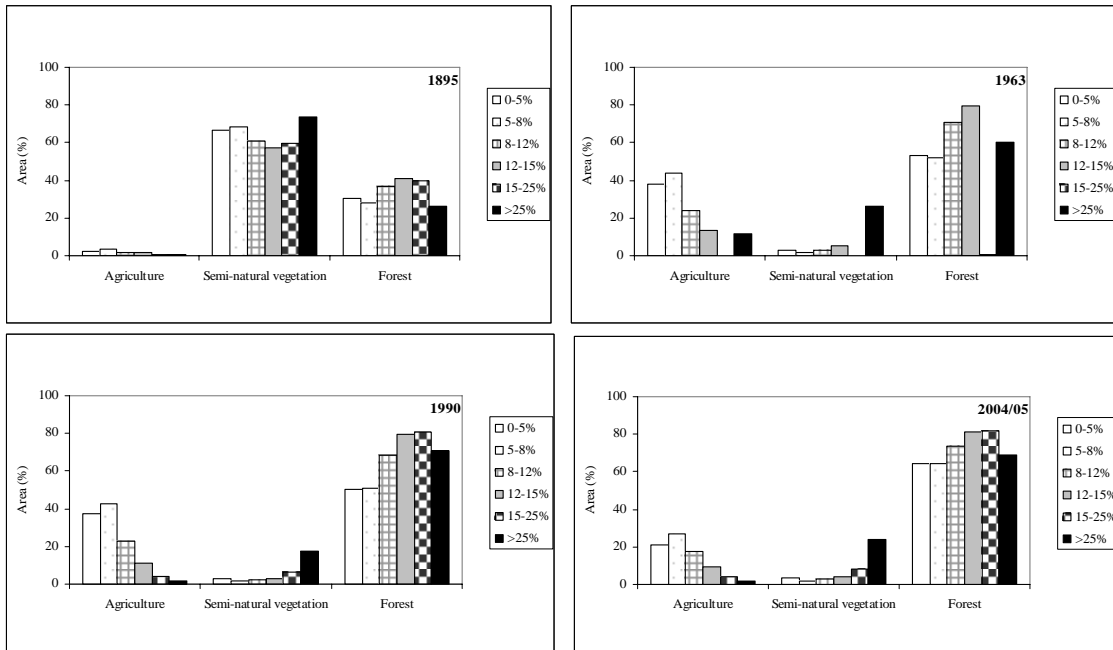
Figure 4: Slope values by land cover class.
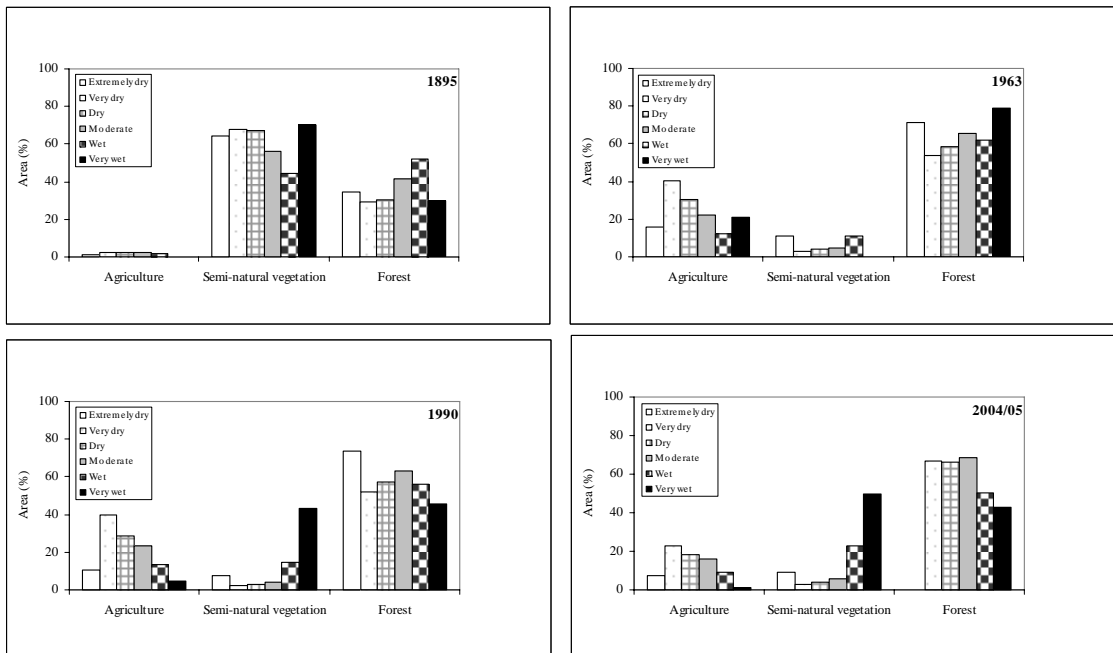
Figure 5: Topographic wetness index by land cover class.
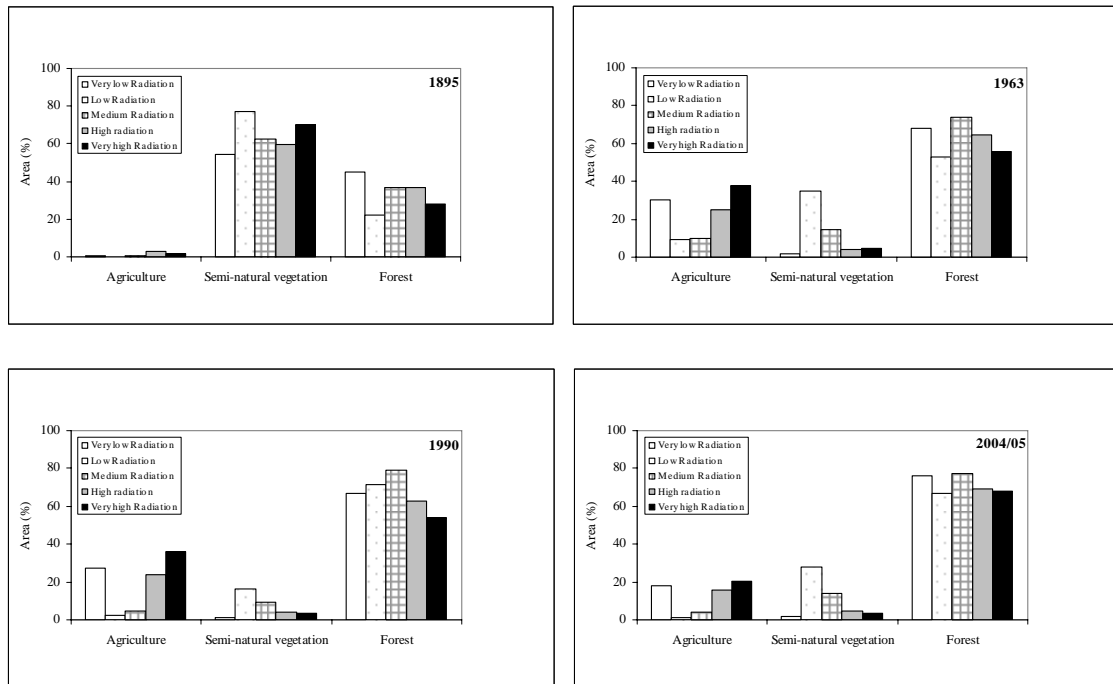
Figure 6: Solar radiation by land cover class.

Landscapes in Transition – Monitoring in Areas of Landslides

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Abstract

The satellite images have been very effective for monitoring the landscapes dynamics. Landscapes vulnerable to disasters can be monitored by change detection techniques. We applied these techniques in areas affected by landslides in November 2008 in Morro do Bau, Santa Catarina State, which led to material and human losses. The study used four images from different dates between 1992 and 2009. Vegetation index were developed using bands 7 and 4, minimizing the atmospheric and radiometric effects. The techniques used were effective to detect changes caused by the disaster, such as soil exposure and deposition; during the study period there was no deforestation in the area of landslides; the event had magnitude greater than the forests protection could promote, mainly high rainfall, combined with the high potential erosion of these mountains sediments. These landscapes are subject to natural relief accommodation events that will inevitably be disaster if associated with human occupation.

Keywords: change detection techniques; landslides; environmental disaster; Itajaí Valley; landscape dynamic.

1. Introduction

The Itajaí Basin covers an area economically very important for the State of Santa Catarina, southern Brazil. The mountainous relief prints fragility of landslides exacerbated by other regional environmental problems as water pollution, illegal occupations and sewer without treatment. Over time, with the rural exodus and urban growth, the region became even more subject to problems of burial and flooding produced by inadequate occupation of urban land and silting and contamination results in erosion and lack of rural waste treatment and urban (Schaefer-Santos, 2003).

All these changes in land cover and land use can be detected through time series of satellite images with the application of techniques of change detection. The mapping can be accomplished from the comparison of classified images, subtraction of bands of the same area at different times, vegetation indices, principal component analysis and neural networks (Carvalho Jr & Silva, 2007).

Some changes, such as the increase or decrease in forest cover, can be evaluated based on vegetation index. Caring for the use of vegetation index should be taken, especially the false changes that may be related to phenological changes, which are those that occur with various species, such as leaf drop, flowering time, appearance of new leaves in spring (Matínez & Gilabert, 2009). In a long term, these changes found may be related to climate change and large-scale disturbances antrogênicos (Bradley *et al*., 2007).

To be chosen images from similar periods of the year, representing the same seasonal cycle of the forest, the effects of phenological changes are minimized as the effects generated by the shadow of a region with rugged. Janoth *et al*. (2007) say that images Landsat–TM and SPOT XI

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showed reliable results for detecting changes in forest areas damaged by wind and snow sliding snow in Sweden and Finland. The procedures used by the authors based on the simple difference of multitemporal images of the spectral bands of red and of mid infrared and change detection pixel to pixel and neighborly relations. The mid infrared, especially, pointed to change in areas of climax forest in which there was the removal of timber, and therefore this technique very effective for monitoring forest. In this study we sought, through the vegetation index found that deforestation could be a predominant factor in landslides occurred in the study area in November 2008 which caused the death of 135 people for burial and for such were used images Landsat 5 TM.

2. Methodology

The study area is located in the Itajaí Basin, which lies between latitudes 26º20' e 27º50' e longitudes 48º40' e 50º20', extending for 150 km north to south and 155 km from east to west (Gaplan, 1988). The study area is located from the middle course of the river Itajaí, and it parts of the Middle subbacia Itajaí and part of Rio subbacia Luis Alves, encompassing the areas of disaster in 2008 (Figure 1). In the watershed area of the Rio Itajaí various formations are found among the Dense Atlantic Rain Forest and some nuclei of Araucaria Forest in the high Itajaí Valley. In the middle and lower regions of Itajai Valley, there is the Dense Atlantic Rain Forest, especially characterized by high density and high species richness of trees, saplings and shrubs, and high density of epiphytes. (Klein, 1978).
The study used 4 images as mentioned below:

1. 10/6/1992;
2. 30/6/1999;
3. 4/6/2007;
4. 1/2/2009.

The images were so selected because they are of the same month (June) acquisition, except the last. The choice of images from the same month, minimized the differences in reflectance due to the effects of phenology of forest and shade relief. The relief shading in images acquired in similar periods of the year, for example, in the same month, the shaded areas are virtually coincident, due to the similarity of the angle of inclination and azimuth of the sun. The image had to be t4 February, for not having another cloudless after the environmental disaster.
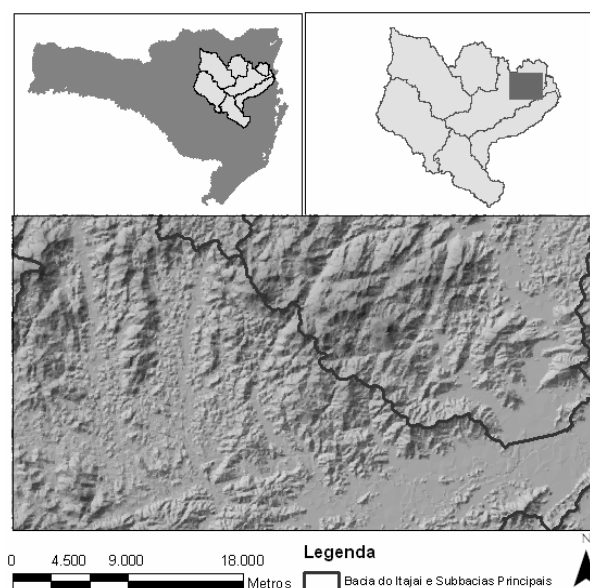
Figura 1: Study area localization.

2.1 Change Detection

The purpose of applying the techniques of change detection is within a set of pixels, identifying those that are significantly different between the first and last image in sequence (Radke et al. 2005). Select the image start (t1) and the final image (t2), where the procedure is repeated between pairs "$t_2 - t_3$" e "$t_4 - t_3$", generating three classified images (*Change Detection$_1$* – CD$_1$, *Change Detection$_2$* – CD$_2$ e *Change Detection$_2$* – CD$_3$). The classification of this study followed values change between -5 and +5. Changes close to zero (from -2 to +2) were ignored, representing "no change", and "abrupt change" were identified as increased and reduced biomass. We used the simple difference method and the percentage difference between Vegetation Index on four occasions (t1, t2, t3 and t4) as follows (1):

$$D(x) = t_2(x) - t_1(x) \tag{1}$$

Onde:
$D(x)$ = classified image by simple difference;
$t_2(x)$ = vegetation index in the final time of the analysis;
$t_1(x)$ = vegetation index in the inicital time of analysis.

3. Results

In the study area can easily locate the areas of landslides and areas with sediment deposition by staining differentiated image 4 (2009), with values close to zero, which represents a lack of vegetation. In this same place, it was observed that the vegetation index have no color differentiation mean that deforestation in the years before the landslide (Figure 2). Figure 3 shows the image obtained of the changes between 2007 and 2009 (CD 3) which can be observed in the landslide area and increasing the forest cover.
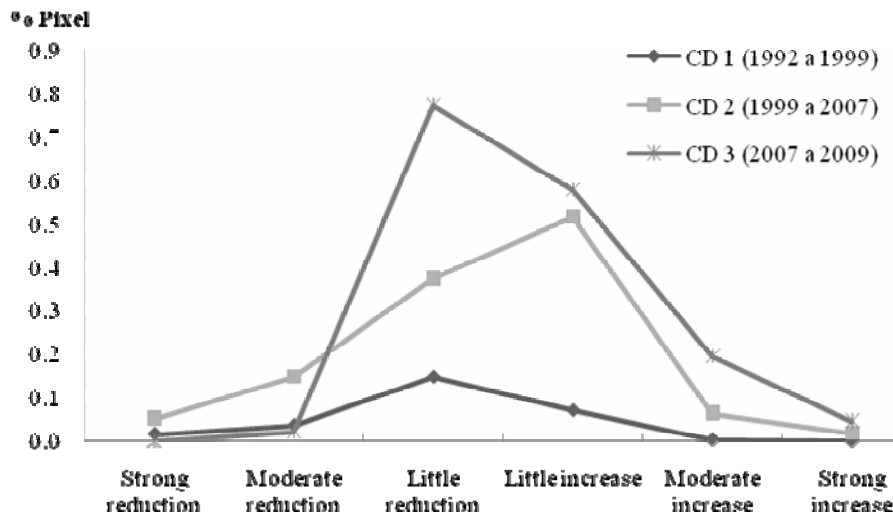
Figura 2: Change detection occurred in the area of landslides since 1992 to 2009.
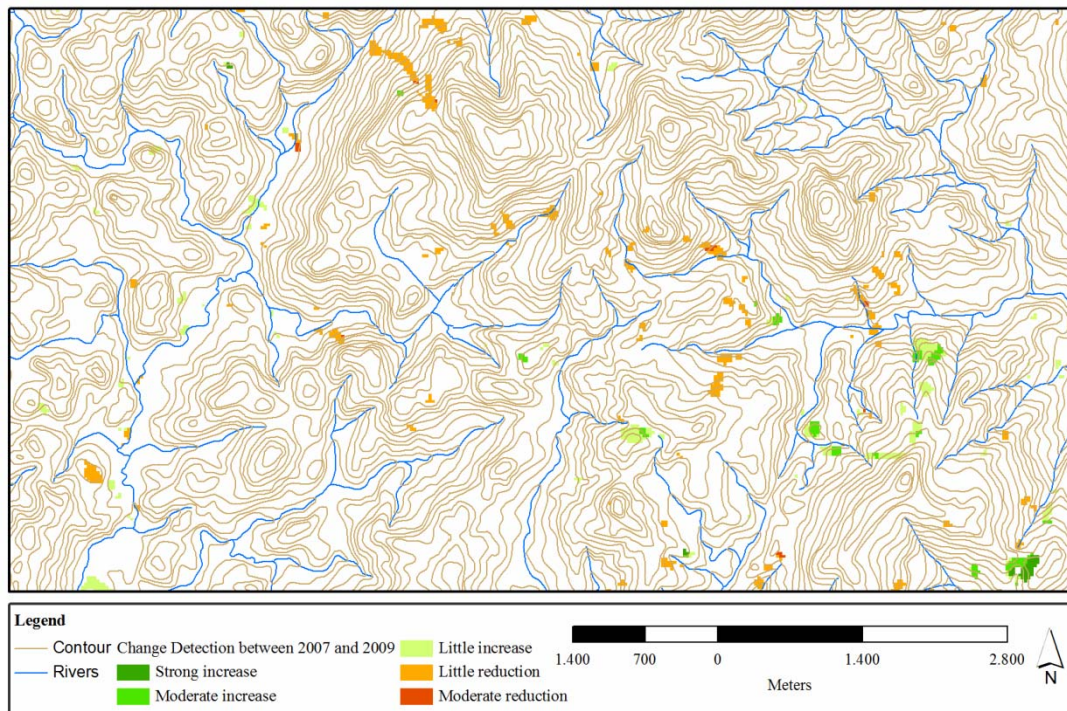
Figura 3: Change detection between years 2007 and 2009.

4. Discussion

The landscape had some changes during the study period. Over time, the study area showed an increase in forest cover (Schaefer-Santos, 2003). In this study we observed that between 1992 and 1999 (CD 1), there were small increases in forest cover and in some places, small losses (Figure 2). Moreover, it is observed between 1999 and 2007 (CD 2) that there is greater movement in the landscape, leading to an increase forest cover in general, since the displacement curve to the area gain of vegetation. Already between 2007 and 2009 (CD 3), as shown in Figure 2 and detailed in Figure 3 is possible to identify the great movement that occurred in the landscape, as areas of landslides are very clearly identified, ie, loss the area forests caused by landslides. These landslides clearly seen on Landsat TM 5 may be considered high intensity occurred in as many areas of surfaces greater than 800m in length. Among the largest, most convergence was associated with water, especially ending in rivers. In this study area, population density is low, however, the weathering mantles are very deep and very fine sediments associated with the relief and deep valleys (Gaplan, 1988), which receive large amounts of marine moisture leading to a natural process of denudation. These circumstances lead to the natural conditions for landslides. Small human changes that have occurred were not detected in this analysis. These possible anthropogenic changes certainly added to the natural conditions may have led to an increased risk factor for disasters. However, the masses of soil were soaked for 04 months due to heavy rains, which were associated with a weather system that meant that only between 21st to 22nd November 2008, occurred rainfall of 300 mm of rain in the Valley Itajaí, with accumulated of 1000 mm in November, the normal precipitation is 1.800 mm in a year (Dias, 2009). This precipitation was two times greater than the rainfall occurred in April 2010 in Rio de Janeiro, however, due to population density, in Rio de Janeiro there were about 250 deaths, as in Santa Catarina, the number was only 135 people killed due to landslides. Natural factors associated with high precipitation were prevalent for the occurrence

of landslides in Santa Catarina in November 2008, leading one to believe that these events are natural and are part of the natural transformation of the landscape.

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The process of urbanization and the environment - the case of irregular occupations in the city of Ponta Grossa, PR, Brazil

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Abstract

This article analyzes the process of urbanization as a social and historical construction, and housing problems arising from this process, through the installation of homes in illegal occupations in the city of Ponta Grossa - Paraná. Trying to understand the dynamics of this phenomenon it explores the socio spatial location as the process of degradation of the environment, researching the specifics that arise for public policy. The methods used were a literature search and document research-based Plan for Social Housing. Thus, it identifies the planning of urban space by a team of professionals from diverse fields as fundamental to promote alternative solutions with adequate infrastructure and legality for the families as well as environmental improvement projects that provide improvements to support the inclusion social and sustainability.

Keywords: urbanization, illegal occupations, environment

1 - The process of urbanization

The urbanization process is a dynamic process, arising from social relations in each historical context related changes in processes of social production and the manner of insertion of each society in general dynamics of capitalism. CASTELLS in his conception over the urban phenomenon means that the analysis of urbanization should follow the knowledge of its social process. It states that: "Explaining the social process that underlies the organization of space is not simply to place the urban phenomenon in context. A sociological problems of urbanization should consider it as a process of organization and development, and therefore, based on relationship between the productive forces, social classes and cultural forms (among which the space). " (1983, p.36)

The human world changes and transformations are becoming more intense and fast. This is also reflected in the organization of space, which is being organized as diverse and complex. Many of their reorganizations made themselves and continue to happen, given the claims of production. Thus, the area is also historic, transforming itself through the social changes occurring over time.

Urbanization has become a reality in Brazil, especially since the second half of the twentieth century, it was from the 1970s that the rural-urban ratio began to reverse the concentration of population to urban. The phenomenon of population concentration in urban areas has changed the dynamics of Brazilian society, resulting in a new lifestyle, urban style.

With differences in each region and each municipality, the phenomenon of urbanization has spread throughout the national territory. Ponta Grossa, inland city of Paraná State, was not immune to the phenomenon of urbanization. Although the Paraná be a state with a strong presence in agricultural production and Ponta Grossa have this characteristic was from the 1960s it became clear the population concentration in urban space.

In the history of Ponta Grossa, you can verify outstanding phases of development that contributed to the emergence and expansion of population and its urbanization process, as the occupation by the troopers, the construction of railroads accelerating process of urbanization, migration movements, especially foreigners, broadening the demographic structure, increasing industrialization through industrial development plans, among other factors.

Among the most significant characteristics of the municipality, is its privileged geographical position, since its emergence as a way for troopers to the installation of major highways and railroads. It is considered a major road and rail junctions in the south of the country, due to its physical location and its access roads that allow the various regions of the state and interstate.

The fact that they constitute a road-rail junction favored high density because it facilitated the transit of persons between the cities, especially those in nearby regions. In 2009, according to the IBGE, the municipality of Ponta Grossa had a population of 314,681 inhabitants. Of the total population of the municipality, the rural end-grossense corresponds to 2.54% of total population and 97.46% of the population resides in urban area.

These indices are above the national average, where 81.23% of the population is urban, which reflects on the one hand an accelerated process of urbanization and the other shows, that the city in recent decades had characterized the growth and / or maintenance a significant rural population.

Thus, the urban space becomes the venue of expression of social struggles and conflicts of the capitalist order which generate demand for the state, among them the demand for housing.

2 - The irregular occupations in Ponta Grossa and its socio-spatial

The city resulting in the spatial form of the urbanization process has as one of its most striking characteristics, diversity. The city has its own dynamics, and in this context that the social needs arise more acutely among those to housing.

The dynamics of urban social expresses itself in different forms of sociospatial structuration. Analyze how people try to solve their housing problem allows us to reflect on the factors that are engendered and which the contradictions that run through urban space.

Urbanization as a social and historical process, it expresses the logic of the use and occupation of urban land. The population demands the fulfillment of their needs to live in the urban environment. Not being met, suffer the consequences, among other factors, lack of infrastructure, competition for urban space being marked mainly by occupations public areas, which in the case of Ponta Grossa is facilitated by the relief which is very bumpy and full of streams.

Lack of access to housing has led the impoverished segments of the urban population living in subhabitações so disorderly and without infrastructure, on land belonging to the government or unoccupied areas owned by individuals. This expresses the precariousness of insertion in the labor market, not from the incorporation of the entire workforce in the formal sector of the market, favoring the inclusion of a significant portion of the population in the informal sector and underemployment, accentuating social inequalities.

In Ponta Grossa, the location of irregular occupation has a tendency to settle on the banks of streams in areas for permanent preservation, causing the destruction of riparian vegetation, thus altering the original landscape. This tendency causes many problems for environmental preservation areas and for families living in these places because often suffer life-threatening situations and unsanitary.

According to data from the Municipal Plan for Social Housing - 2010, Ponta Grossa has 8.778 housing units in the situation of illegal occupation in 162 points

distributed within the city limits, with a large percentage in the valleys, areas with no conditions for building and sanitation. On the other side also contribute to loss of biodiversity and / or change with the removal of riparian vegetation which results in pollution of local water contamination of streams, erosion of hillsides, landslides, and other factors that affect social development and conservation of natural habitat and environment.

To illustrate the situation, shown in Figure 1 to identify the illegal occupations in the urban area of Ponta Grossa.
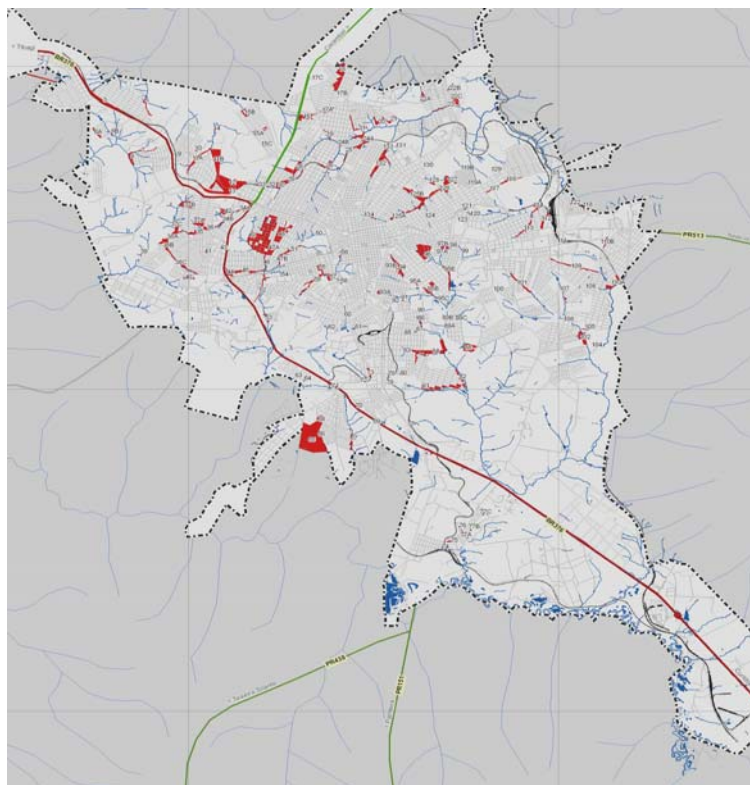
Figure 1 - Irregular occupations in the urban area of Ponta Grossa - 2010
Source: Plan for Social Housing Ponta Grossa – 2010

Some occupations are more recent, but others have already been established for decades in places. As Lowen SAHR (2001), the former slum in Ponta Grossa emerged in the 1950s, intensifying in the following decades, representing 0.8% of urban population in 1960 to 1.9% in 1970, 6.3% in 1980 14% in 1991and according to data from the Municipal Housing Plan, 11,03% in 2010 .

Important to note that not all families living in irregular occupations live in conditions that can be considered slums because not every area of occupation reveals the precariousness of living conditions. Some occupations, even though in irregular areas, belonging to the municipality have a better quality of habitability and environmental suitability.

According to the Municipal Plan for Social Housing in the city of Ponta Grossa, we evaluated the inadequacy of environmental variable and for each illegal occupation of the urban area of Ponta Grossa was awarded points if you are on APP-Area Preservation and case is about risk area. The sum of two sub-components reflects the degree of inadequacy with regard to environmental conditions.

Of the 162 points of irregular occupation, 80 points are in conditions considered high or very high environmental inadequacy, which corresponds to 49,4% of all occupations, alarming to propose coping strategies.

3 - Environment and irregular occupations

Analyze the relationship between urbanization and the environment is fundamental to understand the mediations that arise between the need of social housing and environmental respect.

In the case of Ponta Grossa, its urban area has about only 150 km of streams in urban and largely due to its topography in the valleys, the irregular occupations that are located in these locations.

The preservation of the environment is an essential theme and special Ponta Grossa, this ecological consciousness brings with it a need for a process of environmental education.

Thus, planning the organization of urban space must be examined by a team of professionals in various areas in partnership with the communities concerned to promote alternative solutions with adequate infrastructure and legally for the families as well as environmental remediation projects that provide improvements to support social inclusion and sustainability.

Thus, including the population living in irregular occupations, located in the vicinity of streams, in all steps to propose and implement improvements would create an interaction between nature and man and not treating them as distinct, but as interacting components in environment.

As the prerogative of the Brazilian Agenda 21, sustainable development seeks to improve the lives of all people without increasing the use of natural resources beyond the capacity of the earth.

Thus, the urban planning is crucial to the process of urbanization can be worked in order to avoid further problems and deterioration in physical space. With the relocation of families that generate environmental degradation of streams and riparian areas and consequently live in areas at risk and secondly the regularization of lawfully made possible thereby, whether it was complying with an integrated planning in the city and thinking of all points that comprise the process for solving problems arising from the socio historical process of urbanization in Ponta Grossa and consequent environmental degradation.

It is also essential to undertake actions consistent to prevent new jobs mainly in environmental areas and providing housing programs to meet the housing law. With these proposals would preserve the care of social rights as constitutionally protected environmental law and housing rights, which have the same conceptual core, which is the socio-environmental function of property.

The great challenge for the actors involved in the urban setting is to reconcile these two rights and build a scenario. It is necessary to adopt an inclusive model of urban growth where the humans can live in nature in a sustainable way in terms of promotions.

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The deforestation of loess uplands of SE Poland and its stages as documented by valley deposits (case study: Bystra river valley, Lublin Upland)

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Abstract

Agriculture developing in the loess uplands of SE Poland caused the reduction of woodland areas, which resulted in an increased intensity of erosion processes. A greater amount of mineral deposits was supplied to the bottoms of river valleys. The objective of this study is to link these deposits with stages of prehistoric settlement and deforestation in the Bystra drainage basin. Sediments stored in the valley bottom were analysed in details. Several phases of deforestation related to human activity were described. An attempt to correlate changes of type, characteristics and geochemistry of analysed sediments with stages of deforestation was made.

Keywords: deforestation, loess areas, Poland, valley deposits

1. Introduction

In loess areas, forests are the best form of land cover preventing soil erosion and gully erosion (Rodzik et al. 2009). Agriculture developing in the loess uplands of SE Poland from as early as the Neolithic caused the reduction of woodland areas, which resulted in an increased intensity of erosion processes. In consequence, mainly as a result of gully erosion, a greater amount of mineral deposits was supplied to the bottoms of river valleys. Favourable natural conditions, as well as the long-term and multi-stage nature of erosion processes related to deforestation and agricultural use of land, have caused the accumulation of thick series of deposits in the bottom of valleys. They are represented by terrace deposits and alluvial fan deposits covering them (Superson, Zglobicki 2005).

The objective of the study is to link these deposits with the archaeologically documented stages of prehistoric settlement and deforestation in the Bystra drainage basin based on the findings of archaeological research conducted so far and the authors' own geomorphological studies. Deposits filling the bottom of the Bystra valley may be used as a peculiar geoarchive documenting the development stages of the environment in the area under study, including the changes in the forest cover.

2. Research area and methods

Bystra is a small river flowing into the Vistula in the area where the latter breaks through the upland belt of central Poland (Figure 1). The lower reaches of the Bystra drainage basin are situated within the loess-covered meso-region, the Naleczow Plateau (Lublin Upland). One of the Plateau's characteristic features is the occurrence of the loess cover that is up to 30 m thick. This meso-region is an undulating plateau with the highest elevations ranging from 180 to 220 m a.s.l. The Plateau is dissected by the valleys of the Bystra and its tributaries, up to 125 m a.s.l. deep, as well as numerous trough-shaped valleys and a very dense network of gullies – up to 11 km·km^{-2} (Maruszczak 1973). The loess areas, from the Boreal period of the Holocene, were

covered by multi-species, broad-leaved climax forests consisting of elm, lime, oak, ash and hazel (Ralska-Jasiewiczowa 1991). A typical community growing in gullies nowadays are Tilio-Carpinetum forests; tree stands are composed of hornbeam (Carpinus betulus) with an admixture of small-leaved lime (Tilia cordata), Norway maple (Acer platanoides) and pedunculate oak (Quercus robur). The Bystra drainage basin has been used for agriculture since the early Neolithic (Gurba 1960). Prehistoric settlement networks in this meso-region, reconstructed through archaeological research, rank among the most developed in the Lublin Upland, in Poland and even in Central Europe.

Based on the available archaeological material, an attempt was made to determine the stages of the deforestation of the Bystra basin. The intensity of this process in the past may only be established in qualitative terms and only based on the ascertained or supposed features of agriculture in individual cultures. More detailed quantitative analyses of changes of forested areas are only possible for the last 200 years because relatively precise comparative cartographic material is available for this period. Deposits in the bottom of the Bystra valley were studied during detailed geomorphological and geological investigations (numerous drillings), on the basis of which the character and age of the deposits was determined (radiocarbon dating). The vertical grain-size distribution of mineral deposits and selected geochemical characteristics (heavy metal content) were also determined.

3. Results and discussion

3.1 Stages of deforestation

The deforestation of the Bystra drainage basin began in the later stage of the Atlantic period of the Holocene. It was linked with the influx of the early Neolithic people of the Lublin-Volhynia culture into this area, dated at approximately 3400 BC (Kadrow and Zakoscielna 2000). Those people cultivated small areas located in the neighbourhood of settlements, i.e. raised terraces and lower-lying, flattened promontories of the loess plateau adjoining the valley. Deforestations in that period were linked with a tremendous amount of effort. Since the use of slash-and-burn methods was limited by the natural humidity of valley bottoms and slopes, mechanical tree-felling methods were used. It can be assumed that the agricultural activity of the Lublin-Volhynia culture did not cause considerable changes in the landscape of loess promontories. The deforestation affected small areas in the immediate neighbourhood of settlements.

Approximately 2900 BC, the Funnelbeaker culture people arrived in the Bystra basin. The economic activity of those people encompassed the entire area of the basin. Vast forest areas were burnt out, and fallowing was used to a great extent. The extensive use of the slash-and-burn agriculture resulted in an increased area of cultivated land and dispersal of settlements. Deforestation occurred throughout the Bystra drainage basin, but it was not permanent.

In contrast with the dense Neolithic settlement in the Bystra basin, the settlement process in the Bronze Age was less intensive and developed in two stages: the early Bronze Age, after 1700 BC (Trzciniec culture), and the late Bronze Age, after 1300 BC (Lusatian culture). A small number of dispersed settlements developed in a few places on terraces and in the immediate neighbourhood of the valley bottom. Their economic activity was dominated by animal husbandry (particularly in the later stage), while farming played a secondary role. Settlement sites of the Trzciniec culture usually occur in places that were not occupied by previous Neolithic settlements, which may indicate that the previously used land became overgrown on a considerable scale (Taras 1995). Areas affected by deforestation were small, but the process may have been relatively permanent.

In the Early Iron Age (from 650 BC to 400 AD), the loess areas in the Bystra basin remained beyond the reach of the regular ecumene. Settlement sites are very sparse, located exclusively along the Bystra river, which is interpreted as proof of a very limited human penetration of the drainage basin and a migratory nature of settlement (Stasiak-Cyran 2000).

Early medieval settlement in the Bystra basin dates back to the 7th century. In the pre-statehood period (until the 11th century), numerous, sometimes large settlements were established in the bottom of the Bystra valley and its tributaries, and deforestation in these areas must have been significant. An abrupt increase in the number of settlements can be observed from the mid-11th century. They encroached on the loess plateau top, which resulted in relatively extensive deforestations at this landscape level (Hoczyk-Siwkowa 1991).

Starting from the 14th century, the agricultural use of land in the Bystra basin can be observed, varying over time, but increasingly intensive. Trees were felled in order to acquire new arable land as well as for building and, later, industrial purposes, which led to a considerable deforestation of the drainage basin as early as the 15th and 16th centuries. It is estimated that the deforestation rate in the Lublin region was approximately 20% in 1340 and as much as 50% in 1580 (Maruszczak 1988).

3.2. Information recorded in deposits

Anthropogenic changes in the land cover of the Bystra drainage basin influenced the intensity of the supply of mineral deposits to the valley bottom. Geological and geomorphological studies show that the top of the peat layer, dating back to the Atlantic period, was partially covered as early as the Neolithic by the loam deposits of alluvial fans and by alluvial soils. Neolithic alluvial fan deposits, up to 5 m thick, were found at the mouth of extensive gully systems in the Celejow area. The sedimentation of these deposits should be linked with the deforestation of part of the drainage basin, resulting from the large-area slash-and-burn farming conducted by the people of the Funnelbeaker culture. It was probably then that the first gullies, linked with paths to water sources, formed along the axis of the trough-shaped valleys (Rodzik et all. 2009). Those gullies dissected the valley loams that subsequently were deposited in the form of alluvial fans covering a peat layer.

The subsequent stage of filling the valley bottom with mineral deposits was not initiated until the early Middle Ages, which is indicated by radiocarbon dating carried out for organic formations covered by the alluvial fan at the southern valley side of the Bystra. For a long time, from the end of the Neolithic to the early Middle Ages, mineral deposits probably did not reach the bottom of the river valley or reached it in small quantities. It resulted from the sparse settlement network in the Naleczow Plateau in that period.

The deposits forming the alluvial fans and the floodplain of the Bystra valley in the early Middle Ages are lithologically varied and correspond to the deposits on the slopes of the valley. These facts indicate short-distance, transverse transport as well as a varied erosion dynamics of water. At that time, gullies that had formed in the Neolithic probably became deeper, while new gullies developed in the deforested areas.

The considerable deforestation of the Bystra drainage basin in the 15th and 16th centuries led to the formation of dense net of gullies along the axis of dry and trough-shaped valleys. Due to the absence of a consistent and permanent vegetation cover on vast areas and owing to the humidity of the medieval Climate Optimum, large amounts of material, mainly loams and sandy loams, were deposited in the bottom of the Bystra valley. These deposits form the bulk of alluvial fans and the so-called anthropogenic alluvial soil. The Heldensfeld map of 1804 shows that most contemporary gully systems were already established by then, which attests to the very high intensity of gully erosion in the Middle Ages. The map also indicates that the afforestation of certain gully system basins was considerably higher than today. The cutting down of forests in those basins in the 19th and 20th centuries is reflected in the deposits that make up the alluvial fans, namely the top layer of loams that, in some places, overlies poorly developed fossil soils.

The last millennium was a period of substantial changes in the environment of the western part of the Lublin Upland as well as other parts of Poland (Maruszczak 1988). Progressive deforestation has resulted in increased dynamics of geomorphological processes in slope systems. The intensity of gully erosion, that represents the main source of material supplied to river valleys, has increased noticeably (Maruszczak 1973, 1988, Schmitt et all. 2006, Zglobicki

and Rodzik 2007). Changes in the land cover have been reflected both in the sedimentological features of deposits as well as their geochemistry (heavy metal content). Deforestation along with the accompanying denudation is an important factor causing an increase in the content of elements in deposits.

The last millennium has seen the sedimentation of mineral deposits, i.e. loams, sandy loams and silty sands in the Bystra river valley bottom. The characteristic feature was the occurrence of recurrent episodes of changes in certain parameters of the deposits, which can be linked with episodes of intensive gully erosion (Figure 2). Deposits older than 1000 years were characterised by a larger mean grain-size, ranging from 2 to 4 Φ (sand), whereas in the upper parts of the profiles (younger than 1000 years), the mean size was between 4 and 7 Φ (loams). Diversity also occurred in the case of standard deviation. In the lower part of the profiles, the sorting was very poor, 2-3 Φ, whereas in younger deposits it was poor or very poor, 1-3 Φ. Similar patterns were observed in the case of other valleys in the western part of the Lublin Upland (Table 1). A small decrease in grain-size and slightly better sorting may suggest a modification of the source of material supplied to the fluvial systems under study, which results from the intensive supply of gully erosion products with the predominant silt fraction to the bottoms of river valleys.

It was established that heavy metal content in deposits, particularly lead and copper, has increased over the last millennium in all studied profiles. Minor changes occurred in the case of cadmium and zinc. It has to be emphasized that the geochemical background was distinctly exceeded only in the case of surface samples (0-10 cm), which should be linked with the geochemical contamination of the environment caused by the development of industry in the area (the last 50 to 80 years). Heavy metal enrichment rates in the last millennium were as follows (the ratio between concentration at the top and concentration at the bottom of a layer dating back to the last 1000 years): Cd 1.9-2.3; Cu 1.4-2.6; Pb 1.4-3.1 and Zn 0.7-2.4 (Zglobicki 2008). The concentration of the heavy metals in deposits aged more than 1000 years corresponded quite well with values characteristic of the geochemical background. The mean value of changes in geochemical characteristics, although distinct in vertical profiles, was not significant in terms of absolute values. An analysis of curves representing the trends of changes in heavy metal concentration in river deposits in the western part of the Lublin Upland over the last 1000 years shows that compared to the 10th century, the contemporary values of heavy metal content are between 2.5 (Pb) and 15 (Cd) times higher. In the case of lead and cadmium, the geochemical background value was exceeded around the 10th -11th century, which can be directly linked to the reduction of the forest cover in the area under study (Figure 3).

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Table 1: The diversity of mean grain-size distribution and geochemical parameters of alluvia in the western part of the Lublin Upland (Zgłobicki 2008)

Parameter	Contemporary alluvia	Alluvia aged up to 1000 years	Alluvia older than 1000 years
Mean grain-size [Φ]	5.2	5.9	4.5
Standard deviation [Φ]	1.9	1.7	2.3
Cd content [mg/kg]	0.8	0.3	0.4
Cu content [mg/kg]	14.7	10.7	6.8
Pb content [mg/kg]	32.4	16.0	20.0
Zn content [mg/kg]	42.9	34.7	34.0
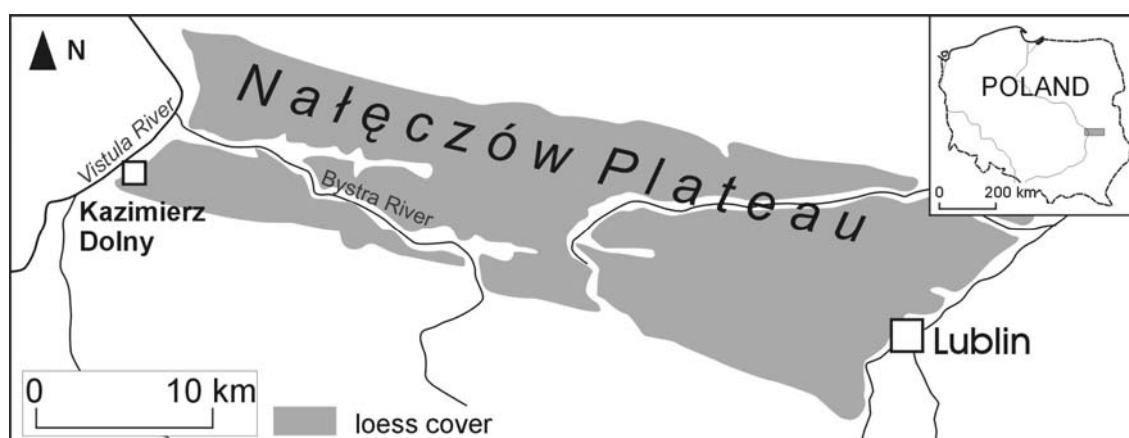
Figure 1: Location of studied area
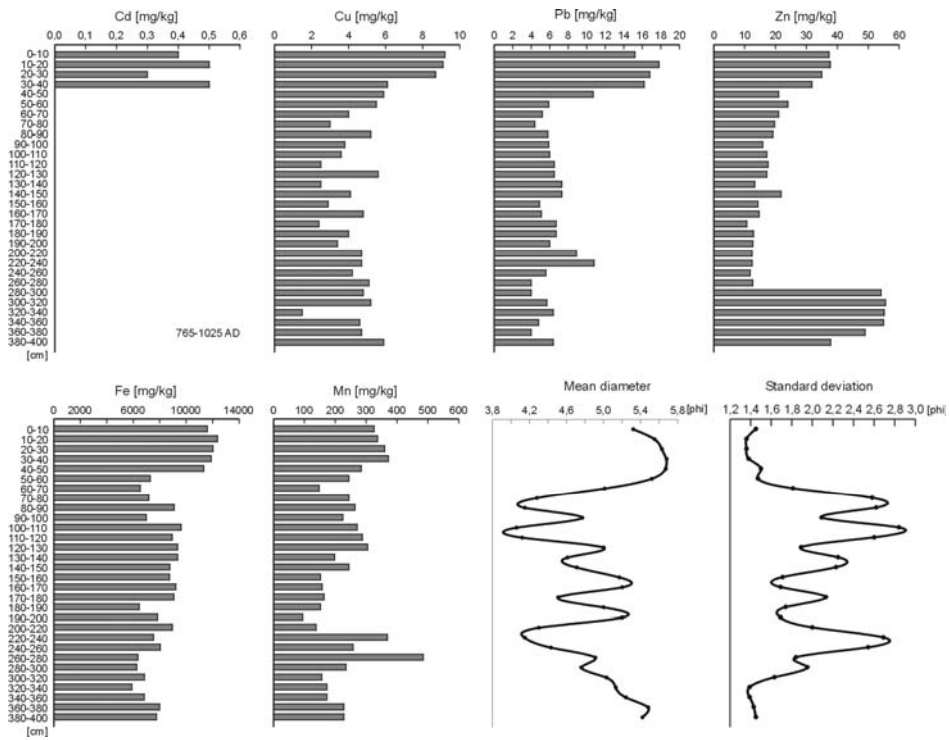
Figure 1: Vertical distribution of heavy metals content and selected indexes of grain size distribution in profile Rablow 1 (Zglobicki 2008)
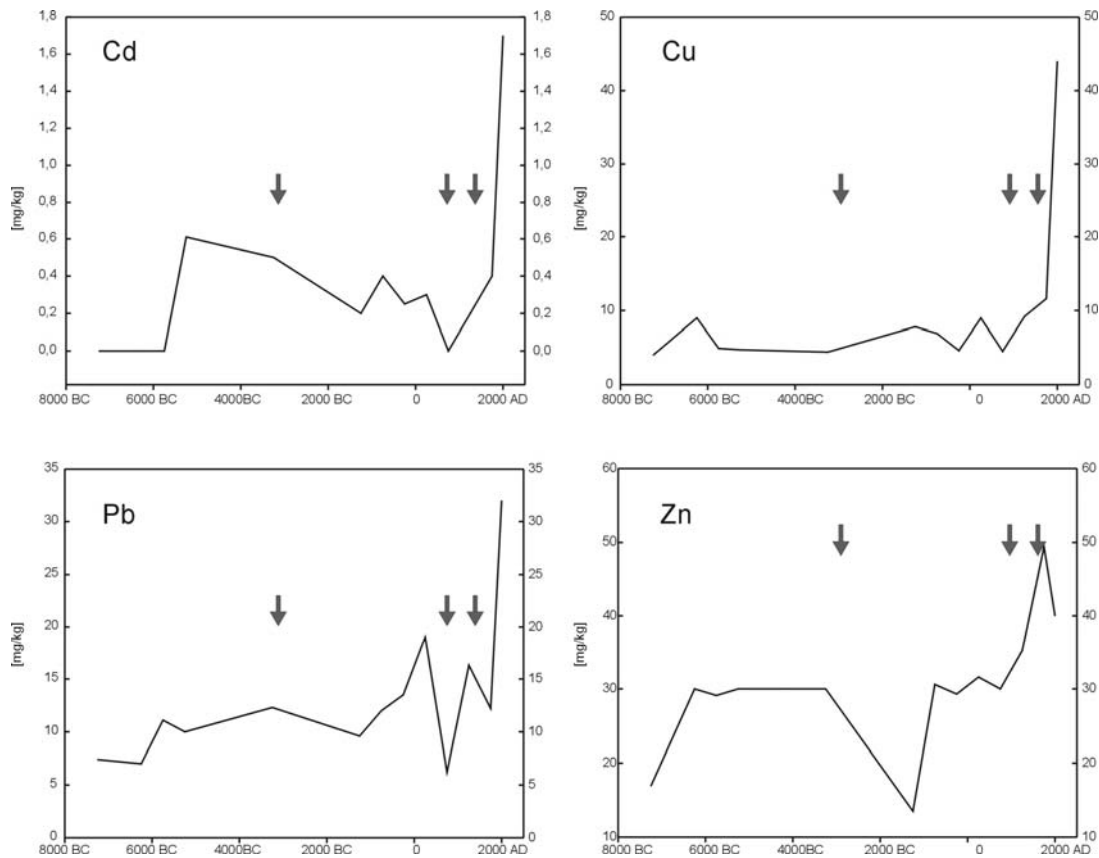
Figure 2: Changes in heavy metal content in sediments of western part of Lublin Upland and main stages of deforestation (grey arrows) during last 10 000 years (Zglobicki 2008)

Impacts of changes in land use and fragmentation patterns on Atlantic coastal forests in northern Spain

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Abstract

In managed northern coast of Spain, negative consequences of forested landscape changes have not been quantified. In one coastal forest we evaluated the landscape transitions and fragmentation patterns over time (1957-2003) by digitalising orthoimages with a high spatial resolution. Major changes on land cover were transitions to eucalypt plantations, which showed the largest increase in area (197%). Forest declined 20% and represented 30% of landscape area in 2003. Forest decline was mostly due to eucalypt plantations and to a water reservoir, although there were some gains by shrubland and cultural fields been recolonised. Forest patches declined in size and core area, and increased in edge length, mean distance and in adjacency, mainly to eucalypts. The results suggested an increase in the degree of forest fragmentation and changes in the matrix surrounding forest patches. This study also shows that land use changes, mostly from eucalypt plantation intensification, negatively affected forested habitats.

Keywords: Eucalypt plantations, Forest patches, Land cover classes, Riparian forest, Transitions

1. Introduction

Fragmentation and forest loss are one of the most threats for biodiversity (Fahrig 2003). Both processes involve patch size decrease, edge length increase and isolation, modifying the viability of populations (Hanski 1999). Despite of several studies have quantified these changes on different types of forests (e.g. Echeverria et al. 2006; Gaveau et al. 2007), in Spain montane and Mediterranean forests have been only considered (e.g. García et al. 2005), whereas Atlantic coastal forests have suffered a large fragmentation not quantified. These forests have been historically altered due to traditional land uses and eucalypt plantations (*Eucalyptus* spp.) (Saura and Carballal 2004). Fragas do Eume Natural Park (NW Spain) is one of the biggest Atlantic coastal forests in Europe and has suffered a large fragmentation. In addition, a water reservoir building has altered the riparian forests, which contain several threatened species. The objectives of this study are: (1) to contribute to the understanding of the patterns of forest loss and fragmentation in the coastal landscapes in northern Spain, (2) to quantify changes and transitions that occurred among land cover classes between 1957 and 2003 to understand how they have affected to space-temporal configuration of forest and, (3) to characterise forest fragmentation patterns using standard landscape metrics and adjacency with other land cover classes as well as to determine the temporal change of those patterns.

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2. Methodology
2.1 Study area

Fragas do Eume NP covers 8 962 ha and it is located in the Galician dorsal range. The reserve spans 43º20'-43º26'N, and 7º52'-8º08'W. There are three native forest types depending on geomorphology: (1) oak forests, located on slopes; (2) alder forests, located on riversides with flooding sediments; and (3) hazel forests, located on steep riversides with rocky river-beds. Alder and hazel forests represent the riparian forests, and they contain threatened species such as the vertebrates *Chioglossa lusitanica* and *Galemys pyrenaicus*, and the ferns *Culcita macrocarpa*, *Trichomanes speciosum* and *Woodwardia radicans*.

2.2 Aerial image processing and land cover classes

We used American Army's aerial photographs from flights for the years 1956-1957 (hereafter 1957) and digital orthoimages of the Geographic Information System of Agrarian Plots for the years 2002-2003 (hereafter 2003). The 1957 aerial photographs consisted of 28 contact copies (24×24 cm) with a scale of ca. 1:30 000. The photographs were scanned at ca. 2.55 m resolution, and they were subsequently georeferenced with the software ERDAS IMAGINE 8.7 using 30-40 ground control points for each frame. Orthoimages from 2003 had a spatial resolution of 0.25 m. The imagery set was implemented into a GIS based on ArcGIS 9.1.

Two maps were drawn showing the different land cover classes in the Fragas do Eume NP in 1957 and 2003. Land cover classification followed the system of the CORINE Land Cover 5th level project (IGN 2002). Table 1 shows the classes we digitised. Riparian forests consisted of extremely thin patches that it was practically impossible to digitise them as polygons. However, given the importance of that habitat for the persistence of key red-listed and protected species, we conducted a specific analysis for riparian forests by digitising the intersection between forests and river courses as polylines to generate a map of riparian forest length.

2.3 Forest fragmentation analysis

Quantification and temporal comparison of the spatial configuration of forest patches were conducted based on a set of standard landscape metrics reported in recent forest fragmentation studies (e.g. Echeverria et al. 2006): (1) largest patch index (%), (2) mean patch size (ha), (3) total edge length (km), (4) total core area (ha), (5) largest patch core area (ha), (6) mean distance (m) and (7) adjacency index (total -km- and relative -%-). To calculate core area, the interior forest was defined at a distance to edge of 50 m. In the case of riparian forest, quantification and temporal comparison was based on lineal segments rather on areas. For each of the two dates, we calculated the number of segments and the absolute and relative length of riparian forest from the polyline maps. We quantified all absolute and relative changes in land cover areas and lengths by calculating the difference between the values in 2003 and 1957.

3. Results

14 classes in 1957 and 12 in 2003 were identified (Table 1, Fig. 1). Forest suffered a 20% decrease in area and more than a two-fold increase in the number of patches between over time. In contrast, eucalypt plantations exhibited a 200% increase in area, accompanied by a moderate increase in the number of patches. Table 1 shows the overall land cover patterns and changes.

In 1957, 86% of total forest area concentrated on a large patch of 2 848 ha located along the Eume river gorge (Fig. 1); the remaining forest area occurred in patches that were smaller than 1000 ha, with only ca. 4% in patches under 100 ha. The 2 848 ha patch from 1957 suffered 28% area loss as well as fragmentation into three patches of 273, 751 and 1 003 ha. The 1 003 ha patch was the largest one in 2003 and was located along the low Eume River gorge (Fig. 1). The

Table 1: Number of patches, absolute (ha) and relative (%) areas for each land cover class in Fragas do Eume Natural Park in 1957 and 2003. Net change (absolute and relative) in number of patches and area is also shown. Change values greater than 0 indicate gains, and those less than 0 indicate losses. * indicates that relative change was not calculated because that land cover class was absent in 1957

Land cover class (abbreviation)	1957			2003			Change 1957-2003		
	Patches	Area		Patches	Area		Patches	Area	Relative
		(ha)	(%)		(ha)	(%)		Absolute	(%)
Forest (Forest)	64	3,306.5	36.9	137	2,659.5	29.7	+73	-647.0	-19.6
Eucalypt plantations (Eucal)	162	615.3	6.9	200	1,829.7	20.4	+38	+1,214.4	+197.4
Pine plantations	0	0.0	0.0	96	144.9	1.6	+96	+144.9	*
Transitional woodland (Trans)	0	0.0	0.0	267	302.9	3.4	+267	+302.9	*
Gorse and heathland (Gorse)	169	3,483.0	38.9	213	2.386.2	26.6	+44	-1,096.8	-31.5
Bare rocks (Bare)	356	254.6	2.8	255	94.2	1.1	-101	-160.4	-63.0
Water courses	1	59.5	0.7	1	24.5	0.3	0	-35.0	-58.8
Water reservoir (Water)	0	0.0	0.0	1	400.1	4.4	+1	+400.1	*
Meadows and pastures (Mead)	23	121.2	1.4	30	268.0	3.0	+7	+156.8	+129.4
Complex cultivation patterns (Comp)	89	1,080.0	12.0	139	799.8	8.9	+50	-280.2	-25.9
Discontinuous urban fabric	69	17.7	0.2	72	26.0	0.3	+3	+8.3	+46.9
Roads	51	11.1	0.1	60	17.9	0.2	+9	+6.8	+61.3
Construction sites	1	10.8	0.1	0	0.0	0.0	-1	-10.8	-100.0
Mineral extraction sites	1	1.6	0.0	4	7.4	0.1	+3	+5.8	+362.5
Industrial or commercial units	1	0.5	0.0	1	0.7	0.0	0	+0.2	+40.0
Total	928	8,961.8	100.0	1,476	8,961.8	100.0	+489	0.0	0.0

Figure 1: Spatial configuration of land cover classes in Fragas do Eume Natural Park in 1957 and 2003
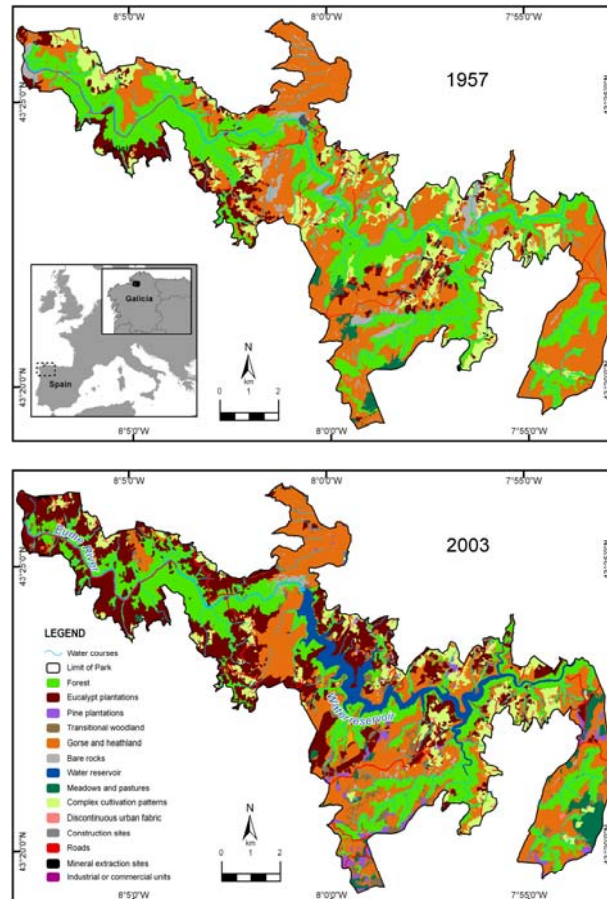
Table 2: Landscape metrics of forest in Fragas do Eume Natural Park in 1957 and 2003. The absolute and relative change of each landscape metric is also shown. Change values greater than 0 indicate gains, and those less than 0 indicate losses

Landscape metric	1957	2003	Change 1957-2003	
			Absolute	Relative (%)
Largest patch index (%)	32	11	-22	-34.4
Mean patch size ± SD (ha)	52 ± 344	19 ± 110	-33	-63.5
Total edge length (km)	367	484	+118	+32.1
Total core area (ha)	2,054	1,178	-876	-42.6
Largest patch core area (ha)	1,842	530	-1312	-71.2
Mean distance ± SD (m)	489 ± 315	641 ± 546	+152	+31.1

number of patches under 10 ha, and particularly those under 1 ha, increased from 1957 to 2003 and represented a higher proportion of the total number of patches.

There was an increase in total edge length and a decline in total core area and also a decline in largest patch core area. Mean distance among patch edges increased 31%. Forest patches also showed an increase of 32% in the total adjacency index between 1957 and 2003 (Table 2).

In 1957, a large proportion (89%) of total water course length was covered by riparian forests, including the whole length of the Eume River (Fig. 2). In 2003, riparian forest length decreased 34%. Losses were associated to eucalypt plantations (11%), and mostly to the building of the water reservoir (23%).

Figure 2: Changes in the spatial distribution of riparian forest in Fragas do Eume Natural Park
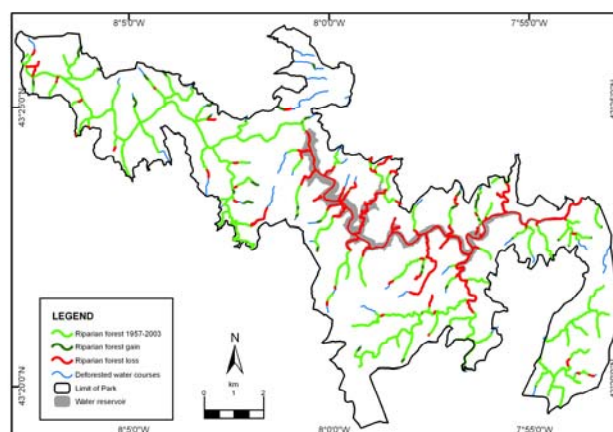
4. Discussion

Our results showed a high spatial heterogeneity in land cover over the whole area in both study periods, with most land cover classes consisting of a large number of patches interspersed with other different classes (Fig. 1). Land cover area comparisons and detailed transition analyses showed that the landscape was highly dynamic over the 50-year period, mostly due to intensification of exotic species plantations (especially eucalypt), farming abandonment and the building of a water reservoir. Eucalypt plantations were mostly introduced in northern Spain during the second half of the 20th century because of their high pulp productivity. Farming abandonment also represented large landscape changes due to depopulation of these rural lowlands during the second half of the 20th century (Calvo-Iglesias et al. 2006).

The forest loss was associated with eucalypt plantations and, in lesser degree, with the building of a water reservoir. This contrasts with the high forest losses reported over the last decades, which were mostly due to logging and agriculture, particularly for tropical areas (e.g. Gaveau et al. 2007). Those factors were also important for European forests, but in historical times prior to the period of our study (Santos et al. 2002). Forest cover was similar to those for other fragmented temperate forests (Fuller 2001; García et al. 2005; but see Santos et al. 2002). Our results also showed changes in forest spatial patterns, thus suggesting an increase in the degree of forest fragmentation over time and they were qualitatively similar to those reported for other forest studies (Fuller 2001; Echeverria et al. 2006). At this point is worth noting the importance of the fine resolution (0.01 ha) used to map patches in this study More than 20% of patches were smaller than 0.1 ha and more than 60% smaller than 1 ha in any of the study years. Temporal changes in forest patterns also implied changes in the nature of the adjacent land cover classes. The more relevant changes were the increase in adjacency with eucalypts and the water reservoir. It is known that exotic eucalypts easily spread around and into native forest patches due to their high growth rate and ability to alter forest floor quality (Fabião et al. 2002). Changes in forest patterns over time and increase in forest edge length adjacent to eucalypt plantations may have negative ecological implications on forest specialists. Eucalypt plantations generate ecological disturbances, such as increases in soil dryness and erosion, which may result in declines in plant species diversity (Fabião et al. 2002) and density of some animals as the northern-Iberian endemic amphibian *C. lusitanica* (Vences 1993). However, a recent genetic study in the area showed low among-population genetic variation for the protected and forest specialist ferns *Culcita macrocarpa* and *Woodwardia radicans* (Quintanilla et al. 2007).

Riparian forests appeared to be relatively well-conserved, because 76% of total river course length was still covered by riparian forest in 2003. However, it was one of the land cover classes that suffered a larger decline over the study period (34%). Thus, evaluation of conservation status for habitats based only on a snapshot of the landscape could lead to equivocal conclusions. Riparian forests have a range of ecological properties which makes them particularly important components of landscapes. Firstly, riparian forests have been acknowledged as dispersal corridors, hence facilitating individual exchange between natural habitat patches (Naiman et al. 1993). Secondly, riparian forests may act as buffers for some forest specialists in fragmented landscapes, as for instance mitigating the impacts derived from forest harvesting and exotic plantations (Homyack and Haas 2009).

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Assessing multi-temporal land cover changes in the Mata Nacional da Peneda Geres National Park (1995 and 2009), Portugal - a land change modeler approach for landscape spatial patterns modelling and structural evaluation

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Abstract

The present study sought to evaluate land cover evolution between 1995 and 2009, within the Mata Nacional of Peneda Geres (Portugal). This study was based on Landsat TM images classification and GIS procedures, such as Land Change Modeller approach. Landscape diversity and structural changes were analysed by means of Mean Shape Index, Shannon's Diversity Index and Patch analysis, in order compare landscape metrics and to calculate land cover dynamics. The achieved results enable to state that land cover classes presented significant structural changes. The most significant changes occur in the land cover classes of *Pinus pinaster; Quercus robur*; *Acacia dealbata*; and shrub land. The most worrying result was achieved for the *Acacia dealbata*, which presented a strong invasive behaviour. Landscape metric analysis showed a significant stratification increasing and a dramatic reduction of patch surfaces. In spite of spatial changes observed, the achieved biodiversity indexes are very alike for both dates.

Keywords: Landscape ecology, Spatial patterns analysis, Changes prediction, Landsat, Gerês

1. Introduction

Natural or National Parks use to be created as way to preserve wild areas and to give a chance to nature undergo its trend. However, due to centuries of anthropogenic action, nature must be under human surveillance in order to redress previous misuse or to guide ecosystem recovery.

Over the last 50 years, natural areas have suffered significant changes, which are visible from land cover and land use changes. These changes are due to several causes: human exodus from rural areas, which leaded to uncontrolled shrub growing and, this way, to wild fire starting and spread, alien species introduction and spread, climatic changes and unbalanced forestry composition.

The Peneda Geres National Park is a good and living example of previous state. From the last 200 years, rural population used wild land for grazing cattle, to cut shrubs for cattle's beds, to grow timber and to cut wood for fireplaces, during rigorous inter. However, from the last 30 years, human action within the Park decreased drastically, both by changes in Portuguese way of life and restrictive policy imposed by law. This actions combination is now very visible in

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landscape and leaded to changes in ecosystem balance. Due to a strong anthropogenic pass, this area must be under continuous surveillance in order to avoid irreversible ecosystem losses and unbalanced evolution.

This is also visible throughout Europe, at different scales and domains, due to changes in technologies, policy and economical growing up (Verburg et al. 2008).

Land cover and land use dynamic analysis and evolution qualification has to be used as a way to estimate environmental consequences due to landscape changes (López et al. 2001, Flamenco-Sandovala, et al. 2007; Rutherford et al., 2008). Multi temporal spatial pattern analysis and quantitative landscape structural analysis have been successful used to derive research in this domain (O´Neill et al. 1988; Bresee et al. 2001, Tischendorf 2001).

This research was derived using Remote Sensing and Geographic Information Systems methods, in order to assess the landscape dynamics in Gerês National Forest. We evaluated the global landscape composition and structure from 1995 to 2009 and made projections for 2015 based on transition observed from the past to 2009.

Was selected Geres National Park, as it is a protected area of high landscape value and ecological, part of the Peneda-Geres (PNPG). The Geres National Park contains one of the most important oak woods, consisting predominantly of a centuries-old oak forest (carvalhal da Albergaria) where is noticed the presence of fauna and flora species characteristic of gerensiana formation. PNPG, it is classified as a Zone of Partial Protection of Natural Environment Area and Rede Natura 2000 (Anonymous, 1995). In general, this area can be classified as an area of mountainous altitude, since about 82% of the territory, has altitudes ranging between 700 and 1400 m.

Due to its morphological characteristics, which result from the conjunction of four mountains (Peneda, Soajo, Amarela e Gerês), this area creates a natural barrier to hot and wet air coming from Atlantic Ocean. This results in high values of mean annual rainfall, ranging from 2400 mm to 2800 mm, or 3000 mm in very wet years. This is the wettest area in Portugal and even in Europe (Fontes, 2005). In this territory we can find several forest species, with high productivities as pines, eucalyptus, oaks and much other conifers and deciduous species. The most species are well adapted and in equilibrium in the ecosystem, however, many introduced species became invaders (e.g. *Acacia dealbata, Acacia melanoxilon*).
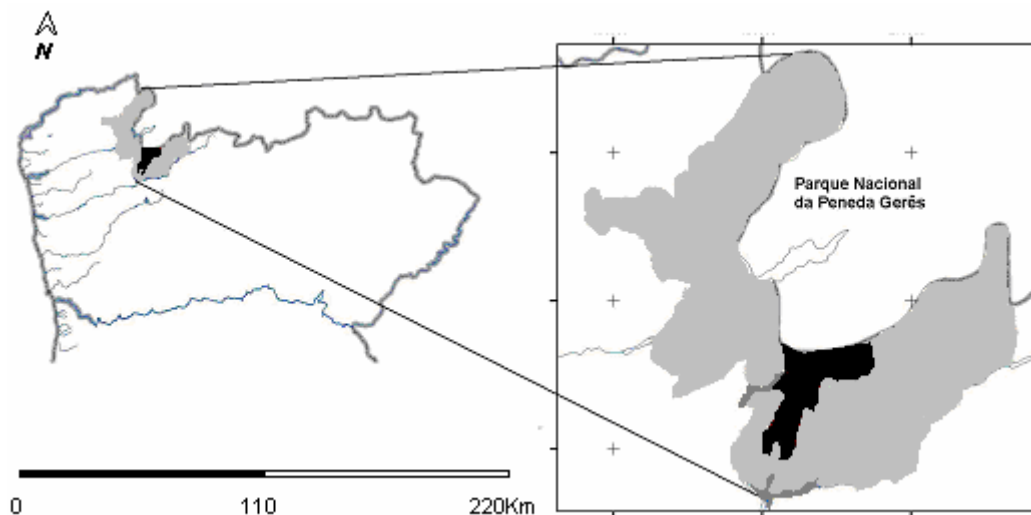
Figure 1: Study area location

2. Methodology

They were used satellite images (Landsat-5 TM, 5/July/1995, Landsat-5 ETM+, 1/April/2001, Landsat-5 TM, 4/August/2006 and Landsat-5 ETM+, 16/June/2009), ancillary data such as: topographic maps at the scale of 1:25 000 with a 10m contour interval, orthophotomaps from 1995, 2000 and 2005 at a scale of 1:10 000, cartographic elements in vector format such as roads, rivers, administrative boundaries and environmental characteristics.

In previous intensive fieldwork, information about land cover classes and ground control points (GCP) were collected using a DGPS (Differential GPS). The GCP were collected in road crosses, barrages or other notable points perfectly visible in the images (Toutin 2004). This data was used as auxiliary tools in the geometric correction, in the definition of training classes and in the validation stage (Lillesand et al. 2004, Toutin 2004, Eastman 2006, Scally 2006, D' Iorio et al. 2007, Tsai 2007

A digital elevation model (DEM) was created from 10m interval contours, collected from the 1:25000 topographic maps of representing the study area, in order to calculate slope and aspect and to apply images topographic normalization.

The conceptual framework of the research included pre-processing stage, image enhancement, image transformation (RGB composition, vegetation indices calculation and principal component analysis), image classification and interpretation and accuracy assessment. It was used IDRISI 32 (Eastman 2006) image processing software for image data processing, and ArcGis 9.x (ESRI 2004) software for GIS based analyses procedures.

During previous field work for data collection, it was used a DGPS (Differential Global Positioning System) in training areas mapping (e.g. coniferous stands, burnt areas, acacia areas, etc.) and ground control points collection (e.g. roads intersection). DGPS data was corrected with Trimble® GPS Pathfinder® Office software.

The adopted land use/cover scheme, used in image classification, was based upon Corine Land Cover classification (CLC2000).

In a first image classification stage, they were used nine land cover classes, in order to create a general land cover map. In a second stage, using a local scale and after fieldwork with a DGPS (Differential Global Positioning System) for accuracy assessment, land cover maps were updated during, in order to assign the correct forestry class name to each land cover class. In total, fifteen land use/cover classes were considered in this study:

- Shrubs,
- Pinus sylvestris,
- Acacia dealbata,
- Quercus robur;
- Mixed Broadleaves;
- Mixed Coniferous;
- Mixed Coniferous and Broadleaves;
- Chamaecyparis lawsoniana,
- Mixed Shrubs and Quercus sp.;
- Fagus sylvatica;
- Acacia melanoxylon;
- Pinus pinaster;
- Pinus nigra;
- Arbutus unedo; and
- Betula celtiberica.

They were performed several automatic classification methods, including unsupervised models and Principal Component Analysis (Asner 1998, Song et al 2001, D' Iorio et al. 2007, Tsai et al. 2007). Supervised classification of multispectral images was performed, running the Maximum

Likelihood classifier (MLC) and the Minimum Distance to Means classifier (MDMC) (Lillesand et al. 2004, Eastman 2006, Scally 2006).

The accuracy of a classified image refers to the extent to which it agrees with a set of reference data. Thus, an error matrix was created in order to compare the accuracy of maps obtained from satellite images classification. The error matrix provides a mean to calculate the overall accuracy and to compute accuracies of each category (Congalton and Green 1999).

It was calculated Kappa statistic (Cohen, 1960), because of its ability to provide information about a single matrix and to statistically compare matrices, in order to get another measure of agreement between the predicted values and the observed values, the, (Cohen, 1960, Rosenfield and Fitzpatrick-Lins 1986, Congalton and Green 1999, Meidinger, 2003).

For land cover changes detection, it was used a pixel-to-pixel comparison of classified images, because it is a method widely used and easily understood. This step preformed by Land Change Modeler (LCM - IDRISI Andes, Eastman, 2006) and aimed to compare the images generated for the different years of study.

Land Change Modeller (LCM - IDRISI Andes, Eastman, 2006) enable landscape changes analysis; Shaping the potential transition of the land cover classes, provide the direction of changes in the future, assessment to their implications for biodiversity and to evaluate plans of action for ecological sustainability maintenance.

At the final stage, land cover maps, created from 1995 to 2009 satellite images, were submitted to pattern analysis in order to assess landscape structural quantification. This stage was performed by means of Patch Analyst 4 (Rempel, 2008), which is a working modulo available in ArcGIS 9.x GIS software.

3. Result

The observed changes, in terms of net percentage change, are more significant in classes: mixed conifer, Shrubs with oaks self seeding, *Arbutus unedo*, *Betula Celtiberica*, *Acacia dealbata, melanoxylon Acacia, Quercus robur*.

The most important modification was recorded in oak areas (*Quercus robur*) with an effective reduction of about 444 ha, representing a decrease of 113.9%. Classes of increasing land cover are: *Acacia dealbata* increased more than 200ha, and *Acacia melanoxylon*, with more than 30ha. The substitution of pure *Quercus robur* stands by shrubs, in a such large area, was due to strong shrub's developed, which is replacing the younger oak areas. It was also noticed that some *Quercus robur* some pure stands, classified in 1995, were classified in 2009 as deciduous and coniferous mixed stands, which can lead to gradual replacement of deciduous trees on these areas.

Analysing the global balance of *Acacia dealbata* changes (gains and losses), *Acacia dealbata* increased its area over *Pinus pinaster* pure stands (80ha) and shrub areas (120ha).

The *Acacia melanoxylon* increasing area was made, as for Acacia dealbata, by the replacement of *Pinus pinaster* pure stands (30ha), and these changes correspond to about 8% decrease of pine in the global balance of gains and losses in forest occupation of this class

Despite the total area assigned to *Pinus pinaster* stands (polygons and 35 319ha in 1995 to 64 292ha in 2009 polygons) and to shrub land (3580ha polygons and 88 in 1995; 3232ha polygons and 522 in 2009) had not varied greatly, in absolute values, the spatial distribution has suffered a large increasing in fragmentation. In the case of shrub land, it was observed that some areas have be replaced by a mix of young oaks and shrubs. The *Pinus pinaster* stands were replaced by scattered trees and shrubs, as well by *Acacia dealtata*, as previous presented. In Table 1 are presented the calculated results for metrics of diversity and inter dispersion for 1995 and 2009.

Table 2: Metrics of diversity and inter dispersion for 1995 and 2009

Metrics	Acronym	1995	2009
Mean shape index	MSI	1.56	1.60
Area weighted mean shape index	AWMSI	5.22	6.42
Mean polygon fractal dimension	MPFD	1.07	1.08
Landscape shape index	LSI	8.46	10.42
Metrics of diversity and inter dispersion			
Mean distance to nearest neighbour (m)	MNN	282.50	186.50
Mean proximity index	MPI	771.39	1680.10
Index of dispersion and overlapping (%)	IDO	43.61	59.20
Shannon diversity index	SDI	1.02	1.13
Simpson diversity index	SIDI	0.47	0.46
Shannon equity diversity index	SEI	0.38	0.42
Simpson equity diversity index	SIEI	0.50	0.49
Modified Simpson diversity index	MSIDI	0.63	0.61
Modified Simpson equity diversity index	MSIEI	0.23	0.23

4. Discussion

Results from this research showed that the vegetal land cover within Mata Nacional of Peneda Geres National Park is under high changing dynamic. For the period in analysis, some land cover classes evidenced significant lost (e.g. *Quercus robu*r) and significant gains (e.g. *Acacia dealbata*).

The achieved results for *Quercus robur*, the ex-libres of Mata Nacional of Peneda Geres National Park showed a strong area decrease, with tendency to be smaller in a new future. This is a strong cut in landscape value and biodiversity.

Open areas within *Quercus robur* stands mapped in 1995 were now occupied by *Pinus pinaster*, *Fagus sylvatica*, shrubs and *Acacia dealbata*.

In general, *Pinus pinaster* and shrubs presented a stabilised land cover area, these classes evidenced some dynamic, but the total areas assigned to both classes are near the same in both dates.

One of the most significant results was achieved for alien trees (*Acacia dealbata* and *Acacia melanoxylon*). According to prediction maps, these species are those with higher potential to enlarging their actual area. These tow trees species are well known because of their strong invasive behaviour, which leads to additional worry, as they can quickly colonize almost all Mata Nacional, leading to a severe ecosystem disturbance.

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Mapping invasive species (*Acacia dealbata* Link) using ASTER/TERRA and LANDSAT 7 ETM+ imagery

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Abstract

The rapid spread of invasive alien species (IAS) is now recognised as one of the greatest threats to the ecological and economic well being of the planet. This study shows a comparison between ASTER/TERRA and ETM+/LANDSAT 7 sensors data suitability for mapping the *Acacia dealbata* Link spots. The work was carried out in central Portugal (Viseu region) where the presence of invader species in pure stands is quite significant. The images were ortho-rectified and submitted to supervised classifications techniques. The achieved results showed an overall accuracy of 89.42% over the ETM+ image and 86.69% over the ASTER image. For the class *Acacia dealbata* Link, the producer's precision was 100% for both images but the user's accuracy was only 23% in ETM+ and 12% in ASTER image. The obtained results suggest good perspectives for the use of this type of satellite images in order to detect and map this invasive species.

Keywords: Alien species, Acacia dealbata, land cover classification, Landsat ETM+, ASTER

1. Introduction

The rapid spread of invasive alien species (IAS) is causing irreparable damage to global ecosystems. Variously referred to as exotic, non-native, alien, noxious, or non-indigenous weeds, these species are causing enormous damage to biodiversity and to the valuable natural agricultural systems, which we depend on (Coimbra 1999; Liberal & Esteves 1999; Aguiar et al. 2001; Aguiar & Ferreira 2005, Viana 2005). In Portugal, the establishment and spread of invasive species, particularly *Acacia dealbata* Link, has increased over time. They were introduced deliberately as silvicultural, for soil fixing, as ornamental or by another pretext, being now a serious problem for the ecosystems, with difficult control and even impossible eradication. Identifying those areas is essential to quantify the real dimension of the problem (Coimbra 1999; Liberal & Esteves 1999; Bargeron et al. 2003; Viana 2005).

With the coming in sight of new image sensors, with different characteristics, and data availability, it is important to test the potentialities for specific uses as IAS detection and mapping (Asner 1998; Bargeron et al. 2003; Leitão et al. 2003; Brundu 2005; Chikhaoui et al. 2005; Viana 2005; D'Iorio et al. 2007).

The Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) is a research facility launched on NASA's Earth Observing System, on board of TERRA satellite (previously called EOS AM-l), in December 1999. As expected ASTER data has been used in specific areas of scientific investigation, including vegetation and ecosystem dynamics, hazard

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monitoring, geology and soils, land surface climatology, hydrology, and land cover change (Abrams 2000; NASA 2004; Tangestani 2004; Chikhaoui et al. 2005; Euroimage 2008).

The Landsat programme constitutes the longest data register of the Land surface from the Space. The Enhanced Thematic Mapper-Plus (ETM+) was launched on April 15, 1999 on board of Landsat7 and, as TM sensor data, imagery have been extensively used for agricultural evaluation, forest management inventories, geological surveys, water resource estimates, coastal zone appraisals, and a host of other applications (Song et al. 2001; Darvishsefat 2003; Thenkabail et al. 2004; Peterson 2005; Viana 2005; NASA 2006; NASA 2007;).

Given the characteristics of ASTER sensor systems, which provide imagery data at higher spatial resolution (15m on VNIR) than ETM+ (30m), the same temporal resolution-16 days, and with a unique combination of wide spectral coverage, in this study we tested and compared both imagery performance in the mapping of a specific class of forest land cover (*Acacia dealbata* Link).

Study Area was a 64Km x 60Km rectangle in the region of Viseu (centre of Portugal) (see Figure 1). It's a heterogeneous area with a complex topography and fragmented land cover, with elevation in the range of 100 to 1800m; high climatic variability, with annual mean precipitation in the range of 800 to 2800 mm and annual mean temperatures of < 7.5 to 16 ºC.
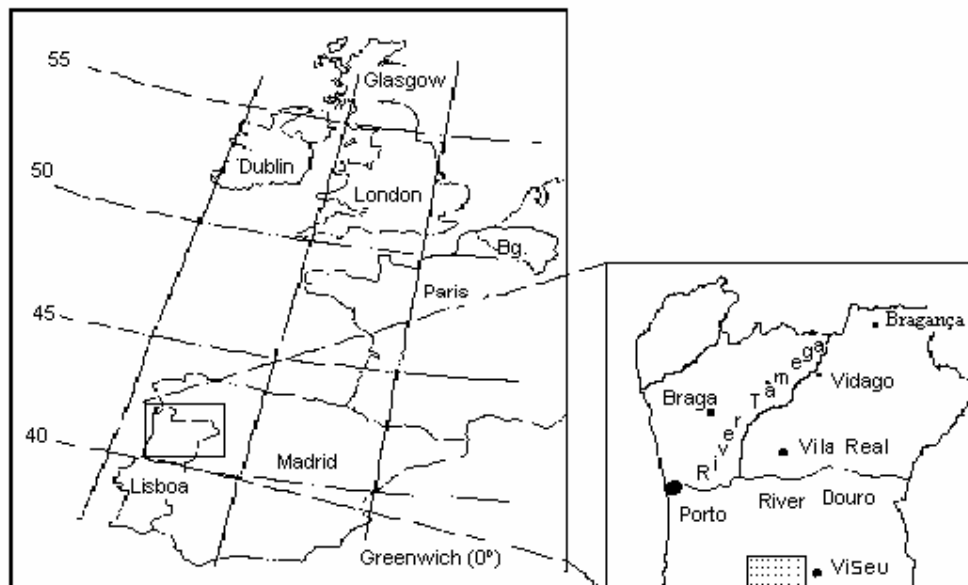
Figure 1: Study area location.

2. Methodology

2.1. Data acquisition

The study was developed using multispectral images covering Viseu's region, in Portugal, provided from the sensor ETM+/Landsat 7, and sensor ASTER/Terra (L1b format), on the VNIR bands. The acquisition date of ETM+ was on 24, January 2003, period in which these plants were flowery and ASTER on 7, October 2003, since it was the available image closest to the ETM+ acquisition date. Topographic maps 1:25000 and orthophotomap 1:10000 were used as auxiliary tools in the definition of training classes and in the validation stage. The collection of spatial information as cartographic elements e.g. land cover classes, roads and ground control points (GCP) was done by GPS. A total of 85 plots of *Acacia dealbata* were measured in a sum of 66.6 hectares, with a mean area around 0.78 hectares, later used for training classes. The GCP

were collected in road crosses, barrages or other notable points visible in the images (Lillesand et al 2004; Viana 2005, Eastman 2006).

2.2. Data processing

The conceptual framework of the research followed 5 central steps: geometric correction, Image enhancement, image transformation (vegetation indices and principal component analysis), classification and interpretation and validation. DGPS (Differential Global Positioning System) data was corrected with Pathfinder Office, image data were processed with IDRISI 32, and GIS based analyses was done with ArcGis software.

In first place the ASTER data (level 1B) of VNIR bands (1, 2, 3N), with 15m spatial resolution, in the HDF format, and ETM+ data of pan band with 15 m and multispectral band (1~5, 7) with 30 m spatial resolution were imported to IDRISI. The ASTER image and pan ETM+ images were registered with GCP, and the multispectral ETM+ bands were based on image-to-image method, using the already registered images as reference.

For image classification, it was adopted a land use/cover scheme based upon the Corine Land Cover classification (CLC2000). They were performed automatic classification methods, unsupervised models and Principal Component Analysis (Song et al. 2001, Tsai et al. 2007). Supervised classification of multispectral images was performed, running the Maximum Likelihood classifier (MLC) and the Minimum Distance to Means Classifier (MDMC) (Lillesand et al. 2004, Eastman 2006, Scally 2006). The accuracy of a classified image refers to the extent to which it agrees with a set of reference data. Thus, an error matrix was created in order to compare the accuracy of maps obtained from satellite images classification. The error matrix provides a mean to calculate the overall accuracy and to compute accuracies of each category (Congalton and Green 1999). Kappa statistic (Cohen 1960), because of its ability to provide information about a single matrix and to statistically compare matrices, was calculated in order to get another measure of agreement between the predicted values and the observed values, the, (Cohen 1960, Rosenfield and Fitzpatrick-Lins 1986, Congalton and Green 1999, Meidinger, 2003).

For land cover changes detection, it was used a pixel-to-pixel comparison of classified images, because it is a method widely used and easily understood.

3. Result

After supervised image classification, the resulting images area very alike. These results were evaluated using a set of 2304 validation points and error matrix. The overall statistics of classifications are summarised in the Tables 1 and 2.

Table 1: Producer's and User's for ETM+ and ASTER imagery classification

Land cover class	Producer's accuracy (%)		User's accuracy (%)	
	ETM+	ASTER	ETM+	ASTER
Forested areas	93.1	94.7	99.9	97.8
Meadow	81.8	56.0	96.8	84.8
Acacia dealbata	100.0	100.0	22.4	11.1

As previous presented table show, both images provided quite similar results. The best classification was achieved with the Maximum Likelihood classifier (Table 2). Although the ETM+ image achieve a higher overall accuracy, and superior user's accuracy, for all the considered land cover classes, only the Md class had higher producer accuracy (81.8% and 56.0%, respectively).

Table 2: Overall accuracy of ETM+ and ASTER imagery classification

Method	Overall accuracy (%)	Kappa statistics
ETM+ - MLC	89.42	0.8543
ETM+ - MDMC	63.53	0.5190
ASTER - MLC	86.69	0.8121
ASTER - MDMC	69.21	0.5688

For the land cover class Fr the reliability of ETM+ image (93.1%) was minor than ASTER (94.7%). In the best classification (MLC), the class "acacias" had shown a Producer's accuracy of 100% in both ETM+ and ASTER images. This happened due to the commission error being 77.57% in ETM+ and 88.89% in ASTER image (Table 3). This means that the vector shapes considered in the creation of this spectral signature were representative of the Ac class, and had been well created, however given the nature of this land cover class (permanent leaf and closed canopy) some pixels belonged to other land cover class were classified as Ad, principally Md class in reason of their similar spectral response.

All Ad (*Acacia dealbata*) spots mapped with a DGPS were well classified by satellite image classification. However, do to small spot dimension and fragmented landscape, some Md (Meadow) were misclassified as Ad (*Acacia dealbata*) areas.

4. Discussion

In this paper/work we have compared ASTER and ETM+ data in forest applications. The accuracy of image classification and interpretation was tested and compared. The resulting conclusions are:

- ASTER data can be registered with elevated accuracy with error less than half pixel.
- ASTER is better than ETM+ data in visual surface feature identification.
- ASTER classification has the same effect as ETM+ with high accuracy;
- With ASTER it was possible to classify land cover shapes with smaller areas in reason of their superior spatial resolution.
- A superior resolution in ASTER (15m) is not an evident advantage when mapping features with reduced dimension such as Ad (*Acacia dealbata*), given that the spectral confusion, fact amplified in fractionated landscapes as in the Centre of Portugal.
- The Maximum Likelihood classifier gave better results than the Minimum Distance to Means classifier in the supervised classification, involving land cover classes (acacias) distributed in parcels with small areas.
- Given the uncertainty about follow-on Landsat ETM+ sensor, ASTER imagery could be supply suitable images for monitoring applications, with similar results.

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Acknowledgement

Section 6
Tools of landscape assessment and management

Investigation on mountain landscape parameters on Juniper species growth (case study: Firozkooh region, Tehran)

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Abstract

It is generally agreed that sustainable development and management of upland natural resource for the welfare of local population should be the key objective of watershed management, which includes sustainable utilization and conservation of forest resource of community or watershed level as one of its important components. *Juniperus polycarpus* L. is one of the species that grows in the mountain areas, and has important role in mountain landscape. Our purpose of this study is study of landscape parameters on Juniper growth, that which parameters have the best effect on this species growth. Therefore in different slope and aspects, we measured parameters include total height, canopy height, canopy diameter and basal diameter. To order of study of grow of juniper species in different slopes and aspects in Aminabad region of Firozkooh (Tehran province), thrown inventory network to systematic random, then in study area, number of 40 sample plots (0.5 ha) was taken. Then parameters include total height, canopy height, canopy diameter and basal diameter were measured. Slope and aspect maps were supplied with GIS. The results show that greatest diameter of trees was in southeastern and the greatest height was in west aspect, and the most height and diameter was in average slopes. Therefore, for planting with this species, at first west, southeastern aspects and average slopes were suggested.

Keywords: mountain landscape, Juniperus polycarpus L., Firozkooh, Iran

Introduction

Iran is located in 26 until 39 degree that is sub-arid, arid and desert region in the world. In the mountain areas in Iran because of humid climate, shrub and tree species are grown. Among tree species, genus of Pistacia with famous species *P. mutica* L. has the largest area in Iran. After that genus of Juniperus with species *J. excelsa* and *J. polycarpus* cover the large area of elevations in Iran.[*]

Genus of Juniperus in Iran has six species and sub- species that grow in mountain landscapes. Juniperus occupied arid lime areas and we can see them in Alborz, Khorasan, Azarbaijan, Arak, Kerman, Balochestan and etc.

Many studies were done in the world about effect of ecologic factors on evergreen and conifer species. Fisher & Gardner (1995), with studying on juniper forests in the north of Oman show that topography, hydrology and climate condition has large effect on Juniper species growth. Kanji (2000), with studying on forests in the north of Japan show that conifers just grow in the south, west or west southern aspects. Razzag (1986), soil depth, rainfall, and aspect are the effective factors on growth of *Pinus eldarica*. Johnson & Miller (2006), they study factors such

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as topography and elevation on the growth of *J. occidntalis* in the USA. The results show that settlement and density of trees in upper elevations and in the north aspects has been increased. Moemeni moghadam (2002), the number of ecologic characteristics of Juniper species was studied in Shirvan (Khorasan province), and then the results show that slope effect on survival, number in hectare and form quotient and aspect effect on canopy height to total height and form quotient and biodiversity.

Our purpose of this study is study of landscape parameters on Juniper growth, that which parameters have the best effect on this species growth. Therefore in this study the effect of slope and aspect on the growth of Juniper species was studied.

Material and methods

In the way of Firozkooh (Tehran province) after Homand, in the slopes and elevations of this region, the stands of Juniper species were determined. Soil depth is low that is 15 to 30 cm, the altitude is 2600 until 2710 m, dominant species is Juniper in this region. The amount of bearing fruit trees is very much, but there are very low seedlings in the region. The study area is located in the Hableroad watershed, in 35∘ 42′ to 35∘ 44′ northern latitude and 52∘ 33′ to52∘ 35′ eastern longitude.

For doing this study, at the first we distinguished the region in the topography map, then thrown the inventory network with 100*500 dimension and 40 plots with 0.5 ha area. After that height and diameter growth variables in the different slopes and aspects were measured. The data were analyzed in the SAS software and with SNK test.

Results

The results show that the most basal diameter was in southeastern (44.67 cm) and the least basal diameter was in northwestern (31.57 cm) (figure 1). The results of the means comparison show that aspect had the significant effect on the height of trees in 1% level of probability and the most height was in west (6.19m) and the least height was in southwestern (5.12m) (figure 2).

The results of the means comparison in different slopes show that slope had significant effect on basal diameter of trees in 5% level of probability, and the most basal diameter was in 80% of slope (40.03 cm) and the least was in 20% of slope (27.84 cm) (figure 3).

In 5% level of probability, slope had the significant effect on height of trees and the most height was in 55% of slope (7.26m) and the least height was in 15% of slope (5.03 m) (figure 4).

Canopy height had the different significant in different aspects in 1% level and the most canopy height was in west (6 m) and the least canopy height was in southwestern (5.2 m) (figure 5). The most canopy diameter was in west (4.57 m) and the least was in west southern (3.57 m) (figure 6).

The results show that slope had the significant effect on the canopy diameter of trees in 5% level that the most canopy diameter was in 55% of slope (4.57 m) and the least was in 20% slope (3.6 m) (figure 7). Slope in 5% level of probability had the significant effect on canopy height and the most was in 55% of slope (7.3 m) and the least was in 15% of slope (5.04 m) (figure 8).

Discussion and conclusion

Because these species was grown in mountain regions and in the hard condition as climatic and etc., in these regions for assessment growth variables, factors such as basal diameter because of b coppice, canopy diameter and height because of much distance between trees that cause increasing diameter growth, were measured.

The results of this study shows that aspect and slope as mountain landscape parameters had the significant effect on basal diameter, total height, canopy height and canopy diameter. The highest trees were in the west and the most diameters were in southeastern aspect. Jonhson (2006), in his study on Western Juniper shows that topography is the effective factor on its growth.

Kanji (2000) conifers grow in the west, south and south western. In our study too, we show that the most growth was in the west.

Fisher and Razzag (1995 & 1998) topography factors and aspect have significant effect on the growth of Juniper species and *Pinus eldarica*. In our study too, aspect had the significant effect on the Juniper growth.

Therefore we can suggest that for planting with Juniper species in the mountain area for sustainable development of these regions and better management, at the first, west aspect then eastern and in average slopes was selected.

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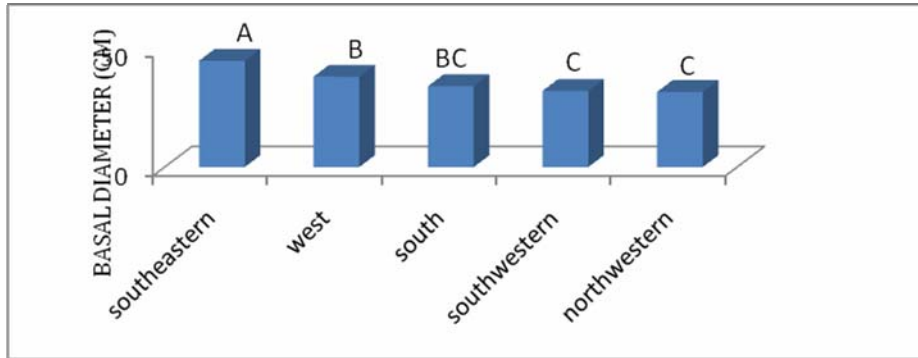
Figure 1: basal diameter of trees in different aspects
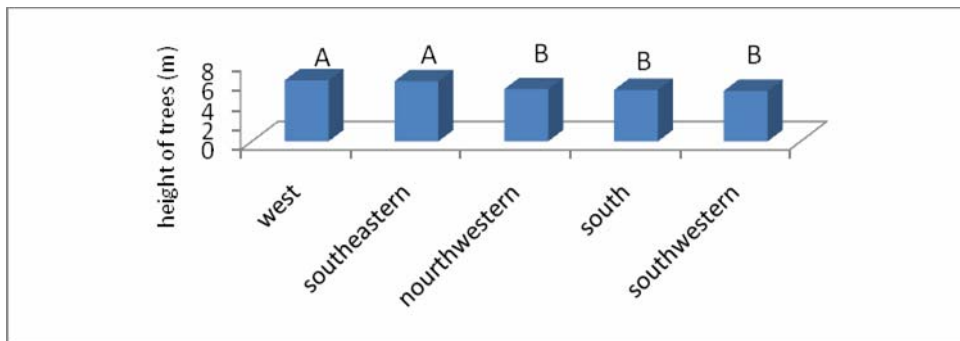
Figure 2: total height of trees in different aspects
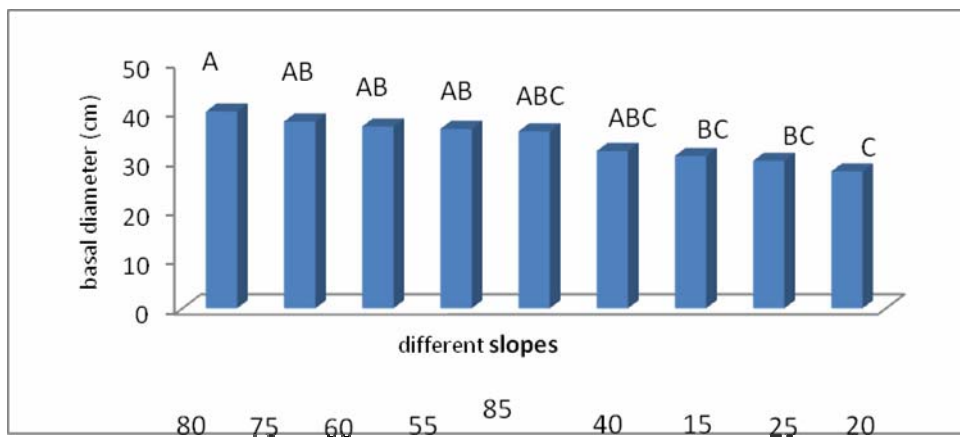
Figure 3: basal diameter in different slopes
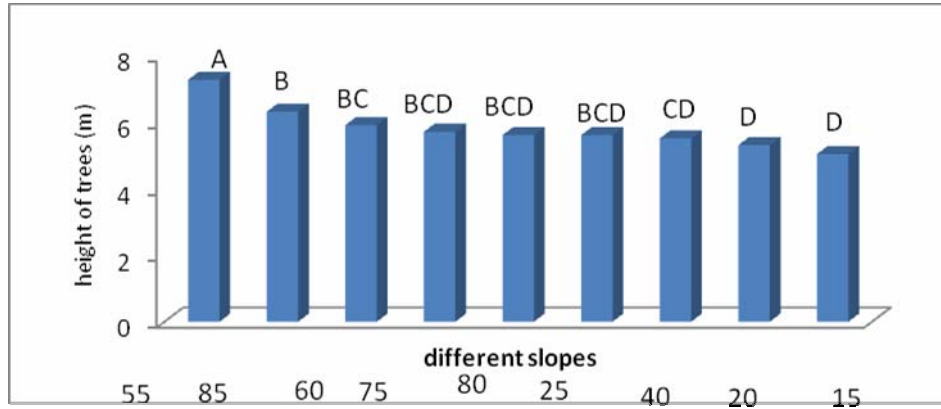
Figure 4: height of trees in different slopes
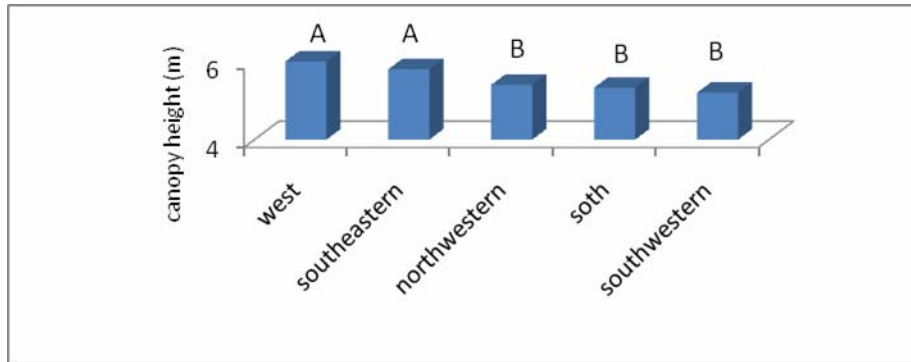
Figure 5: canopy height in different aspects
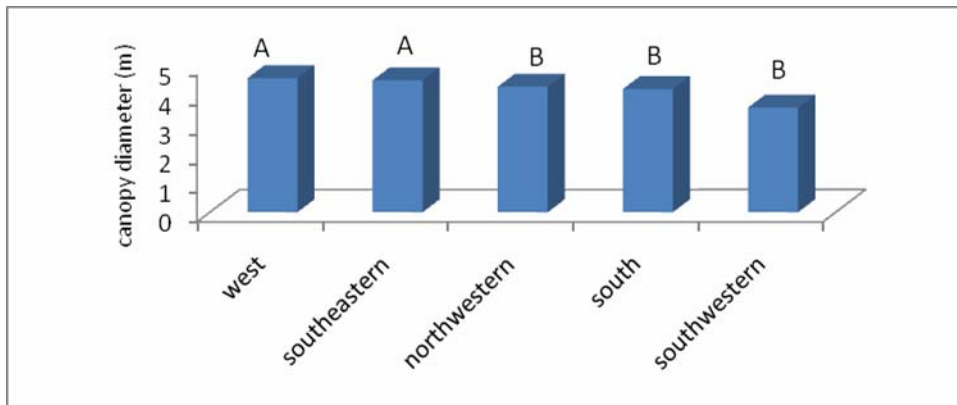
Figure 6: canopy diameter in different aspects
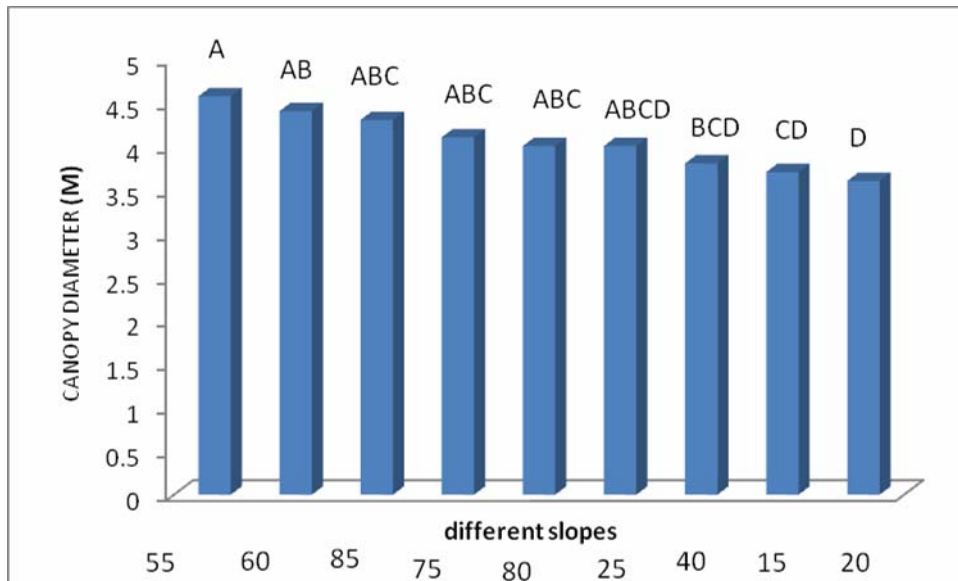
Figure 7: canopy diameter in different slopes
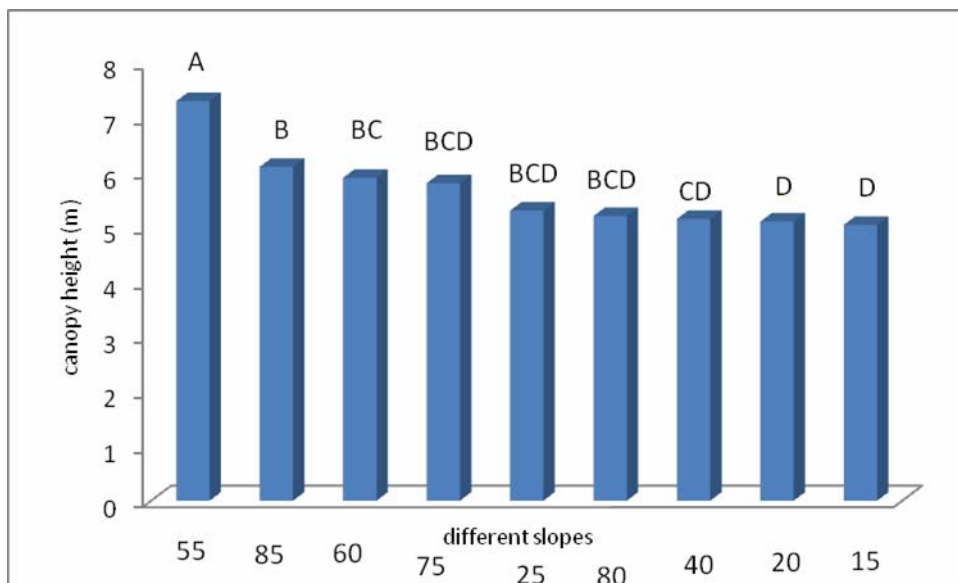
Figure 8: canopy height in different slopes

Spatial dynamics of chestnut blight disease at the plot level using the Ripley's K function

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Abstract

We used the Ripley's K function to describe the spatial dynamics of chestnut blight (*Cryphonectria parasitica* (Murrill) Barr) in sweet chestnut orchards to look at pattern in the pathogen distribution over time and the effect of the location of infected trees on the pattern of disease spread. We used data on infected and dead trees in 2003, 2004, 2005, and 2009 in 4 orchards located in Curopos parish, Portugal. We found both random and aggregated patterns of infected trees in the beginning of the study period and significant association of infected trees between successive dates, particularly at short distances. Two of the 4 studied orchards showed significant clustering of infected and dead trees in any of the dates observed but random spatial pattern in the remaining two which can possibly be explained by both natural propagation of the disease and management practices.

Keywords: Cryphonectria parasitica, chestnut blight, Ripley's K function, Portugal

1. Introduction

Although the recognition of the importance of the spatial dimension in the study of infectious diseases is not new, only recently significant developments in spatial pathology and epidemiology took place. Landscape and spatial epidemiology emerged in the 2000's from the application of landscape ecological concepts and methods in the analysis of disease dispersal in animal, human, and plant hosts (Ostfeld 2005, Plantegenest et al. 2007). Similarly, landscape pathology has grown within landscape ecology and forest pathology dealing with large scale disease propagation processes and the ways they affect and are affected by landscape heterogeneity (Holdenrieder et al. 2004).

The spatial propagation of pathogens at small scales (e.g., forest stand) is also ecologically relevant, although seldom approached in the literature. The understanding of small scale epidemiology processes is of interest in explaining, modeling and forecasting pathogen related spatial processes at this particular scale as well as at larger scales such as national- or regional-level pathogen dispersal (e.g., Kelly and Meentemeyer 2002).

In this study, we analyzed spatial patterns of chestnut blight (Cryphonectria parasitica (Murrill) Barr) infected trees at the orchard level over time. The objectives were to i) investigate pathogen spread temporal and spatial pattern, and ii) analyze the effect of the location of infected trees on the spatial pattern of disease spread.

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2. Methodology

We used data from 4 orchards located in the Curopos parish, Vinhais, Portugal, that have been monitored for individual tree health condition based on field surveys in 2003, 2004, 2005 and 2009 (Table 1; Fig 1). Common management practices in these plots included pruning, excision of cankers and replacement of dead trees.

Table 1: Area of study plots and number of dead and infected trees per plot and year

	Plot 1	Plot 2	Plot 3	Plot 4
Area (ha)	1.34	1.85	0.92	1.05
Dead and infected trees (no.)				
2003	21	37	12	71
2004	38	60	18	88
2005	14	54	11	94
2009	96	148	118	104

We analyzed the spatial pattern of dead trees and trees presenting symptoms of blight disease with the Ripley's K function (Ripley 1976). This second-order analysis method allows summarizing spatial patterns, fitting models to describe patterns and comparing patterns among events at variable scales (Dixon 2002). Although the method fits the point-set structure of trees at the plot level the use of Ripley's K is very rare in plot level pathology studies.

The Ripley's K(t) is estimated as (Haase, 1995):

$$\hat{K}(t) = n^{-2} A \sum_{i \neq j} \sum w_{ij}^{-1} I_t(u_{ij}) \tag{1}$$

where
n is the number of individuals (locations) in the plot,
A is the area of the plot (m^2)
I_t is a counting variable,
u_{ij} is the distance between i and j locations, and
w_{ij} is a weighting factor for edge correction purposes.

The bivariate form of K(t) is estimated as (Dixon, 2002):

$$\hat{K}(t) = n_1 n_2^{-1} A \sum_{i}^{n_1} \sum_{j}^{n_2} w_{ij}^{-1} I_t(u_{ij}) \tag{2}$$

where n_1 and n_2 are the number of individuals in the populations under comparison.

K can be normalized as $L(t) = \sqrt{K(t)/\pi}$ and represented graphically as $L(t)$-t as a function of t. Positive values of $L(t)$-t indicate aggregation of events while negative values indicate a regular pattern. In the bivariate form, positive values indicate association between populations of events and negative values indicate segregation. Zero values indicate complete spatial randomness (Poisson) in the univariate case and no pattern in the bivariate case. Confidence intervals are created to test for significance of pattern.

We used RIPPER (Feagin & Wu, personal communication) to calculate Ripley's K with the edge correction method of Getis & Franklin (1987). Maximum distance was half side of the plot and the same box size was used in each plot for all the dates considered. 95% confidence intervals were established based upon 200 Monte Carlo simulations.

Plot 1   **Plot 2**

Plot 3   **Plot 4**
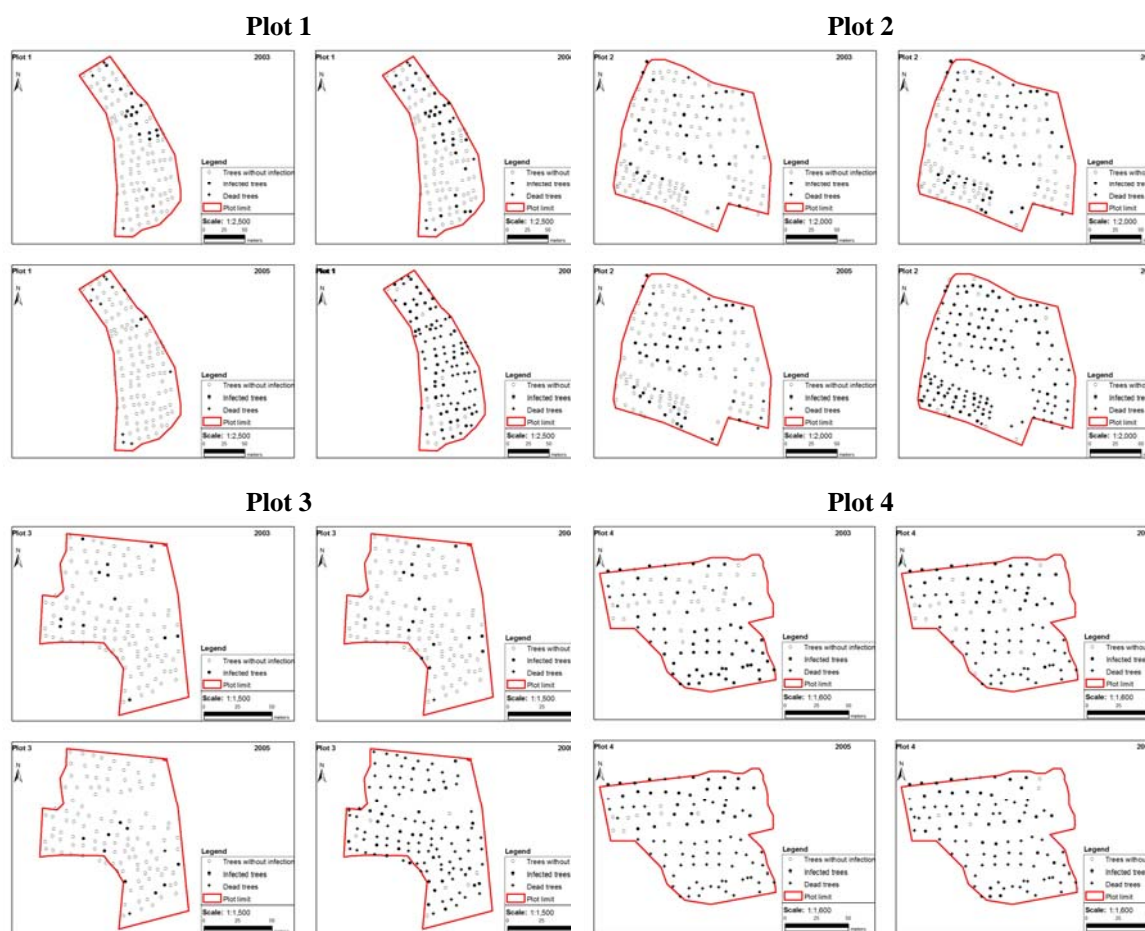
Figure 1. 2003, 2004, 2005, and 2009 health status of individual trees in 4 plots in the Curopos parish, Portugal.

3. Resuls

In Plot 1, there was statistically significant clustering of infected trees at distances above 10m in any of the surveyed years (Figure 2). The same pattern was observed in Plot 4 although the strength of clustering was much lower. Plots 2 and 3 showed weak aggregation, often non-statistically significant. In Plot 2 there was slightly significant clustering for distances from15 to 25m in 2004 and 2005 and above 10m in 2009. In Plot 3 there was significant clustering from 25 to 50m in 2005 and above 10m in 2009 (Figure 3).

Plots 1 and 4 revealed association of infected trees at all distances between all compared dates with the exception of the 2005-2009 period in Plot 1, where statistically significant association was observed below 10m only (Figure 4). Plot 2 showed significant association for distances shorter than 35m for all comparisons. Plot 3 showed significant association for short distances (20m) for 2003-2004 and 2004-2005 and for almost all distances for the 2005-2009 comparison.

4. Discussion

As suggested in previous research on this host-pathogen relationship in the same region and at the same scale (Gouveia et al. 2005), the infection pattern of chestnut blight at the orchard level is random at the beginning of the disease spread process. It becomes later aggregated when

contamination occurs from the initially infected trees either naturally and by means of management practices, such as pruning, that increases infection at near distances. In this study we analysed data from a period of time larger than in Gouveia (2005), in a stage of dispersal when blight is present in the entire region and when spread within orchards at short distances already took place. Therefore, clustered patterns were to be expected for infected trees in all plots. This happened only in Plots 1 and 4, however. Plots 2 and 3, showed a pattern generally random in 2003, 2004 and 2005. The reasons for this are still unknown.
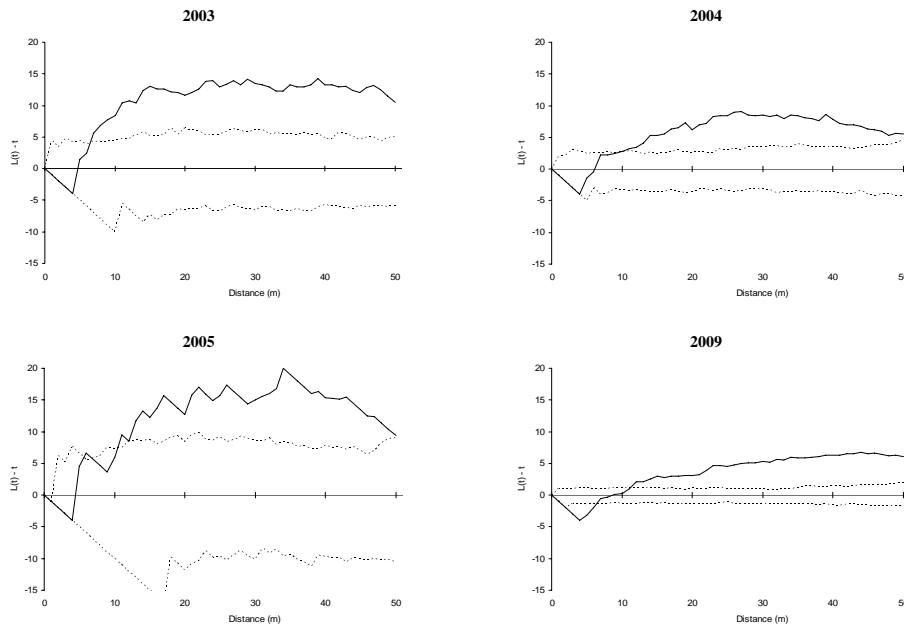
Figure 2. *L(t)-t* plots (solid lines) for 2003, 2004, 2005 and 2009 dead and infected chestnut trees in Plot 1. Dashed lines are 0.025 and 0.975 quantiles of L(t) - t estimated from 200 Monte Carlo simulations.
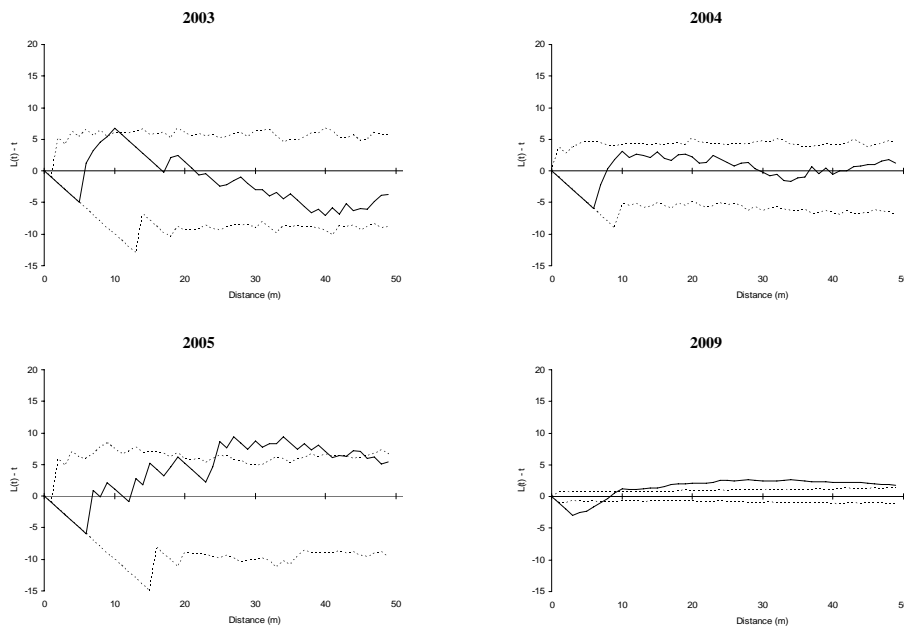
Figure 3. *L(t)-t* plots (solid lines) for 2003, 2004, 2005 and 2009 dead and infected chestnut trees in Plot 3. Dashed lines are 0.025 and 0.975 quantiles of L(t) - t estimated from 200 Monte Carlo simulations.

It should also be expected that the location of infected trees in one date was associated with the location of infected tree in the previous date. We observed significant association in most of the cases, stronger for shorter distances. This seems to corroborate the previously presented hypothesis, according to which infected trees are spreading blight to the nearer neighbouring trees. In any case the spread of chestnut blight was very fast at the orchard level. Notice the infection and/or death in the 2005-2009 period (Table 1; Fig 1).

The role of management practices in the spread of the disease is still unclear but it is certain that fast spread of blight as observed here could be also due to anthropogenic factors such as the infection of adjacent trees with infected tools.
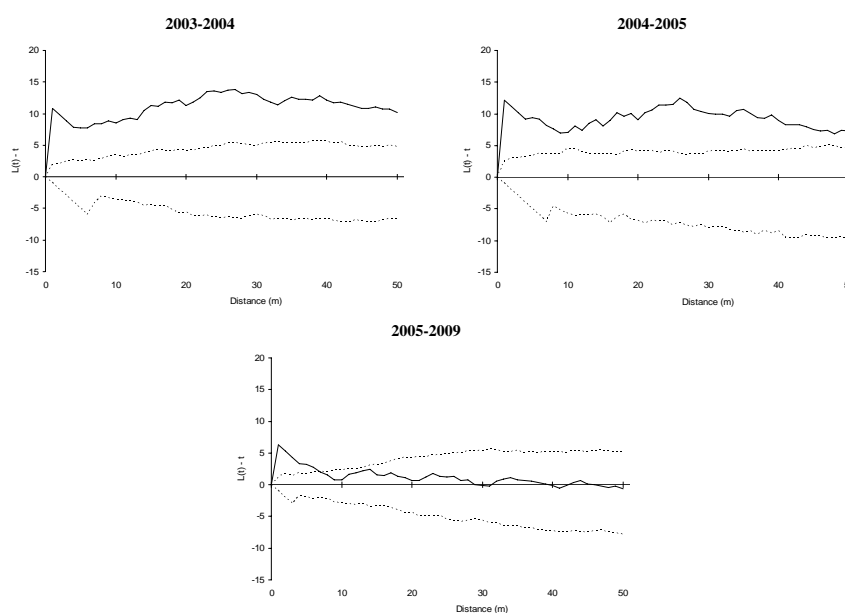
Figure 4. *L(t)-t* plots (solid lines) for comparisons of dead and infected trees in Plot 1 for the 2003-2004, 2004-2005 and 2005-2009 periods. Dashed lines are 0.025 and 0.975 quantiles of L(t) - t estimated from 200 Monte Carlo simulations.

5. Conclusion

In this study we found that in 2 of the 4 studied orchards there was significant clustering of infected trees in any of the dates observed. In the other two cases infected and dead trees showed a random pattern. Infected trees in one date were spatially associated with trees infected the previous date. The results indicate that fast short distance spread of chestnut blight occurs within orchards.

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The third dimension in landscape metrics analysis applied to central Alentejo - Portugal

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Abstract

Landscape metrics have been widely developed over the last two decades, although the question remains: How does landscape metrics relates with ecological processes?

One of the major recent developments in landscape metrics analysis was the third dimension integration. Topography has an extremely important role on ecosystems function and structure, even though the common analysis in landscape ecology only conceives planimetric surface which leads to some erroneous results, particularly in mountain areas.

The analytical process tested patch, class and landscape metrics behavior in 11 sample areas of 100 sqkm each in several topographical conditions of Central Alentejo. It is presented the significance analysis of the results achieved in planimetric and 3D environments.

Keywords: Landscape metrics; 3D, topography, Local Landscape Units, Alentejo, OTALEX

1. Introduction

Landscape ecology studies landscape structure, functions and changes. Landscape structure is characterized by the composition and configuration of landscape patterns. One of the main premise is that landscape structure is connected with landscape functions and processes (Turner 1989, von Drop & Opdam 1987, McIntyre & Wiens 1999). 3D-issue in Landscape Ecology have been studied and applied by several researchers in the past 10 years, in many different approaches (Dorner *et al* 2002, Bowden *et al* 2003, Jenness 2004, Lefsky *et al* 2002, MacNab 1992, Pike 2000, Sebastiá 2004, McGarigal *et al* 2008). Topography is actually a key factor for many ecological processes, such as erosion, flow direction and accumulation, temperature and biodiversity distribution and fire (Swanson *et al* 1988, Burnett *et al* 1998, Bolstad *et al* 1998, Davis & Goetz, 1990 and Blaschke *et al* 2004). However it is not taken in to account in most landscape ecological studies. Only a few recent studies applied 3D to landscape metrics (Hoechstetter *et al* 2006, Hoechstetter *et al* 2008, Hoechstetter 2009, Jenness 2004, Jenness 2010, Walz *et al* 2010). Others issues like viewsheds and landscape preferences have been studied by Sang *et al* (2008).

This paper presents part of the landscape studies carried out by the Environmental Indicators Working Group (EIWG) of OTALEX - Alentejo Extremadura Territorial Observatory (www.ideotalex.eu) (in OTALEX II Project co-financed by Operational Program for Cooperation between cross border Regions of Spain and Portugal - POCTEP), in Central Alentejo (Portugal). The main questions are analyzed:

- Are there significant differences in landscape metrics calculated using real surface area (3D) instead of planimetric area (2D)?
- Are there significant differences between the sample areas?

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2. Methodology
2.1 Characterization of study area
The study area is located in Central Alentejo, South of Portugal. It covers about 7.400 sqkm and has about 175000 inhabitants, concentrated in small and median villages and cities. Altimetry varies between 7 and 648 m. We selected 11 sample areas, of 100 sqkm each, located along Central Alentejo, representing 15% of the total area (figure 1).

2.2 Local Landscape Units (LLU)
The definition of landscape units (paths) was based on Corinne Land Cover level 5 (CLC N5) map at scale 1:10.000 (Batista *in press*), altimetry (MDT 25m) and soil units (at sale 1:25.000). Land cover (LC) map applies hierarchical CLC N5 legend developed by Guiomar *et al* (2006, 2009), with 295 LC classes. The land cover map was elaborated using digital ortophotomaps from 2005 (from DGRF 2006) and field validation at the end of 2008. The LC map has been previously generalized to create the LLU map. From the overlay of these maps derived 103 Local Landscape Units (LLU) (figura 2).

2.3 True Surface Area and Perimeter Calculation and Landscape Metrics
3D applied to landscape metrics implies to calculate those using true surface area and perimeter measurements (Hoechstetter 2009). Surface area provides a better estimate of the land area available than planimetric area, and the ratio of this surface area to planimetric area provides a useful measure of topographic roughness of the landscape (Jenness 2004).
It was used LandMetrics-3D developed by Walz *et al* (2010), which is an ARCGIS extension that integrates the available tools for calculating true surface area developed by Jenness (2004, 2010) (http://www.jennessent.com/arcgis/surface_area.htm, last modified April 8, 2010) and the fragstats landscape metrics of McGarigal *et al* (2002). The application uses a moving window algorithm and estimates the true surface area for each grid cell using a triangulation method (Figure 3). Each of the triangles is located in three-dimensional space and connects the focal cell with the centre points of adjacent cells. The lengths of the triangle sides and the area of each triangle can easily be calculated by means of the Pythagorean Theorem. The eight resulting triangles are summed up to produce the total surface area of the underlying cell (for details see Hoechstetter *et al* 2008, Hoechstetter 2009 or Jenness 2010).
The analytical process integrates the calculation of Patch, Class and Landscape metrics for the 11 sample areas, for 2D and 3D. The metrics analyzed where: Patch Geometry - Patch Area (Area) and Perimeter (Perim), Shape Metrics - Fractal Dimension (FractDim), Perimeter /Area Racio (Racio), Shape Index (Shape), Density/Edge Metrics - Edge Density (EdgeDens), Edge Contrast (Edgecont), number of patches (Numofp), Surface Metrology – Average Roughness (Avrough) and RMS Roughness (RMSrough).

3. Results
The statistical analysis involved 221.382 records generated by 3D-LandMetrics software, for the 2 dimensions (2D and 3D), 11 sample areas and 9 landscape metrics. An ANOVA with multiple comparing of means (LSD de Fisher method) was run (table 3), resulting in pairwise comparison, for $p<0,05$, significant differences between dimensions (2D and 3D) (table 4), between sample areas and between metrics and interactions between dimensions / sample areas and dimensions /metrics. In table 5 are presented the results of multiple comparisons between sample areas, with a significance level of 5%. Metrics presents a p-value=0,000, which means that all presents significant differences among them.

4. Discussion
This first approach to the analysis of landscape metrics in the Central Alentejo revealed that the introduction of the third dimension in landscape metrics calculation induces significant differences among the studied landscape metrics, and should be considered in landscape

analysis. However these results should be carefully interpreted as in previous research developed by Hoechstetter (2009), certain metrics groups do not reveal a significant difference between their 2D- and 3D-versions (e.g. shape metrics), and some of the algorithms (especially for the distance metrics) involve a considerable computational effort.
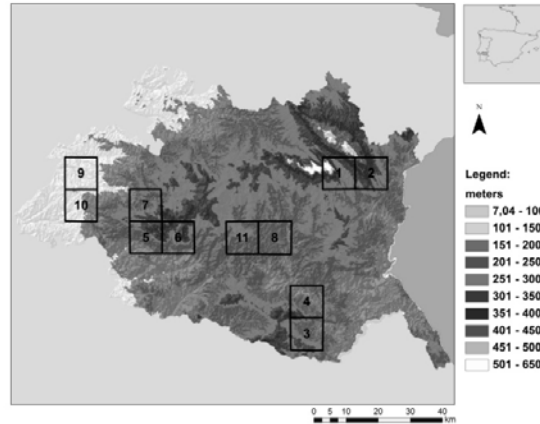
Figure 1: Sample areas localization. Central Alentejo – Portugal
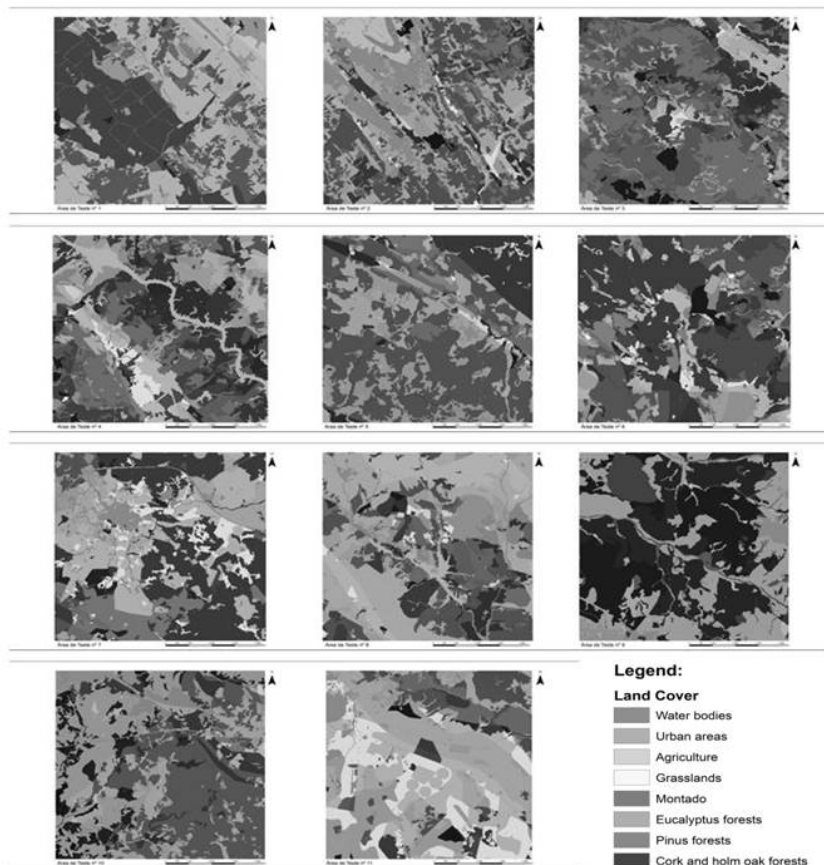
Figure 2: Sample areas local landscape units
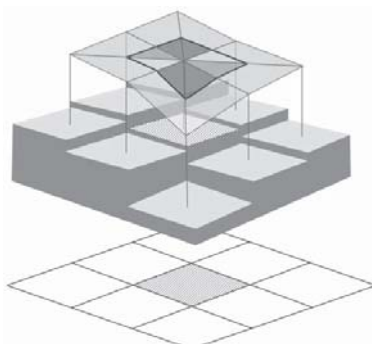
Figure 3: Method to determine true surface area and true surface perimeter of patches. (figure redrawn according to Jenness 2004 by Hoechstetter et al 2008).

Table 2: Subject factors for significance analysis

Between-Subjects Factors

		Value Label	Nº
Dimension	1	2D	110691
	2	3D	110691
Area	1	Quadr2 (A1)	18990
	2	Quadr4 (A2)	31842
	3	Quadr5 (A3)	25578
	4	Quadr6 (A4)	20538
	5	Quadr7 (A5)	18054
	6	Quadr8 (A6)	17892
	7	Quadr9 (A7)	22626
	8	Quadr10 (A8)	22158
	9	Quadr11 (A9)	9882
	10	Quadr12 (A10)	19980
	11	Quadr13 (A11)	13842
Metrics	1	EgdeDens_LSC	24598
	2	AvgRough_LSC	24598
	3	RMSRough	24598
	4	EdgeCont_LSC	24598
	5	Shape_LSC	24598
	6	NumOfP_LSC	24598
	7	Perim_P	24598
	8	Ratio_LSC	24598
	9	FractDim_LSC	24598

Table 3: ANOVA results

	Df	Sum Sq	Mean Sq	F value		Pr(>F)	
Dimension	1	4,18E+13	4,18E+13	62459,7	<	2.2e-16	***
SampleArea	10	1,36E+12	1,36E+11	203,75	<	2.2e-16	***
Metrics	8	6,23E+14	7,79E+13	116345,7	<	2.2e-16	***
Dimension/Area	10	7,48E+11	7,48E+10	111,66	<	2.2e-16	***
Dimension/Metrics	8	8,11E+13	1,01E+13	15147,26	<	2.2e-16	***
Residuals	221344	1,48E+14	6,70E+08				

Signif. Codes: 0'***'; 0,001 '**'; 0,01 '*'; 0,05 '.'; 0,1 ' ' ; 1

Table 4: Pairwise comparison between 2D and 3D

Dependent Variable:Rank of Results

(I) Dimension	(J) Dimension	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
2D	3D	-27062,292[*]	112,650	,000	-27283,082	-26841,502
3D	2D	27062,292[*]	112,650	,000	26841,502	27283,082

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 5: Results of pairwise comparison between the sample areas

	Differes from:
Quadrado 2 – A1	Quadrado 4,6,7,10,11,12,13
Quadrado 4 – A2	Quadrado 2,5,6,7,8,10,11,12,13
Quadrado 5 – A3	Quadrado 4,6,7,9,10,11,12,13
Quadrado 6 – A4	Quadrado 2,4,5,7,8,9,10,12,13
Quadrado 7 – A5	Todas as áreas
Quadrado 8 – A6	Quadrado 4,6,7,10,11,12,13
Quadrado 9 – A7	Quadrado 5,6,7,10,11,12,13
Quadrado 10 – A8	Todas as áreas
Quadrado 11 – A9	Todas as áreas excepto a do quadrado 6
Quadrado 12 – A10	Todas as áreas
Quadrado 13 – A11	Todas as áreas

Acknowledgments

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New classification and utilization of forest functions in landscape

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Abstract

Main aim of the research task is scientific assessment of acquired knowledge on functional effects of forests under real ecological, forest management and socio-economic conditions of the regions of Slovakia. Constructed is new classification system in which we divided strictly tree species functions understanding how influences or effects on particular compounds of environment (- ecological sphere) and their utilization by a human society in economic and social sphere. In this way can be offered integrated functions of tree species and their communities how goods or service.

To the forest function (tree species function) and its classification we access individual. Here are important indicators structure and ecological stability of tree species community. To the possibilities of utilization of forest functions we use integration of forest functions and economic access.

Current ecological or ecosystem approach to the forest functions and possibilities of their utilization changed actual access to forest functions.

Key words: Forest functions, classification of forest functions, utilization of the functions of forest tree species

1. Introduction

Forests and other communities of tree species play irreplaceable functions in the landscape from the viewpoint of the ecological stability of the landscape, its rational utilization and sustainable development. Forests represent a basic landscape forming and ecological and stabilizing element of the landscape. They are the most important source of renewable resources and thanks to their functions they play an important role also in the formation and protection of individual components of natural environment as well as the environment changed by anthropogenic activities and anthropic (artificial environment created by a man).

1. 1 Aim of scientific-research activities

Main aim of the research task is to assess recent knowledge on functional effects of forests in real ecological, forest management and socio-economic conditions of individual regions of Slovakia with the utilization of the latest knowledge of present ecology and economics of natural resources. On the basis of that was created new classification, a classification system, methodology of the valuation of forest functions and it will be proposed the methodology of determining the rate of ecological-stabilization effect of forests in the landscape.

Main objectives of research task dealing with forest functionsare dissemination of scientific knowledge on forest functions and possibilities of their utilization in the landscape, construction of classification system of forest functions, construction of a system of assessment and valuation of forest functions and tree species communities from the viewpoint of their multifunctional utilization.

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1.2 Significance of the issues solved

The importance of these issues follows also from the fact the European Commission issued COM no. (88) 255 concerning the strategy and action plan of the Community in forestry and set up in total 6 objectives for forest sector, of them 4 are directly related to the solved issue:

- Support the participation of the whole forest sector in planning the utilization of the landscape and thus to contribute to rural development
- Contribute to the protection and improvement of the environment
- Secure dynamic development of forestry that would enable better fulfilment of individual forest functions
- Enhance importance of forests as a natural environment for recreation.

It follows from the mentioned above that the future of forestry depends on the importance of the forests in a society. Interrelations of human society and tree species and their utilization of their functions have changed in time and space. A man used the functions of tree species and their communities in the landscape in dependence on the number of a concrete human population, natural conditions, and way of living as well as in dependence on social, economic and cultural development of a society.

In accordance with EU forestry strategy one of basic goals of forest policy in Slovakia is enhancement of multifunctional (functionally integrated) management of forests and protection of the potential of their functions. We must handle functional potential of forests as the natural wealth and to preserve and improve it by proper management.

Among the most serious problems limiting effective applying the system of multifunctional forest management is mainly discordance between social order for forest functions and their economic funding.

2. Methodology
2.1 Theoretical and methodical starting points

Despite the fact the issues of forest functions were solved mainly in the 70-80s of the past century the solution has not been completely and satisfactorily finished what concerns the functions of tree species and their communities in new ecological and socio-economic conditions of Slovakia. Recently prevailing perception of the nature and forest, which served the man and his requirements caused that forest functions were considered services with purposeful selection and social utilitarian prioritisation.

Modern ecological approach to forest and forest functions in the landscape must consider the latest knowledge on ecosystem research of forest. This view at forest ecosystems must necessarily consider long-term time factor bringing about various dynamics of the changes of ecological, economic and social conditions, but mainly different view at forest functions and their utilization. From this viewpoint the way of functional integration seems to be substantially more effective and more pragmatic than the way of purposeful differentiation and prioritisation of some of the functions.

To be able to use this approach it is necessary to extend greatly scientific knowledge on forest functions and possibilities of their utilization in the landscape as well as to construction a new classification system of forest functions that would consider ecological approach to forest as to ecosystem.

This approach presupposes construction of basic typology and the system of the evaluation of forest functions potential and assessment of real fulfilment of the functions by forest growing under various site conditions, various types of the landscape (with various use and degree of anthropic changes), with regard to the health condition of a real forest, its current tree species composition, age and spatial arrangement of forest as well as to with regard to its ecological stability considering expected global and regional (mainly climatic) changes with regard to social requirements and the interests of forest owners.

Forest management as a production sector lives on the sale of own products. From this viewpoint production forest functions brings profit and all other forest functions are only a load for forest manager, it means they are not equal to production function. The core of the integration of forest functions is namely mutual comparison and evaluation of various forest functions, their reflection in the system of management in forest and assessment of benefits resulting from various ways and interlinking of forest functions use into optimal proportions. Forest manager must know which forest benefits the society needs to be able to set the goals of management.

Our task was not simple as it is to construct the classification system of the assessment of the potential of forest functions and real fulfilment of the functions by forest growing in various site conditions and types of the landscape with various utilization and degree of anthropic changes with regard to real state of forest, its current tree species composition, age and spatial structure, ecological stability considering not only historical development and present state but also expected global and regional (mainly climatic) changes and anthropogenic effects as well as with regard to social requirements and interests of the owners.

2.2 Analysis of ecological-stabilization and functional effectiveness of forest ecosystems in the landscape

On the basis of available literature experimental results there was carried out primary analysis of the functional effectiveness of forest ecosystems in the landscape and the system for its detection and classification was worked out. This system follows up the system of the classification of ecological stability (Caboun 2002, 2003), as long-term ecological stability is a basic precondition for securing long-term functionality of forests.

We understand ecological stability as an ability of the ecosystem to resist or compensate external as well as internal effects without any marked permanent disturbing of the functional structure of this system.

Natural ecosystem develops in accordance with given conditions and usual abiotic and biotic factors. These conditions and factors form ecosystem (the effect of the environment) what appears also for the given conditions in its specific structure (tree species composition, age and spatial structure) and subsequently in its ecological stability. Optimal solution from the viewpoint of ecological stability, and thus also optimal functionality of the ecosystem is on the basis of our knowledge solution of nature through natural ecosystems. A man from the viewpoint of the need of satisfying own needs influenced the structure of forests to different extent, and thus he influenced also their ecological balance, ecological stability and subsequently resulting fulfilment of the forest functions.

Graphs of percent reduction of partial ecological stability in dependence on the degree of difference of the studied indicator of a real (assessed) forest ecosystem in comparison with optimal forest ecosystem corresponding to the site are a part of the classification system of partial ecological stability of individual indicators. Construction of models or their specification to the level of forest types or types of forest is a demanding and long-term task of further research in cooperation with the people who implemented and verified the proposed system.

The determination of the ecological stability for individual time horizons is based on individual development phases or their changes during the studied period as well as presupposed site changes during this time.

For each development phase it is possible to determine in general the range of its primary – initial ecological stability on the basis of hypothetical models of ecological stability and its components of individual development phases of tree species.

The sense and practical importance of ecological stability lies in the fact that on the basis of found facts and values it is possible to propose and optimal way of management in accordance with natural regularities in a way to strengthen the required component of ecological stability – resistance or flexibility with regard to the fulfilment of the required forest functions, the time of

fulfilment of these functions and mainly with regard to expected decisive factors influencing the existence and ecological stability of a concrete forest. Interlinking of functional effectiveness and ecological stability through the structure corresponding to site follows up with the proposal of starting points for the construction of the classification system of forest functions.

3. Results: Forest functions – classification and possibilities of their utilization

In the proposal of the classification system of forest functions there are clearly distinct forest functions being perceived as the effect of forest on individual components of the environment from the utilization of these functions by a man. Systematic solution of the methodological approach to forest functions and their classification is presented in Figure 1.
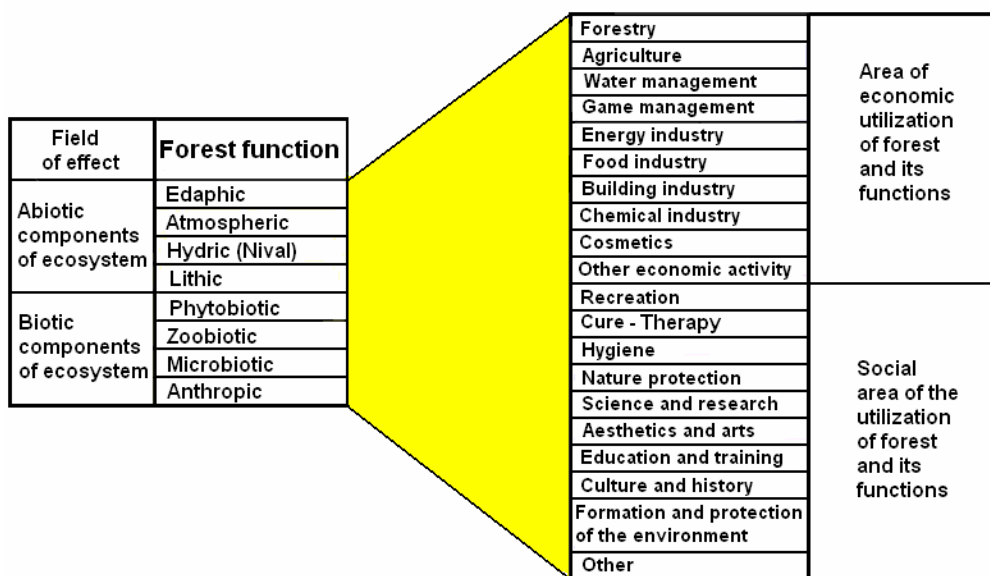
Figure 1 Ecosystem approach to forest and other communities of tree species in the landscape, their functions and possibilities of functions utilization in economic and social fields (Caboun 2005)

We distinguish basic forest functions affecting abiotic components of the environment (air, water, soil) and biotic components (plants, animals, microorganisms, man).

In this way tree species and their communities fulfil in the landscape edaphic, atmospheric, hydric and lithic function what concerns abiotic components of the ecosystem, and phytobiotic, zoobiotic, microbiotic and anthropic function what concerns biotic components of the ecosystem. In other words it is the quality and quantity of the effect of tree species and their communities on the soil, climate, water, rocks, plants, animals, microorganisms and man.

These functions are divided into partial functions. For example edaphic function comprises soil forming, soil reclamation and soil protection functions, which consists of erosion control, anti deflation, anti slides function, avalanche control and bank protection function.

A human society may use a complex of these functions for economic purposes or in a social area. Then forestry, water management, game management, agriculture, energy industry, food industry, building industry, chemical industry, cosmetics, pharmacy etc. belong to anthropic fields using forest functions in economic area. Similarly, forest functions may be used in social area, it means for recreation, curing, hygiene, for nature protection, formation and protection of the environment, science and research, education and training, aesthetics and arts, culture and history and others.

This classification of forest functions creates a basic information base for the possibility of the utilization of the functions of tree species and their communities in the landscape by human society.

The aim is to construct the classification system for the assessment of the potential of forest functions and real fulfilment of the functions of a forest growing in different site conditions and types of the landscape with various use and degree of anthropic changes. An emphasis will be put on the real state of forest, its current tree species composition, age and spatial structure, ecological stability considering not only historical development but also present state as well as its expected development, global and regional (mainly climatic) changes and anthropogenic effects, and social requirements and the interests of the forests owners.

A new important element in the utilization of forest functions is financial reimbursement paid to the forest owner for the provided services

Philosophy of practical use and methodology in detecting, classifying and valuation of forest functions in the landscape is expressed briefly in following points:

- Setting apart a part of the landscape for the assessment and valuation of forest functions
- Ecological-functional typifying of determined part of the landscape and attributing of corresponding (potential) communities of tree species
- Evaluation of the difference of the structure of real forests with optimal structure of potential forests in the determined part of the landscape
- Determination of ecological-stabilization rate (effect) of real forests in the determined part of the landscape (classification of ecological stability of forests and particular part of the landscape)
- Assessment of real functionality of forests and communities of tree species in the determined part of the landscape from the viewpoint of their structure
- Assessment of social requirements on the use of the determined part of the landscape and on fulfilment of the functions by forest tree species and their communities
- Appraisal and valuation of forest functions with regard to the type of the determined part of the landscape and requirements on fulfilment and utilization of forest functions in the determined part of the landscape
- Proposal of management and measures to optimise the structure of forests and their functions in the determined part of the landscape with regard to the state, ecological stability and financially grounded requirements on the use of forest functions and the functions of communities of tree species in this particular part of the landscape.

From the viewpoint of prediction of the development of fulfilment and utilization of the functions of tree species communities in the landscape it must be noted that as it is possible with ecological stability to determine its probable development on the basis of supposed changed of site conditions and the structure of forest ecosystem, it is also possible to predict the development of the capability of this ecosystem to fulfil individual functions in the landscape or environment. But it is very difficult to predict the need, capability and social willingness of the utilization of these functions with their adequate financial reimbursement.

It is possible and appropriate to present in graph the comparison of potential and present fulfilment of the functions by tree species and their communities in the studied area.

Similarly, real utilization of the functions of tree species and their communities on the studied territory as well as comparison of real utilization of the functions with social order can be illustrated in graph.

4. .Discussion and conclusion

From insinuated way is possible to compare real possibilities of particular ecosystem to fulfil required functions what subsequently shows the need of the management of this ecosystem. The

management comprises influencing the structure of community and thus also ecological stability and fulfilment of individual functions. With regard to the fact that in our solution we prefer integration of functions and not their prioritisation, a more complex utilization of forest functions will be aimed at close to nature management, potential – optimal forest community. The presented approach has not only maximal economic benefit but ecological stability of concrete ecosystem as a part of the landscape where it is located is increasing and the importance of tree species and their communities, mainly of forest in the landscape, will increase substantially as well.

The core and substance of the integration of forest functions is namely mutual comparison and evaluation of various forest functions, their reflection in the system of management in forest and considering benefits following from various ways and degrees of interlinking of forest functions and their utilization into optimal proportions. Forest manager must know what forest benefits the society needs to be able to set properly the objectives of management in the given area that will secure optimal utilization of forest functions with their concrete structure and with regard to their ecological stability for clearly defined time period.

Then priorities will follow from the proposal of the management and measures for optimisation of the structure of forests and their functions in determined part of the landscape with regard to the state, ecological stability and financially reasoned requirements on the utilization of the functions of forests and tree species communities in this landscape.

On the basis of current knowledge and the latest approaches to forest functions, functions of forest tree species and their communities the way of functional integration seems to be more effective and more pragmatic than the way of purposeful differentiation and prioritisation of some of the functions.

Extending of scientific knowledge on forest functions, forest tree species and their communities and possibilities of their use in the landscape will enable not only their real use in the environment but also construction of a new classification system of the functions of forests, forest tree species and their communities considering ecological and subsequently economic approach.

This approach presupposes construction of basic typology and the system of the assessment of forest functions potential as well as the assessment of real fulfilment of the functions of forest growing in various site conditions, various types of the landscape (various use and degree of anthropic changes), with regard to the health condition of real forest, its present tree species composition, age and spatial structure, its ecological stability that considers expected global and regional (mainly climatic) changes with regard to social requirements and the interests of the owners of forests.

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Connecting landscape conservation and management with traditional ecological knowledge: does it matter how people perceive landscape and nature?

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Abstract

Ethnobotanical surveys conducted in Trás-os-Montes (Portugal) highlighted a renewed interest in cultural values of landscapes. Long term interactions between traditional ecological knowledge (TEK) and natural processes provided landscapes characterized by high diversity and relative stability. Rural contexts are facing social and economical constraints and landscapes are change accordingly.

On a basis of ethnographic methodologies (consented interviews and participant observation), recent landscape changes at a local level and people' perceptions are briefly described and discussed as important tools for landscape conservation and management.

Young and some middle aged people value some of these changes, which they consider less hard-working and a symbol of modernity. Others see actual transformations as a waste of resources and abandonment and thus landscape is perceived as unproductive, which is considered reprehensible. Most of the informants are aware of a dynamic process taking place and conscious that landscape, like themselves, must adapt to changing times.

Keywords: TEK, Portuguese ethnobotany, cultural landscapes, rural landscapes dynamics

1. Introduction: Cultural landscape and traditional ecological knowledge (TEK)

Traditional rural landscapes are culturally relevant and a consequence of an integration of natural and anthropogenic processes that resulted in a great diversity of sustainable landscapes (Council of Europe 2000; Antrop 2005).

Human influence, especially related to agriculture and land-use patterns, have determined greater impacts on rural landscape than the ecological features and processes over the last decades. In Europe, long and complex history of land uses have promoted a rich diversity of cultural landscapes that have been shaped by local practices, believes and specific purposes, and maintained in those areas where physical, socio-economic and political constrains have prevented modernization and changing in farming systems until recent times (Vos and Meekes 1999; Antrop 2005; Plieninger, Hochtl and Spek 2006; Calvo-Iglesias, Fra-Palelo and Diaz-Varela 2009).

Ethnobotanical studies deal with local people knowledge and perceptions of nature and environment. Traditional ecological knowledge (TEK) has great cultural significance and refers to the use of many wild or domesticated resources and the management of natural habitats and

agroecosystems. TEK refers, as well, to some other important rural activities and practices, such as cattle transhumance, agricultural techniques (e.g. crop rotation, irrigation methods, multi use parcels and partial harvest), land management (e.g. land holding fragmentation, terraces, natural or artificial boundaries), rituals and ceremonies, oral traditions and symbolism, communitarian features and settlement patterns (Martin 1995; Cunningham 2001).

Coherent relations between the physical environment, TEK and local adaptation result in well-established regionally differentiated patterns of settlements, land use systems and field structure that characterize European cultural landscapes (Vos and Meekes 1999). Local people knowledge and traditional rural landscapes are fundamental for the conservation of biodiversity and also a source of information on the past and present cultural landscapes, focusing on the land-use system, management techniques, cultural heritage, and farmers' perception of changes (Antrop 2005; Calvo-Iglesias, Fra-Palelo and Diaz-Varela 2009).

Cultural landscapes dynamics pressuposes change according to changing TEK, values and policies. For many centuries these changes had local impact and thus cultural landscapes were perceiveid as rather stable (Vos and Meekes 1999; Antrop 2005; Calvo-Iglesias, Crecente-Maseda, Fra-Paleo, 2006; Carvalho 2010).

Nowadays, rural contexts face sudden and faster social and economical transformations and rural landscapes are rapidly changing and diversifying. The geographical and social conditions that led to the isolation of some European regions are no longer prevalent, and so changes in the cultural, economic and political contexts of plant use and landscape are coming faster and faster. The current reduction in the human population, due to out-migration and a general drop in the birth rate, and the abandonment of agriculture have been critical for rural areas and ways of life and have promoted the loss of cultural traditions. These changes are affecting the system of local knowledge of plant resources and the maintenance of traditional plant use practices (Carvalho and Morales 2010). Landscape changes observed and locally perceived are some of the topics addressed in this paper, based on research in such a region of northeastern Portugal.

2. Methodology

The landscape topic emerged from several ethnobotanical surveys carried out in Trás-os-Montes (a Portuguese region) for almost nine years (2000-2009) within the scope of three different research projects that aimed to record and document traditional knowledge on plant resources use, related technologies and management.(Ramos, 2008; Frazão-Moreira, Carvalho and Martins 2009; Carvalho 2010).

The study area is located in the most northeastern part of the Trás-os-Montes region and included in two important natural protected areas (the Natural Park of Montesinho and the Natural Park of Douro Internacional) corresponding to Vinhais, Bragança and Miranda do Douro municipalities. Mostly a mountainous and very isolated rural area, with small villages (many of them less than 100 inhabitants) scattered all over the landscape. The local economy was/is based on small farming systems, with an important crop production diversity, a high level of subsistence strategies avoiding productive risks, and mostly affected by agriculture abandonment and both population ageing and erosion, due to several migratory flows.

Traditional landscapes are characterized by a mosaic composed of different patches finely linked to each other, particularly highlighted by the seasonal contrasts of the vegetation and agricultural activities (e.g. fallows, manure, hay or grazed meadows, orchards, gardens).

Within the research projects, we used a random stratified sampling of approximately 40% of the villages in the study area which had a history of agropastoral activities and homegardens until very recently (at least 2005). In every case study, consented semi-structured interviews as well as participant observation were conducted during all seasons of the year. Informants (a total of 165) were selected using random sample and snow-ball methods (Martin 1995; Alexiades 1996). In-depth interviews have been held with 30 local experts or key informants (informants with profound knowledge of a particular aspect of local culture, e.g. shepherds, smugglers, hunters,

healers), a sub-group selected from those informants considered knowledgeable by their neighbors (Martin 1995; Carvalho 2010).

For the purpose of this paper we have only considered the information provided by key informants (18 women and 12 men, nearly all over 60 years old) that have lived most of their lives in the selected villages, were acquainted with forestry, animal husbandry, agricultural practices and local farming systems and culture, and that were able to remember or have participated in different management scenarios of natural and traditional landscape (e.g. plows, clearings, common lands, forestation, road system, irrigation canals and mining, for instance).

As a photographic collection and an ethnobotanical database were created, it was possible to compare structural components of traditional landscapes and some elements such as land cover, building and infrastructural construction for a time period of almost a decade.

3. Results

A descriptive and qualitative analysis of the reported data show that landscape changing in structure and land use has been locally detected in the last two decades in all the studied areas. Key informants considered that the main signs of landscape structural changing are:

- The emergence of a road system since the 1990s allowing a better physical communication between some villages and nearest towns, as it was very inefficient or nonexistent in many of cases;
- The village planning since 1975. For instance, sewage system, water distribution network, paving, small medical centers, rebuilding and scattered secondary housing, formal meeting places;
- Rebuilding and preservation of collective facilities (e.g. water mill, forge, press, communitarian stable) with no current use or considered obsolete;
- Stagnation, abandonment and aging, more relevant after 2005. Building increased but houses are closed. Small medical centers and schools, local and regional services for farmers were disabled and relative recent infrastructures are closed and abandoned. A great majority of the inhabitants is older than 60 and there is serious lack of children and young.

Informants have also reported noticeable changes in land use and cover such as no cattle grazing, quite abandoned meadows and arable lands, the absence of once usual crops, for instance, flax and hops, the afforestation of individual fields, more diverse homegardens adjacent to houses, the presence of many cultivated and exotic ornamentals, and fenced fields and plots.

Some of these topics that were also identified and perceived as probable causes of landscape changing are detailed and summarized as follows.

3.1 Cultural heritage and aesthetical values

For a long time, villages' subsistence was based mainly on forestry, pastoralism (cattle, sheep and goats) and sustainable farming systems with specific gardening techniques. People's food and medical needs relied on materials found in the natural surroundings, on small-scale animal breeding, on fishing and hunting and on self-sufficient and subsistence oriented agriculture. Wild-gathered species were an important supplement and alternative to the regular diet and often used to prepare homemade remedies for primary healthcare and treatment of human and animal diseases. Arable crops, scrubland and woods provided food and supplied other basic needs, such as fuel, domestic tools, textiles and building raw materials. At times, surpluses of grains, chestnuts, potatoes, livestock, textiles, handicrafts, charcoal and wood were traded or sold, to generate extra income. Mining, smuggling and other men activities complemented the household income.

According to informants' testimony, those were days of great activity in the villages; women and children were active plant gatherers and foragers, while most of the men cultivated field

crops, worked in the woods or had jobs outside the community in farming, mining, road works and reforestation programs. Over time, this close relationship between people and their natural and agricultural environment has led to the development of a rich knowledge base on plants, plant uses and related practices (Carvalho and Morales 2010).

Key informants have emphasized that over the recent two to five decades people's adaptive management of natural resources has built a multifunctional, productive and diverse landscape. Land-use system respected a circular configuration with settlements in the middle; surrounding the houses, homegardens, arable lands, scrubland, woods and crop rotation (rye - more or less long fallow) following a decreasing gradient of soil fertility but increasingly slope and distance to center; meadows were and still are transversal to theses aureoles (Aguiar et al. 2009).

This traditional landscape is considered part of their cultural heritage and has embedded intangible values such as dwelling and aesthetical values, local tradition, neighborly and inter-generational relations.

3.2 Disabling traditional agricultural activities

Cereal production, crop rotation and animal husbandry are locally considered as linked practices and skills that may not last alone because they are meaningless without each other. As they explained growing wheat or rye usually provided three sub-products: straw for litter and basket weaving, grain for selling in the market and to keep at home, stubbles and fallows for feeding sheep in late summer and after the first autumn rains.

People were able to remember the enlargement of the areas assigned to rye, wheat and fodder production during the 1950s, as well as, the satisfactory performances of local varieties well adapted and the consequent increase of cattle and sheep, which in turn, also concerned the management of the scrublands, meadows and pastures, fallows and stubbles. Cycles of slash-and-burn, cultivation, and scrub were still common in the 1970s. Species from the scrubland were used as fertilizer, litter, pasture, firewood, and some to make charcoal.

Considering the informants reports, there is a general idea that traditional agricultural farming systems have been affected by a succession of CAP (Common Agricultural Policy) reforms and 'flanking' measures, beginning in 1992 and continuing for twelve years, that cancelled or reduced some crop subsidies, introduced new varieties and imposed strict production conditions. These measures disappointed many local farmers and caused the abandonment of several crops (such as cereal grain, potatoes, fodder, fibers and hop). Breeders experienced some difficulties to meet municipal ordinances and innovative requirements concerning animal welfare and veterinary care, which require continued technical assistance. New policies constrained the ability of small farmers to diversify and reduced the mosaic of farming activity. Agriculture was suddenly viewed as an impossible task without competitive advantages because of rising production costs versus low profits and uncertain wages.

Perceived main indicators of landscaping changing due to non prevailing agricultural practices are abandoned arable lands and meadows that progressively exhibit a different floristic composition and scrubland represented by a tallest stratum with increased risk of wildfires.

As meadows are not cut for hay or grazed the early colonizers will be shaded out when woody plants become well-established. Several medicinal plants often gathered in these fields are no more available.

3.3 Perennial rather than seasonal crops

In general, afforestation of farmland is regard as a good alternative to seasonal crops and abandonment because it allows absenteeism, provides income and represents a patrimony for future generations.

Chestnut, walnut tree, cherry tree and red oak are the most mentioned species for afforestation. Arable lands, dry prairies and common lands have been afforested for both timber and fruit

production. In wet meadows, fast-growing hybrid poplars are grown on plantations and sold for pulpwood and as inexpensive hardwood timber, used for pallets and cheap plywood.

Altough it seems a good alternative, several informants comented that there is a risk of plant diseases, especially ink-desease in chestnut. Moreover, seasonal labor for fruit recollection and species management is considered expensive, scarce and difficult to hire.

Afforestation changes the traditional lanscape mosaic, as there are scattered afforested patches, combined with annual crops, meadows and scrubland.

3.4 New food plants and new herbaceous and woody ornamentals

Floral composition of homegardens and new green spaces inside the settlements are also signals of trasnformation in land use and traditional landscape. According to female informants, the number of cultivated species has increased with the introduction of a wide range of greens and ornamental species in the last three decades. These plants or propagation materials have been brought from remote areas, exchanged between relatives and neighbours or bought from retailers at the local markets. For instance, the gathering and consumption of wild edible plants is in steady decline throughout the area; therefore women have brought some of the most popular plants used as food additives and beverages from the wild to grow in their homegardens, in order to make them easily available.

Both a decline of agriculture and recent demographic trends have generated new approaches to homegardens. In former times they were less diverse because other agricultural activities such as forestry, grain production and animal husbandry were considered much more important for the household economy. Food production in homegardens was very limited and they were mainly used to grow fodder and flax to make linen.

In order to replicate urban lifestyles, villages' authorities created new areas and gardens where they have introduced exotic herbaceous and woody ornamentals which are, whenever possible, quickly propagated and used in homegardens. These ornamentals are also use in rituals and cerimonies and have taken the place of wild species previously harvested from the forest by women and children.

More diverse homegardens and new ornamental gardens are also perceived as new structural components of landscapes

4. Discussion

Along the interviews, new farming practices, abandonment of farming and husbandry activities, a better mobility and a new concept of residential housing were the most mentioned causes for landscape changing. Key informants perceive that young and some middle aged people value some of these changes, which they consider less hard-working and a symbol of modernity allowing a more like urban lifestyle (e.g. weekends and holidays). Others regret actual landscape transformations which they view as a signal of abandonment, waste of resources, reprehensibly unproductive. Nevertheless, most of the informants are aware of a dynamic process that is taking place and conscious that landscape, like themselves, must adapt to changing times.

Beginning as children, some people have learned how to discover and understand the signs of nature and to observe changes in the landscape. However, they have also shaped landscape according to their own beliefs and material needs. This adaptive knowledge is often a practical one, based on empirical observation and long experience, and transmitted through oral traditions. Such knowledge is not merely of academic or historical interest but is fundamental to maintaining cultural continuity and identity and, possibly, could play a role in achieving sustainable use of plant resources in the future. It is also useful for providing more realistic evaluations of environment, natural resources and production systems. TEK may improve success by involving local people in the planning processes. Therefore TEK and local conceptions can be considered important tools for landscape conservation and management.

By interviewing specifically on folk nomenclature and identification of useful plants we observed that the loss of TEK and loss of vocabulary begin with people aged less than 50 years. The lost of traditional knowledge and local categorization and naming are not completely coupled: a few interviewees of the middle generation seem to be often able to remember the names of plants, but not to identify them or to explain their traditional use or to find the sites were these plants were usually gathered.

It became clear that in the past thirty years, homegardens have become areas of *in situ* and *ex situ* conservation for both nostalgic and pragmatic reasons. Some crops and landraces are no longer cultivated in arable fields and wild species are threatened by new access roads, wild fires, and reforestation activities.

Although some of the components may stay unchanged, much of aesthetic, historical or cultural value of rural landscapes remains to be inventoried and recorded which is urgent before it disappears.

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Identification and characterization of forest edge segments for mapping edge diversity in rural landscapes.

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Abstract

Forest edges are key components of rural landscapes and they influence major ecological processes. There is a variability of forest edges, according to their physiognomy, orientation, history and topography, but few methods are available to identify automatically these different types of edges and to map them at a large scale. We propose to identify edge segments based on morphological subdivision of forest boundaries. These segments can be mapped and characterized by other spatial data. A procedure based on Arcgis tools, applied on the output from GUIDOS tools, is used to identify edge segments. We provide examples of edge segments descriptors obtained from a digital elevation model and from a landcover map. Results showed the feasibility of the automatic mapping of edge variability over a large scale. It opens new perspectives for the analysis of landscape dynamics and their effects on biodiversity.

Keywords: Forest edge, GIS, edge segment, morphology

1. Introduction

Forest edges are key components of rural landscapes by their influence on major ecological processes important for biodiversity conservation (Murcia, 1995). A better understanding and measurement of the extent and of the variability of edge effects in rural landscapes is required by land managers to base their decisions on accurate estimations.

Forest edge influence on both microenvironmental conditions and vegetation depends on edge type (Alignier & Deconchat, 2010). There is a variability of forest edges, according to their physiognomy, orientation, history and topography, but few methods are available to identify automatically these different types of edges and to map them at a large scale. Essen et al (2006) proposed a method based on aerial photography interpretation with a systematic sampling of edges by a square grid. This method suffers from the difficulty to be applied on very large areas, the bias associated to the size of the sampling grid and the impossibility to produce a synthetic map of edge diversity. GUIDOS is a GIS tool developed for the European Union in order to measure and map habitat fragmentation (Vogt et al., 2007). In this method, edges are defined as the contour of large tracks of forest, they can be mapped but there is no evaluation of their diversity. Fragstat (McGarigal et al., 2002) is a set of GIS tools aiming at measuring fragmentation by patch metrics. It includes several outputs describing edge characteristics, but with few possibilities to take into account their diversity. Zeng & Wu (2005) introduced the concept of edge segment as the basic component for computing edge-based metrics to describe landscape fragmentation. This approach open up new perspective and define the basis for a systematic and coherent method to map edge diversity in rural landscape.

The aim of the presentation is to introduce the details of a GIS method to identify and characterize edge segments in landscape, defined from morphological subdivision of forest boundaries, in the same general framework proposed by GUIDOS. This method, called

Mapedge, is a step toward landscape metrics that put more emphasis on interactions between land covers than classical area-based metrics (McGarigal et al., 2009).

2. Methodology

The central idea of the method is to subdivide the contours of the forest patches in a set of segments that can be characterized by them or by GIS queries on other data maps (i. e. digital elevation model and land cover map).

Segmentation of edges

There are several ways to cut forest contours in a set of edge segments. We chose to base our segmentation on forest edge morphology. We followed on this point the position adopted by GUIDOS authors who define different parts of forest cover according to morphological parameters (area, shape index, etc.) (Vogt et al., 2007). With this option, our method is forest-centered and edge segments are defined only by forest characteristics and not by elements outside the forest. Each step needs to select one or several parameters that may change the final result.

In a first step (Figure 1), the input of **Mapedge** is a forest/non-forest cover map, obtained in our case from a remote sensed image (SPOT) classified with supervised control. In a second step (Figure 1), this map is processed through a GUIDOS tool, MPSA (for "Morphological Spatial Pattern Analysis") in order to identify true forest patches and to discard the other smaller forested landscape elements (i. e. hedgerows, branches) for which edge segmentation is not relevant. By convenience, we selected a depth of edge of 20 m (2 pixels) (Table 1). The output of MSPA was a classified forest map from which forest edges and cores were extracted.
After that, the method is based on Arcgis 9.3 tools and several additional extensions (ETGeowizards 9.7; Hawth's analysis tools 3.27; EasyCalculate 5.0) or free download scripts (Vba and Python languages). In a near future, all the processing operations will be encapsulated in a single application turned under Model Builder.

The contours of the forest patches are then vectorized and generalized in order to obtain a smooth shape of the patches (Figure 1). The parameter of this step is T (Tolerance for generalization) (Table 1). The forest patch polygons are converted to polylines. Polylines are then split in segments and each segment is numbered and oriented, allowing to know on which side the forest is. Orientation, length, etc. of the segments can be extracted easily from the map and tabulated in order to provide edge-based metrics of the landscape structure. An attribute table is attached to the map of edge segments and contains a set of variables describing each segment. This table can be filled by data obtained from map queries and introduced in statistical analysis of landscape structure.

Map queries

We decided that the query of other maps will be based on transects perpendicular to the medium point of the edge segments towards the open habitat. We chose a fixed length of transect based on depth of edge (2*DE)(Table 1).

As topography is known to be of prime importance for ecological edge effects, we combined the map of edge segments with a Digital Elevation Model (DEM). According to the difference of elevation along the transect and along the edge segment, we measured the position of the edge relatively to the main slope. We were then able to identify 3 classes: 1) edge where the open habitat is at a higher elevation than the edge (downslope), 2) edge where the open habitat is at a lower elevation than the edge (upslope) and 3) the other cases where the slope of the edge segment is higher than the slope of the transect (inslope).

Adjacent land cover was measured with a spatial query between the summit of the transect and a land cover map obtained in our case from the same remote sensed image treatment as the input forest map.

Legend

In order to be able to map the diversity of edge segment, for visual interpretations and communication, we defined a system of symbols for edge segments based on the transects. They appeared on the map as pin-like symbols, with a color and a shape of the pin-head defined according to the characteristics of the edge segment (Figure 1).

3. Results

Figure 2 is an example of a result map with a focus on small area in order to show clearly the symbols that were used to display the different types of edge segments. Visual interpretation of the map, which would be statistically confirmed by an analysis of the attribute table, indicates that, in this very small area, meadow seemed to be the more frequent as an adjacent land cover for woods 3 and 4 than for the others, more in contact with crops. Wooded elements of the landscape (loop, branch, forest defined according to GUIDOS) were in the near vicinity of all the woods.

4. Discussion

Interfaces and interactions between forests and the other land covers in landscape are becoming focus questions for land management in the perspective of global changes. Our method,

Mapedge, contributes to provide managers with a new set of tools to take these interactions into account in their decisions. For example, metrics based on edges can provide measures of landscape fragmentation to be compared with area based metrics (McGarigal et al., 2009). Some edge types may be more sensitive to landscape changes than other (Taylor et al., 2008). The feasibility of edge diversity mapping has been demonstrated with our first results.

Mapedge is an efficient method to identify and characterize edge segments in landscape. Despite the need to combine several tools to process the data, the **Mapedge** methodology is rather simple and easy to apply. The number of parameters has been reduced as much as possible and rules have been defined to select their values. We are now testing several sets of parameters in order to assess how they influence the final output of the method (sensibility analysis). In a near future, we will set up a unique tool that will apply all the treatments which are separated for the moment. From a landscape ecology point of view, our method will provide new landscape descriptors that will give a higher role to interfaces in landscape analysis.

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Table 1: Description of the paramaters used in the different step of the process of **Mapedge**.

Step	Process			Parameter	Value
1	Classification			Resolution of SPOT 5	10 m
2	Treatment under Guidos : Morphological Spatial Pattern Analysis			**Foreground Connectivity,** for a set of 3 x 3 pixels the center pixel is connected to its adjacent neighboor pixels by having either.	Connectivity = 8 pixels
				Edge Depth.	Size = 2 pixels
				Transition pixels are those pixels of an edge or a perforation where the core area intersects with a loop or a bridge. If Transition is set to 0 then the perforation and the edges will be closed core boundaries.	Transition = 0
				Intext allows distinguishing internal from external features, where internal features are defined as being enclosed by a Perforation. The default is to enable this distinction which will add a second layer of classes to the seven basic classes.	Intext = 0
3	Generalization			**Generalize tolerance** reduces the number of vertices required to represent a polygon, the features of a polygon layer using the Douglas-Poiker algorithm.	20 meters
5	Calculation	Creation of transect 90°		Script python what create perpendicular lines, takes a line shapefile and generates perpendicular lines to each record with **length expected**.	40 meters
			Land cover	Intersects the end-point of transect to land cover at a **point distance expected.**	40 meters
		Slope of the edge		Get Z characteristics with **Digital Elevation Model**	25 meters resolution
				Compare the edge to the transect segment with same **length**	40 meter
				Result : - Inslope with **tolerance** - Downslope - Upslope	Tolerance 1 meter
		Cardinal orientation		Calculates the angle of a polyline in degrees	360 degrees
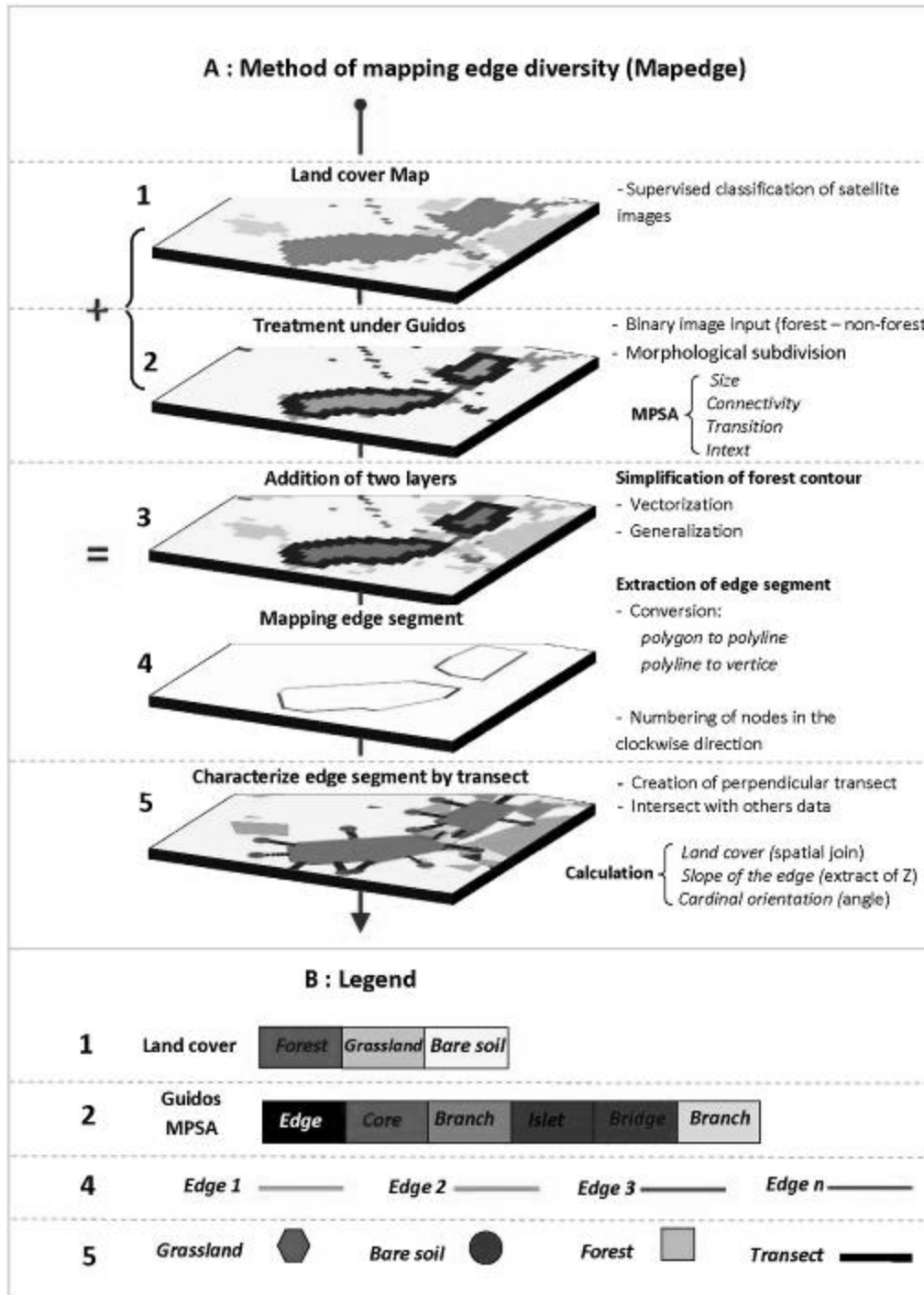
Figure 1 : GIS method in Arcgis using default functionalities of ArcToolbox and additional tools (extensions and scripts). In part A, we give the most important steps of the **Mapedge** method on small image composed with 2 woodlots. In step 1, input data come from supervised classification of satellite images (SPOT 5). In step 2, we used GUIDOS tool to make MPSA (Morphological Spatial Pattern Analysis). In step 3, we combine the 2 raster layers and convert to vector data and generalize to simplify features. In step4, we check direction of vertices and label them. In step 5, we create transect features from rotation of vertices and use them to calculate edge descriptors (about interface with adjacent land cover; about topography with Digital Elevation Model and orientation). We will apply the same method at landscape level (several hundred polygons of woodlots) and transfer output results to statistical analyses. In Part B, we give legend of symbols.
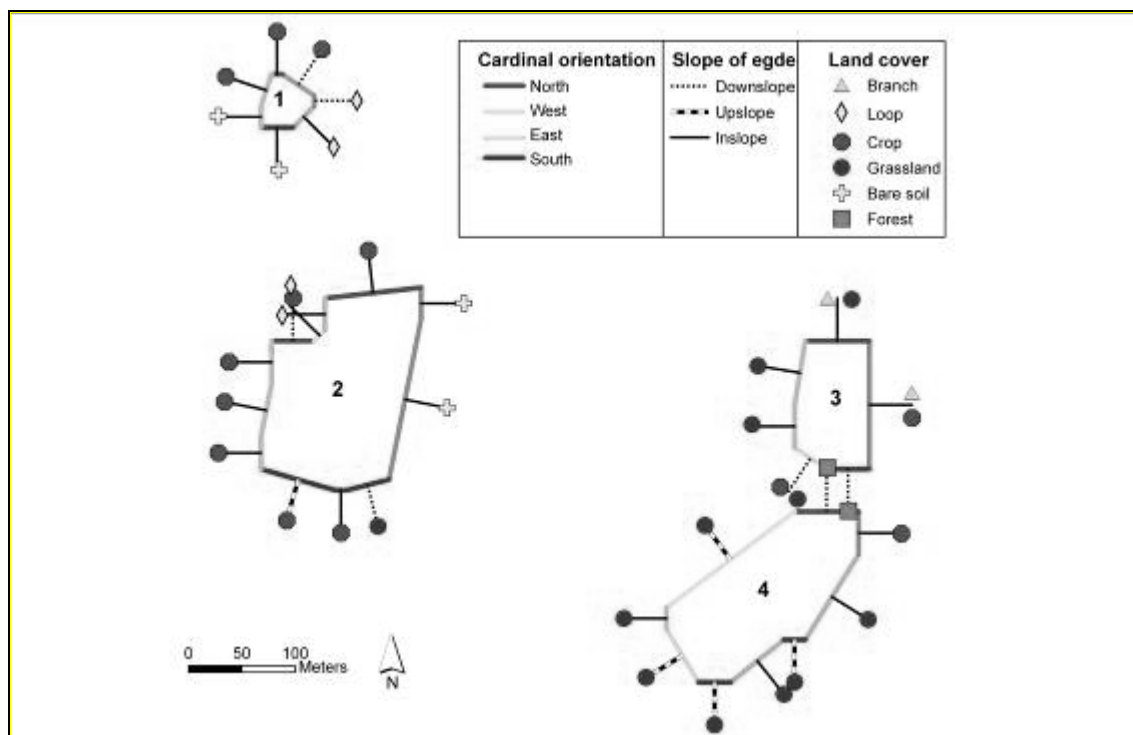
Figure 2: Overview map of all descriptors calculated for test image made with 4 woodlots. We obtain 34 edge segments. We symbolize cardinal orientation on edge segment, slope of edge on perpendicular transect and land cover on pin-head of the transect.

Visibility analysis and visual diversity assessment in rural landscapes

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Abstract

Analysing the visibility of landscape features is usually based on methods which calculate the number of locations from which such features are visible. However, visibility analysis using Geographic Information Systems (GIS) suffers from several limitations which can significantly influence the results. In this study the authors have tested the differences in visibility through time, and used a Digital Elevation Model which includes the heights of land cover features.

The results provided information about the visibility of each land cover type, at each of three dates: 1954, 1974 and 1995. The derived maps of visibility were used as inputs to analysis of the visual content of the landscape, which were then used to evaluate the visual diversity at each date, and to provide an input to the derivation of information on landscape visual quality. The results show significant differences in both visual content and diversity through time, and illustrate a difference between the potential perceptions of change, and the real extent of change in an area.

Keywords: visibility analysis, landscape visual diversity, landscape content

1. Introduction

The planning and management of land use requires an understanding of the benefits and impacts of change with respect to environmental, economic and social objectives. One aspect of management which links across these three broad headings is in relation to the visual landscape, and the contributions made by the extent and distribution of different types of land cover, and associated uses. An analysis of diversity in the visual landscape, and how it changes through time (Antrop, 2005), is an aid to understanding the wider significance of the impacts of drivers of ch'ange (Bell, 2001) (e.g. climate change; demographic change) and the consequent changes in land cover (e.g. forest fire; urbanisation) than only the areas they occupy.

An analysis of the visibility of land cover types, and associated uses was undertaken, based on the methodology applied by Miller (2001), Gaspar *et al.* (2002) and Ode (2003). The outputs provided a basis for deriving indicators of visual diversity in the landscape, and the visual complexity and content in the view.

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2. Methodology

The methodology uses data on elevation, land use and the height of features, focusing on forest areas, to derive and analyse the visibility of each land use. The method is based on the measurment of the extent of land from which different land cover types may be visibile (Bolós, 1992), on a cell-by-cell basis. The visibility calculations use a Digital Terrain Model (DTM), to which the height of the different forest species derived from growth models or inventory data were added, in order to obtain visibility results for each land cover class across the municipality.

Data were compiled for three dates: 1954, 1974 and 1995. The 1954 and 1974 data were digitised from paper maps of the land use as mapped by the agriculture surveying services. The 1995 data were produced by aerial photo-interpretation of false color imagery.

The calculation of visibility is applied to the coverage of each type of land cover, for each date, thus enabling an analysis of the combinations of visual influences of different types of land cover at any point in the landscape (Miller, 2001; Gaspar and Fidalgo, 2002). Due to the extent of the study site, this study does not consider the effects of distance decay (Bolós, 1992) on the visibility of features (Gaspar *et al*., 2004).

The individual visibility maps are combined to derive the land cover types visible from each point in the municipality, as represented by a regular grid across the area. Three different levels of landscape content were used to characterise the diversity of the views.

3. Results

To enable comparisons between land use maps from different sources and with different classification schemes, a general classification scheme was developed with 9 classes (Gaspar, 2005).

Table 1. Extent of land cover classes for 1954, 1974 and 1995.

Land cover class	1954	1974	1995
Dry cropland	13,7%	10,1%	8,5%
Irrigated crops	7,5%	7,9%	2,7%
Maritime pine	49,5%	64,4%	22,9%
Eucalyptus	0,0%	1,7%	11,4%
Broadleaved species	1,6%	1,4%	3,9%
Other needle leaved species	0,1%	0,1%	0,2%
Water	0,4%	0,4%	1,3%
Other land uses	26,7%	13,1%	47,5%
Social areas	0,5%	0,9%	1,8%
Total	100%	100%	100%

The 1954 to 1974 period was marked by the progressive abandonment of agriculture areas and large plantations of Maritime pine (*Pinus pinaster*) (Table 1). Although tourism is now considered as one path towards a prosperous future, one of the main sources of income for the population is forest production, mainly associated to the paper industry, with the lower valleys

being occupied by Eucalyptus (*Eucalyptus globulus*) (Table 1). However, forest fires are a major driver of change of the landscape.

The results of the visibility analysis for each of the land cover classes were combined to derive the values of visual diversity (Figure 1).

Figure 1 Landscape visual diversity: number of land cover types visible for 1954, 1974 and 1995.
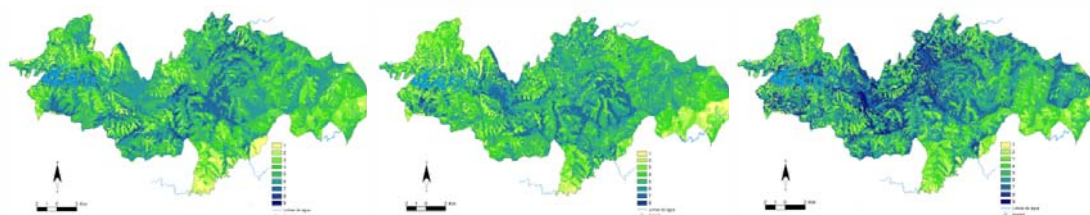
The changes in visual diversity through time shows a comparatively small change between 1954 and 1974, but more significant changes by 1995, with an increase of the higher diversity values (7, 8 and 9), and a decrease of the lower diversity values. These changes will be influenced by the reduction in the overall number of patches of land cover classes between 1954 and 1974, but an increase in the area and patches of Maritime pine and Other land uses. The combination of these changes has led to an increase in the mean patch size, and the increase in the distance between patches of the same land cover classes having a significant influence on the distribution of the visual diversity.

The period between 1974 and 1995 shows a significant increase in higher visual diversity values, which can be explained by the increase of fragmentation, but also the new patches of Eucalyptus and Broadleaved species in highly visibile areas. The effect of forest fires also had a srong effect in terms of patch fragmentation, and provided conditions to increase the visibility of abandoned agriculture areas.

Table 2 Landscape content.

Land cover class visibility	1954			1974			1995		
	30%	50%	70%	30%	50%	70%	30%	50%	70%
Dry cropland	1.0	1.2	0.6		0.3		0.6	0.5	
Irrigated crops									
Maritime pine	59.4	68.9	38.2	81.3	86.7	55.4	21.3	14.5	4.6
Eucalyptus				0.6	0.8		9.2	6.9	1.5
Broadleaved species							0.5	0.5	
Other conifers									
Water									
Other land uses	14.2	17.8	10.7	4.2	7.0	3.3	41.1	40.7	26.8
Social areas									
Maritime pine + Dry cropland	1.9			1.4			0.3		
Maritime pine + Irrigated crops	0.5								
Maritime pine + Eucalyptus				1.1			4.6		
Other land uses + Maritime pine	21.3			10.6			13.3		
Other land uses + Eucalyptus							4.6		
Other land uses + Broadleaved species							0.4		
Other land uses + Water							0.3		
Total	98.3	87.9	49.6	99.3	94.8	58.8	96.2	63.1	32.9

The analysis of the changes in landscape content for each cell through time was derived using the individual visibility maps (Table 2, and Figures 2, 3 and 4). Three levels of viewshed content were considered. The lower value considered was 30% of the cell visibility content, the intermediate value 50% and the highest 70%.

The analysis of the results shows a significant dominance in the landscape of the Maritime pine (1954 and 1974) (Table 2). For example, in 1974, this cover type was present in 55.4% of the area with a 70% level of landscape content (Table 2). There is also an increase in the area where only one land cover type dominates the landscape view content.

The land cover change between 1974 and 1995 (Table 2) provided conditions for significant variations in terms of landscape visual content. The landscape is dominated by the Other land uses class in all levels of landscape content (Figures 2, 3 and 4).

The Maritime pine areas are the second largest class in terms of levels of visibility, which can be due to the presence in highly visible areas, and the significant increase in Eucalyptus in terms of both area and visibility.

Figure 2 Landscape content 30% in 1995.
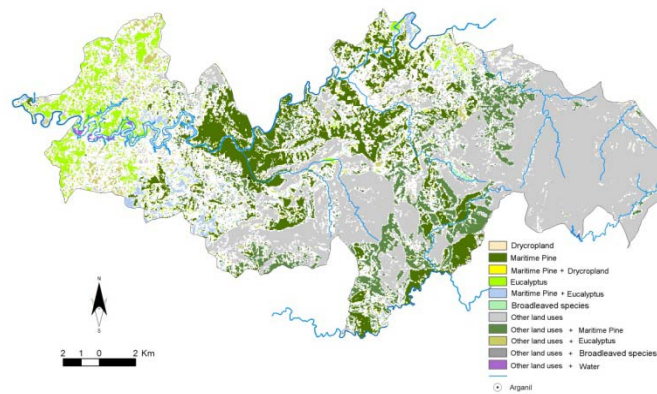
The number of classes visible at the 30% level shows an increase in number and type when compared to the data for 1954 and 1974, which could be due to the increase of number of patches in each class, and related to the spatial distribution of these patches across the landscape.

Figure 3 Landscape content 50% in 1995.
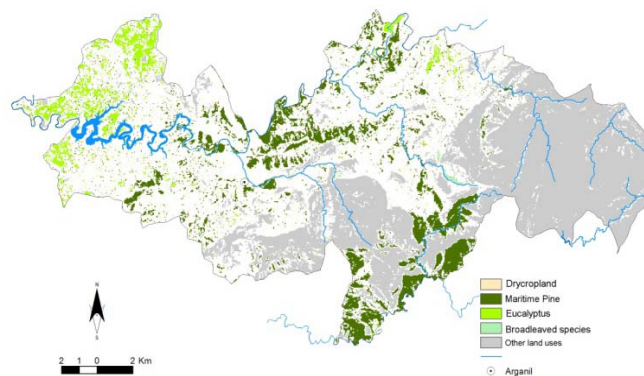
Figure 4 Landscape content 70% in 1995.
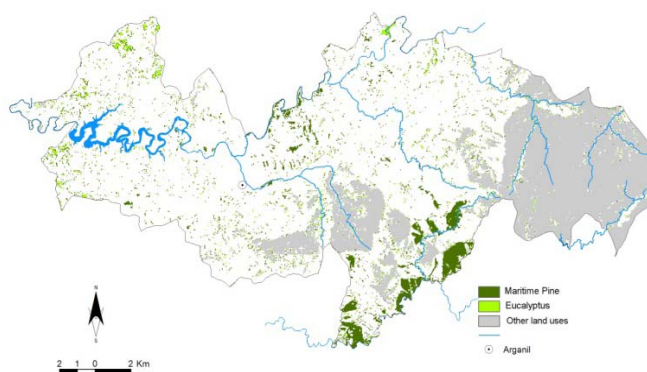
4. Discussion

This paper presents an approach to analysing visual diversity and content of land cover and change, using GIS tools. The landscape diversity and content maps provide information for use in forest management and planning. The final analysis and evaluation of the results is ongoing, based on expert experience and opinion. This will include an assessment of their value in terms of parameters for use in planning tourist routes.

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Landscape runoff, precipitation variation and reservoir limnology

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Abstract

Landscape runoff potential impact on reservoir limnology was indirectly evaluated by assessing the effect of precipitation variation on several water quality parameters, on *Anabaena* (Cyanophyta) and crustacean zooplankton abundances. The obtained results showed that total phosphorus increased with strong precipitation events whereas water transparency presented an opposite trend. Wet periods followed by long dry periods favored *Anabaena* dominance, which induced an accentuated decreasing on all crustacean zooplankton species abundance. Therefore, in a climate changing scenario these data are crucial to monitor and predict the effect of landscape changes on aquatic ecosystem integrity and ultimately in water quality.

Keywords:Landscape runoff impact,Precipitation,Reservoir limnology ,Water quality

1. Introduction

In Mediterranean region, both intensity and quantity of precipitation can vary markedly from one year to another. Such variability can generate different kinds of seasonal patterns, modifying water turnover time and changing the intensity of environmental and biological processes occurring in the water column of aquatic systems. Furthermore, the external loading of nutrients, organic matter and pollutants often increases with intensive precipitation events. The intensity and the magnitude of these loadings depend on land use, vegetation cover and landscape patchiness. Azibo Reservoir is located in the Iberian Peninsula on the Portuguese part of international River Douro catchment. In this region, most precipitation occurs between October and March in a very irregular pattern from one year to another (Fig. 1). Total annual precipitation varies between is around 760 mm, and in a "normal" autumn/winter season total precipitation is around 500 mm (Instituto de Meteorologia, 2009). In contrast to what happens in other reservoirs in the region, water level fluctuations caused by human activity are not very accentuated in Azibo. Thus, this reservoir provides a good environment to study the potential effects of quantity and intensity of precipitation without the interference of internal disturbances generated by extreme anthropogenic water level fluctuations. The objective of the present research is to evaluate the potential impact of landscape runoff on reservoir limnology. This was achieved indirectly through the assessment of the effects of precipitation variation on (1) environmental variables such as total phosphorous (TP), dissolved oxygen (DO), conductivity, pH, water transparency and chlorophyll *a* (Chl *a*); (2) *Anabaena* and crustacean zooplankton species abundance.

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2. Methodology

Water, *Anabaena* and crustacean zooplankton samples were collected in the deepest point of the reservoir in four distinct hydrological years: (1) 2000/2001; (2) 2001/2002; (3) 2007/2008 and (4) 2008/2009. Details on sampling methodology and laboratorial procedure are described in Geraldes and Boavida (2004; 2007). As most precipitation occurs between October and March samples collected during this period were classified as "winter season" the others were considered as "summer station". A Kruskal-Wallis test was performed for each environmental variable and *Anabaena* abundance to determine whether mean values obtained for each year were significantly different. Non-metric Multidimentional Scaling (N-MSD) was used for expressing similarity between zooplankton samples. In this method samples are arranged in a continuum in such a way that those close together are similar and those which are far apart are dissimilar The statistical analysis were performed using SPSS 16 and CAP 3, respectively.

3. Results

The total precipitation recorded during the period of study is presented in Table 1. Significant inter-annual differences were found for TP (χ= 10.01; p= 0.001), for conductivity (χ= 34.71; p= 0.000), for water transparency (χ= 19.74; p= 0.000) and for *Anabaena* densities (χ= 13.97; p= 0.003). The maxima of TP and the minima of water transparency was recorded in the winter 2000/2001. The low value of water transparency observed in winter 2001/2002 was a consequence of the increasing of *Anabaena* abundances (Table 1). The lowest densities for all crustacean zooplankton species was coincident with this period and with winter 2001/2002 (Table 2). N-MSD for zooplankton samples also indicate the existence of seasonal and annual differences in crustacean zooplankton abundances (Figure 2).

4. Discussion

The observed variations in TP, water transparency and in *Anabaena* and crustacean zooplankton abundances were related to changes in rainfall/ landscape runoff intensity. Similar results were obtained by authors studying reservoirs located in other regions influenced by Mediterranean climate (e.g. Armengol *et al.* 1999; Soria *et al.* 2000). The variation of landscape runoff concomitantly with precipitation intensity was evidenced by the notice that TP concentrations in water samples obtained downstream of one of Azibo Reservoir tributary were 103μg l^{-1} at the beginning of the rainfall period decreasing subsequently to 76 μg l^{-1} and to 16 μg l^{-1} by the end of rainfall period (Geraldes, unpubl. data). Besides, the lowest mean values of TP and the highest values of water transparency noticed in the reservoir during the years with low precipitation reinforce the above evidence. The dominance of *Anabaena* from October 2001 to December 2001 (dry winter) occurred subsequently to a wet winter. The nutrient increasing scenario created during the wet period (Winter 2000/01) followed by the environmental conditions (e.g. absence of water turbulence, larger water residence time and higher irradiance) created by the subsequent dry periods (summer 2001 and winter 2001/2002), had lead to *Anabaena* dominance over the other groups of phytoplankton assemblage. As this alga is not edible by the most of the species of crustacean zooplankton their densities decreased accentualy. Changes in limnological parameters are related to variations in precipitation intensity, which ultimately influence landscape runoff. Therefore, long term data series on reservoir abiotic and biotic components will allow to understand how changes in surrounding landscape will influence reservoir ecological processes and consequently water quality.

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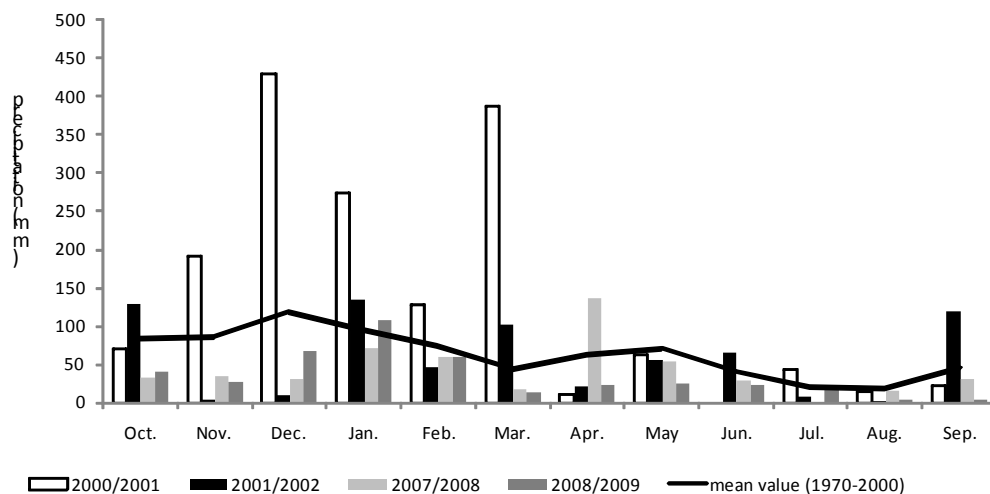
Figure1: Precipitation noticed for hydrological years of 2000/2001, 2001/2002, 2007/2008 and 2008/2009 in the Bragança city (Agroclima Lab-ESAB unpubl. data) the other data (Instituto de Meteorologia, 2009)
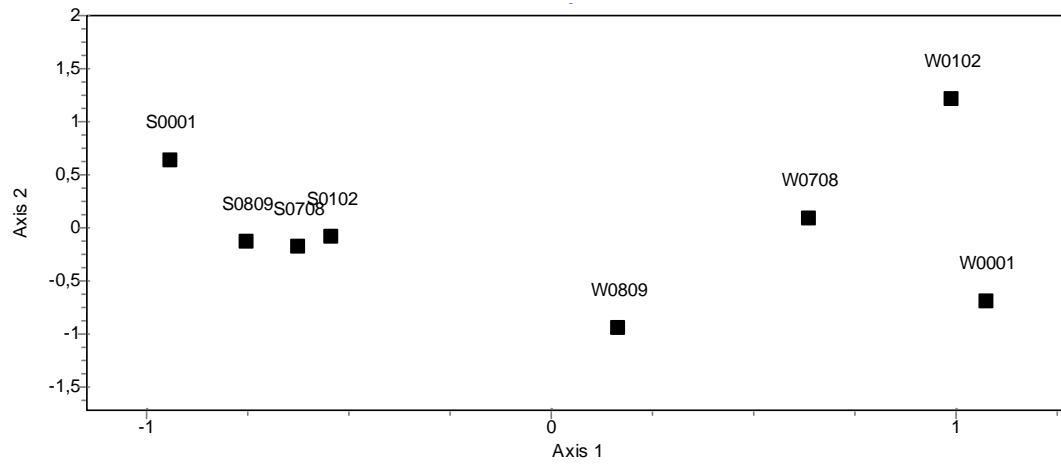
Figure 2: N-MDS analysis for crustacean zooplankton data.

Table 1: Total precipitation, mean and standard deviation (in brackets) of environmental variables

Variables	2000/2001		2001/2002		2007/2008		2008/2009	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Total precipitation (mm)	1482	156.9	423.5	217.7	245.5	263.9	315.9	97.7
TP (µg/l)	66.96 (21.70)	64.30(18.15)	60.29(9.85)	61.45(7.15)	47.53(10.06)	31.56(7.16)	46.67(18.62)	31.67(24.01)
Water temperature (ºC)	10.68 (2.66)	20.33(3.19)	10.09 (3.77)	18.87(4.72)	10.54(3.27)	18.38(3.55)	10.58(3.65)	20.00(4.04)
Conductivity (µS cm^{-1})	54.67(10.67)	58.92(6.65)	48.42(4.92)	64.33(9.17)	91.60 (2.78)	90.35(3.19)	89.92(4.56)	98.78(1.16)
DO (mg/l)	9.06 (1.39)	9.70(1.42)	8.71(0.46)	8.48(0.76)	8.58(1.16)	8.58(1.29)	9.67(0.67)	9.44(1.07)
pH	6.6-7.0	7.0-8.4	6.9-8.3	7.5-7.9	6.0-6.4	6.3-7.2	6.0-6.8	6.5-8.2
Water transparency (m)	2.83(1.51)	4.33(0.44)	3.00(0.71)	4.21(1.74)	4.30(0.67)	5.75(0.42)	5.42(1.07)	6.42(1.5)
Chl a (µg/l)	2.05(0.95)	1.16(0.77)	3.31 (1.68)	1.10(0.48)	2.54(1.46)	1.58(1.33)	1.31(3.45)	2.67(1.50)
Anabaena (ind l^{-1}x 10^3)	0.23(0.26)	14.97(33.76)	90.07(97.91)	0.29(0.43)	0.0	0.0	0.0	4.78(7.84)

Table 2: Mean densities and standard deviation (in brackets) of the crustacean zooplankton species.

Species (ind m^{3}x 10^3)	2000/2001		2001/2002		2007/2008		2008/2009	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Cladocera								
Daphnia longispina/pulex	0.90 (0.98)	1.89(3.72)	0.30(0.19)	0.54(0.69)	0.62(0.71)	2.16(2.07)	3.41(2.51)	1.30(1.69)
Ceriodaphnia pulchella	2.98 (5.79)	3.19(3.70)	0.14 (0.24)	3.93(4.33)	1.19(1.35)	3.52(6.47)	2.32(4.30)	3.60(7.87)
Diaphanosoma. brachyurum	0.0	0.31(0.54)	0.0	0.71(1.13)	0.21(0.31)	1.24(2.11)	0.40(0.83)	1.21(1.16)
Bosmina longirostris	0.07 (0.09)	0.22(0.18)	0.06(0.02)	0.17(0.16)	0.06(0.08)	0.06(0.05)	0.07(0.04)	0.19(0.32)
Copepoda								
Acanthocyclops robustus	0.04(0.04)	0.21(0.16)	0.10 (0.12)	0.09(0.66)	0.11(0.06)	0.07(0.04)	0.05(0.07)	0.13(0.14)
Copidodiaptomus numidicus	2.65(2.20)	3.47(2.84)	0.86(0.86)	5.67(0.92)	3.07(2.02)	4.39(1.36)	3.66(3.20)	4.52(1.50)
Nauplii	0.22(0.28)	1.97(1.53)	0.88(0.67)	2.56(1.50)	1.65(1.63)	1.63(0.82)	2.18(2.34)	3.18(3.37)

Reservoirs: Mirrors of the surrounding landscape?

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Abstract

To assess in what extent the environmental quality of aquatic systems reflect landscape features several water quality parameters were determined in two reservoirs. Concomitantly, the surrounding landscape was characterized and the existing potential sources of phosphorous and nitrogen runoff were identified and when possible estimated. Located in a mountainous area with negligible direct human influence, it was expected to find lower amounts of suspended organic matter and nutrients in Serra Serrada Reservoir. Water level fluctuations caused by intensive human water use, grazing and frequent land fires in the surrounding landscape can explain the unexpected high values of the mentioned parameters. In Azibo Reservoir the factors with greatest influence on water parameters seem to be allochthonous sources of nutrients originated from agriculture and grazing in the catchment area and recreational activities. However, in this particular case the potential sources of nutrients could have been minimized by the patchy structure of the surrounding landscape.

Keywords: Landscape, Water quality Land use, Phosphorous and Nitrogen sources

1. Introduction

Pressure caused by human activities in the catchment area and reservoir vicinity generally leads to an intensification of surface runoff, causing an increase in eutrophication, thus threatening water quality. Runoff rates depend mainly on land use, vegetation cover and landscape mosaic. The present study was carried out for two years on S. Serrada and Azibo reservoirs located at the Portuguese part of the international Douro catchment basin, in Trás-os-Montes region (NE Portugal). Location, morphological and hydrological characteristics of both reservoirs are shown in Table 1. Serra Serrada Reservoir was built to supply water to the city of Bragança and to generate hydroelectric power. Consequently, pronounced water level fluctuations occur, ranging between 8 and 10 m. Direct human influence on this reservoir impoundment is considered negligible. There are no villages, there has been no agricultural activity for approximately 20 years and recreational activities are not significant. However, in the catchment basin grazing can be very intense in summer months. All over the year there are only about 200 sheep grazing in the S. Serrada catchment, yet from May to August about 5,000 sheep from lowlands are transported from the surrounding lowlands to graze in the catchment and reservoir surroundings. Consequently, this area is very often subjected to wildfires which are mainly induced by shepherds to obtain better graze. Azibo Reservoir was built for water supply and irrigation, but those activities are not significant and the reservoir is used mainly for recreation. In Azibo direct influence of human activities is greater during summer when reservoir and

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surroundings are used by about 10,000 people for recreation such as swimming, camping and boating. Angling is also an important activity. The watershed area is occupied by meadows (1286 ha), woodlands and scrub (935 ha) and extensive agriculture (2235 ha). The latter is found all over the year and the main crops are olives (657 ha), chestnuts (650 ha), cereals (546 ha), vineyards (144 ha) and potato (85 ha). In the reservoir shore there are intensive crops, which are less than 1% of all crops (INE, 1999). Extensive grazing also occurs in this drainage basin. In Azibo catchment area there are several small villages. The total of inhabitants is about 1,500 and most of them are more than 50 years old (INE, 2001). Passing nearby and over of one stream that feed this reservoir there is a highway, IP4. In this highway the average daily traffic volume is 6,000 vehicles (Barbosa and Hvitved-Jacobsen, 1999). There is no industrial activity in both reservoir catchments. Therefore, the purpose of this research was to find out whether in what extent the environmental quality of aquatic systems reflect landscape occupation by assessing several water quality parameters.

2. Methodology

Water samples were collected monthly in winter and biweekly in summer, from January 2000 to December 2001 in both reservoirs. Details concerning sampling methodology, laboratorial procedure, statistical analysis and the determination of potential allochthonous sources of phosphorus and nitrogen can be found in Geraldes and Boavida (2003).

3. Results

Maximum and minimum ranges as well as mean and standard deviation values for water temperature, dissolved oxygen, conductivity, pH and water colour observed for both S. Serrada and Azibo are presented on Table 2. Both reservoirs were classified as meso-eutrophic. The potential allochthonous sources of phosphorus and nitrogen are presented in figure 1. In S. Serrada, grazing can contribute 30,450 kg of N and 13,050 kg of P per year. Wildfires can also contribute with substantial loads. However, for this region there are no data allowing quantification of this source. In Azibo trophic state is possibly influenced by agriculture, grazing, sewage, as well as by angling and bathing. Agriculture can contribute 36,394 kg of N and 49,192 kg of P per year, grazing 172,956 kg of N and 60,786 kg of P per year and sewage 4,927 kg of N and 1,752 Kg of P per year. Angling and bathing can contribute 28,080 kg of N and 5,184 kg of P and 900 kg of N and 41.5 kg of P per year, respectively. Results of MDS are depicted on figure 2. In this kind of diagram sample to sample dissimilarity is represented by the distance between points. So, the gradation in the spread of the points indicated the existence of two groups: One formed by samples obtained at S. Serrada and one formed those obtained at Azibo. This means that there is an inter-reservoirs variability related with some of the studied parameters. In fact, according to Kolmogorov - Smirnov test, nutrient and CHL *a* concentrations showed no significant differences between reservoirs in spite of differences in landscape occupation, water use and exposure to different degrees of disturbance. However, differences between reservoirs were found for conductivity ($D_m = 1$; $P<0.05$), water temperature ($D_m = 0.364$; $P<0.05$), pH ($D_m = 0.758$; $P<0.05$), transparency ($D_m = 0.455$; $P<0.05$) and water colour ($D_m = 0.643$; $P<0.05$).

4. Discussion

The values of the studied water quality parameters were similar for both reservoirs in spite of different landscape occupation, water use patterns and exposure to different factors of

disturbance. The observed differences in water temperature, conductivity and pH might be the result of the synergistic effect of reservoir altitude, and geological zone.

S. Serrrada is a highly disturbed system if compared with other located in similar geological and climate regions (Negro *et al*., 2001). There are two sorts of disturbance: One internal because of water level fluctuation, and the other external originating by the combined effect of grazing and fire. Furthermore, the areas of both reservoir and catchment are small. Thus, the intensity of use of water and grazing activity which could not have had a strong impact in systems with larger areas, in this reservoir could have induced a severe reduction in water quality. In fact, the observed ressuspension of bottom sediments and organic matter following water runoff input after the first rains, plus the turbulence generated by water level rising and the periodical exposure of littoral sediments to cycles of drying and wetting could explain the high phosphorus concentrations. On the other hand, grazing is not only a source of nutrients but also the main cause of fires in this region, since those are induced by shepherds to obtain better graze. Actually, this catchment is one of the areas with more fires per year in the Montesinho Natural Park (Rainha and Cabral, 2001). There are no studies quantifying the nutrient inputs to this reservoir because of the erosive impact of rainfall on post-burned soils. However, considering the high slope and the dominant soil type in this area, which according to Agroconsultores and Coba (1991) bear a high potential risk of erosion, high rates of soil erosion and consequently high surface runoff are expected. Besides, some research developed in other regions has shown that the consequences of a fire can be the increase in trophic state and the subsequent decrease of water quality in the adjacent water bodies. Those effects are more accentuated in sloppy areas and after intense precipitation events.

In Azibo internal disturbance caused by water level fluctuation is minimal. Moreover, the areas of reservoir and catchment are larger, landscape is patchy and fires are not frequent. However, other sources of disturbance such as agriculture, mainly the intensive cultures in reservoir shore, grazing and recreational activities, can explain the trophic state classification. According to estimations of the potential allochthonous sources of nutrients, agriculture and grazing seemed to be the greatest sources of N and P in the Azibo catchment. The intensity of exportation of nutrients from those activities and from sewage seems to be highly seasonal. In fact, in the beginning of the wet season the nutrient concentrations in water runoff were higher than in the water runoff generated by end of season rains. However, agricultural and grazing sources of nutrients can decrease within few years, since most of the farmers are more than 50 years old nowadays (INE, 1999; 2001) and that there is a considerable tendency for human desertification because of the low rentability of agricultural practices. Besides, the landscape in this catchment is very patchy and consequently there are numerous buffer areas such as woodlands, meadows and riparian vegetation that can minimise those potential sources of nutrients. Thus, intensive agriculture practices in the reservoir shore and recreational activities in summer are or might become in a near future the main nutrient sources to Azibo Reservoir. In fact, the values of nutrient concentrations obtained in summer can be related to those activities, which are more intensive in this period. Another, a possible source of pollutants that can also affect the water quality in Azibo is the highway IP4. According to Barbosa and Hvitved-Jacobsen (1999) the average concentration levels of Pb, Zn and Cu in the IP4 highway runoff are 10.8, 172 and 10.7 µg/l, respectively. Besides, the projected golf course in Azibo Reservoir shores if implemented might be a important new source of phosphorous and nitrogen. From the obtained data it seems undeniable that reservoirs can be regarded as mirrors of the surrounding landscape. However, there is a lack of data concerning for instance soil nutrient retention capacity and erosion rates. Such data are fundamental to develop export coefficient models adapted to these areas, allowing the correct estimation of nutrient and pollutant inputs, and to make possible the development of correct management measures for these reservoirs and the surrounding landscape.

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Table 1: Main general features of S. Serrada and Azibo reservoirs.

	S.Serrada	Azibo
Location	Latitude: 41º57'12''(N)	Latitude: 41º32'50''(N)
	Longitude: 6º 46' 44'' (W)	Longitude: 6º 53' 38'' (W)
Altitude (m)	1300	500
Geology	granitic bedrock	schistic bedrock
Mean annual precipitation (mm)	1300	800-1000
Watershed area (Km^2)	6.7	89.0
Reservoir area (Km^2)	0.25	4.10
Total capacity (m^3)	1680×10^3	54470×10^3
Max. Depth (m)	18	30
Mean depth (m)	6.72	13.2
Water residence time (years)	0.36	2.22
Year of filling	1995	1982

Table 2: Physical factors recorded for S. Serrada and Azibo reservoirs. Are shown minimum-maximum range; mean and standard deviation in brackets.

	2000	**2001**
S. Serrada		
Water temperature (ºC)	1.46-21.39 (12.51/6.59)	2.70-20.19 (12.90/6.46)
Dissolved oxygen (mg/l)	7.38-12.42 (8.55/1.45)	6.20-10.72 (8.55/1.49)
Conductivity (µS/cm)	4-10 (6.94/1.84)	3-8 (5.95/1.61)
Water transparency (m)	4.50-1.00 (2.66/1.09)	1-5 (2.85/1.14)
pH	5.77-6.56 (6.18/0.28)	5.95-8.34 (6.89/1.03)
Water colour (Pt units)	0.44-46.35 (17.39/14.27)	5.24-35.45 (18.55/9.36)
Azibo		
Temperature (ºC)	5.58-24.7 (16.52/6.13)	8.06-23.83 (17.16/5.73)
Dissolved oxygen (mg/l)	7.54-11.53 (9.09/1.06)	7.21-10.78 (8.99/1.33)
Conductivity (µS/cm)	51-81 (69.87/11.09)	43-66 (56.23/7.64)
Water transparency (m)	1.5-6.0 (4.72/1.25)	1.5-5.5 (3.50/1.14)
pH	6.71-8.05 (7.33/0.37)	6.64-8.36 (7.40/0.81)
Water colour (Pt units)	0.0-9.02 (2.82/3.02)	0.0-21.81 (6.21/5.66)
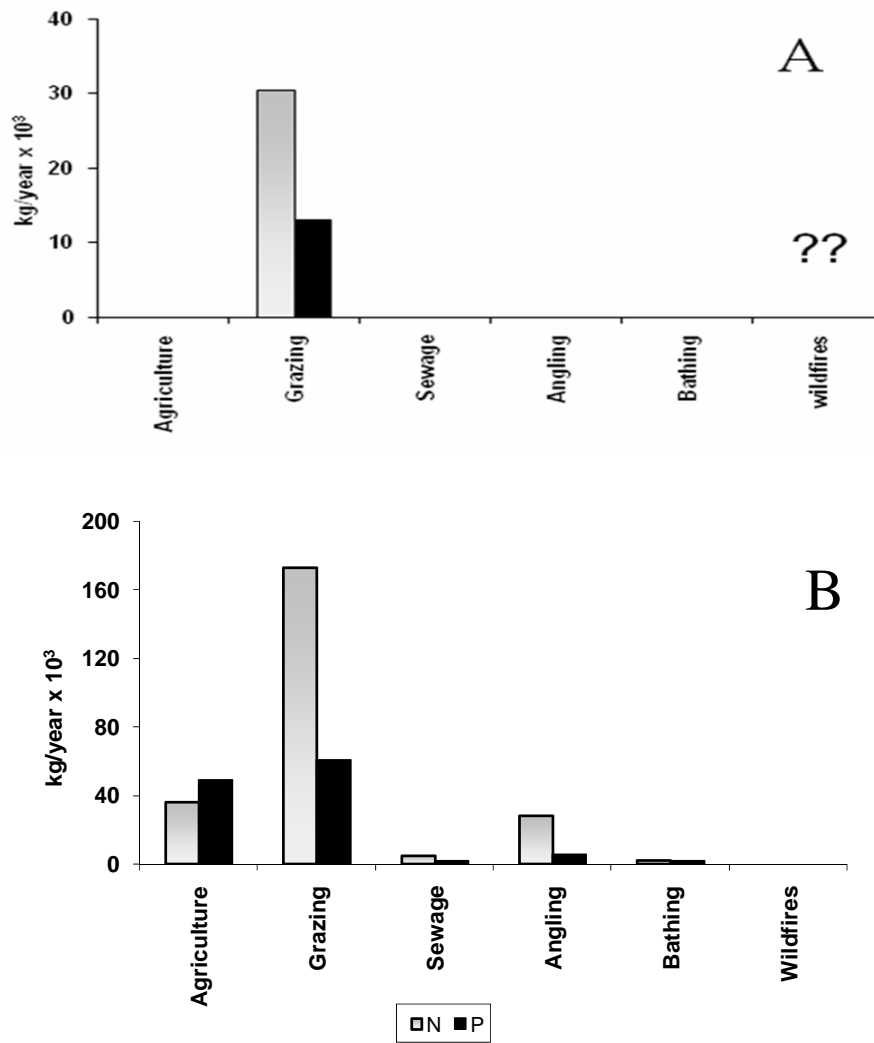
Figure 1: Potential external sources of nitrogen and phosphorus to S. Serrada (A) and Azibo (B) reservoirs (?? means non quantified source).
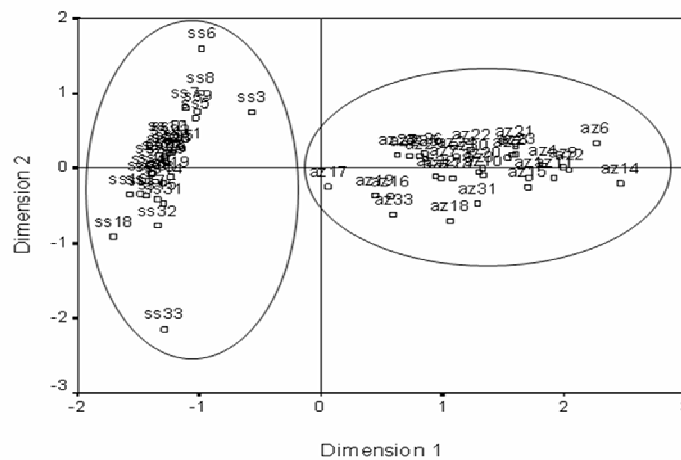
Figure 2: Results of MDS ordination (ss-Samples performed in S. Serrada; az-Samples performed in Azibo).

Using a multi-criteria approach to fit the evaluation basis of the modified 2-D cellular automaton "Pimp Your Landscape"

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Abstract

This contribution presents an evaluation approach that is used within the framework of the land-use management support tool "Pimp your landscape". "Pimp your landscape" is a modified 2-D cellular automaton, which enables a multi-criteria impact assessment of land-use management planning decisions. To evaluate land-cover changes, values are assigned to each land-use type; these values describe its contribution to regionally specific sets of ecosystem services and / or environmental risks.

A major problem is that universally valid indicators that facilitate the estimation of such values are rare. Indicators taken from sectoral evaluation approaches, such as those that are available from forest or agricultural research, often times address different target scales, thus negating their suitability for a holistic evaluation on landscape level.

We focus here on the question of how to quantify the impact of planning measures. A combination of participatory multi-criteria and indicator-based analysis is developed to arrive at a comprehensive evaluation.

Keywords: Pimp Your Landscape, ecosystem services, land-use type, landscape evaluation, criteria and indicators

1. Introduction

Land-use pattern change is one of many important factors that generate climate change. Land-management affects ecosystem functioning in many ways. Therefore, management measures and planning targets connected to climate change adaption are related to alterations in land-use types or management intensity. These changes will impact ecosystem services (MEA 2005). For the current project region in Saxony, Germany, we have chosen six ecosystem services: ecological functioning, aesthetical value, human health and well being, CC mitigation, bio-resource provision and economic wealth.

In our approach we aim at estimating the consequences of land cover and management changes on landscape level. We intend to support decision makers who are confronted with the challenge to take into account multiple objectives. For this purpose the tool Pimp your landscape (PYL) has been developed. PYL is software that simulates and visualizes the impact of management or planning scenarios on ecosystem services at the landscape level; these include structural landscape aspects and environmental data (climate, soil, topography). The end-user receives feed-back in real-time and can easily simulate and compare manifold scenarios. The software is based on a cellular automaton approach including GIS-features. The cell size is fixed at 100 x 100m. To each cell, the predominant land-use type (LUT) taken from the CORINE land-cover (CLC) 2000 or regional land cover data is assigned (Fürst et al. 2010).

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2. Methodology

Within PYL the provision of ecosystem services is evaluated in a first step for each land-use type and infrastructural element. In a second step, the value at the landscape level is calculated as the average of all cell values; this includes an additional correction of the result from the point of view of positive or negative aspects gleaned from the landscape structure (cf. Fig. 1 in Fürst et al., 2010).

Within PYL the land use classification standards of CLC 2000 and the environmental services (and functions) (LUF) set previously described (Pérez-Soba et al. 2008) are available as initial settings. The user can modify these initial settings or adopt completely different settings according to the regional application targets. After having selected a set of LUTs and LUFs, the resulting value matrix must be filled out. Evaluation of the land-use types follows classification, on a relative scale from 0 (worst case) to 100 (best case), of the specific regional contribution of a LUT to a LUF. The introduction of this relative scale aims to facilitate the multi-criteria evaluation of planning measures.

The value matrix contains initial impact values of the land use types and infrastructural elements on the environmental services. The initial value of a land use type for an environmental service represents the maximum in the regional context, which can only be reduced (a) with regard to environmental cell attributes from additional information layers such as height above sea level, mean annual precipitation, temperature, soil type and exposition. (b) The impact of the cell environment (homogeneous land use types vs. different land use types) and neighbourhood type (edge to edge vs. corner to corner) can impact the original maximum value. The influence of structural features on the final evaluation is discussed elsewhere (cf. contribution of Frank et al.).

2.1 Indicator-based assessment

2.1.1 Statistical indicators

Evaluation of ecosystem services is commonly based on indicators. For our assessment the challenge is to find or generate indicators associated to LUTs which can then be processed in an aggregation framework to estimate comparative scores.

Despite the general scarcity of indicators, a few economic-evaluation indicators are available that allow for a comparison of LUT-related land prices. We used standard ground value, land rent and market price to compute land-use dependent value points. We had two prerequisites for the choice of an indicator. The first condition was a thematic relation to at least two LUTs. Second, data had to be available on a per unit area basis due to 100 x 100m grid cells used as the reference unit in PYL. Quotients of indicator values were calculated to reflect the value of an LUT in comparison to another LUT (see table 1). For each LUT the mean of quotient-values was determined and normalised to the scoring scale (0 – 100 value points) using equation 1. The standard ground value acts as a "cross link" as it integrates information about semi-natural and artificial (urban) LUTs.

Tab. 1

2.1.2 Measured and modeled indicators

Other sources of indicators are regional studies with a land-use oriented background. Data relating to N-export (LfULG 2009), soil sealing and run-off coefficient (Arlt 2001) could be derived from such studies (table 2). Indicator values were normalized using equation 1 or 2. When an indicator's link to the performance of an LUF was negative, equation 2 was utilized. In

this concept, an indicator can be applied to one or more LUFs. Since the impact of an indicator on an LUF may vary, weights need to be indicated.

$$I_{norm} = \left(\frac{I - I_{min}}{I_{max} - I_{min}}\right) * 100 \tag{1}$$

$$I_{norm} = \left(\frac{I - I_{max}}{I_{min} - I_{max}}\right) * 100 \tag{2}$$

where I_{norm} is the indicator value for a given LUT normalised to a score between 0 and 100 and I is the value of the indicator assigned to the LUT. I_{min} and I_{max} correspond to the minimum and maximum of indicator values.

Tab. 2

2.2 Participatory-based assessment

A preliminary study showed that landscape assessment based on an evaluation of LUTs cannot be achieved by using quantitative indicators only (cf. chapter 2.1). With measured or calculated indicator values most evaluation-criteria cannot be assessed across land-uses. For this, CLC (2000) classes are too coarse in terms of spatial and thematic resolution. At the landscape level a more general approach is required.

Multi-Criteria Analysis (MCA) involving expert consultation is a suitable tool for support of the evaluation. Because of their comprehensive character, MCA techniques are often used to rank alternatives for decision-making or to assign values, if there are multiple objectives involved.

LUFs were broken down to a set of criteria which are actually evaluated. Table 3 illustrates a draft of a matrix showing LUFs (environmental services) and connected criteria which are relevant in the context of the REGKLAM-project. LUTs are placed on the y-axis, while environmental services are arranged on the x-axis. The matrix will be used to appraise the capacity of the LUTs to provide goods and services.

Tab. 3

We combine normalized indicator values and expert estimation within the matrix. The expert group should (i) discuss relevant functions and criteria, and (ii) interpolate gaps between indicator values for LUTs that have not been ascertained. In addition (iii) the respondents will be asked to evaluate the LUTs in terms of other criteria, the description of which cannot be related to any measurable indicator values.

The contribution of an indicator depends on regional significance and the number of indicators/ criteria that correspond to an LUF. Hence, prior to an aggregation framework, stakeholders (iv) have to assign weights to the criteria, whereby preferences are expressed as well. According to the preliminary matrix, experts would have to make 529 decisions.

3. Results and Discussion

Indicator-based assessment of capacities of LUTs to provide certain services has proven difficult. When using an indicator set for evaluation of the economic value, an extreme imbalance between the value of urban and semi-natural (rural) areas results. As a consequence, for example, the contribution of forest and agricultural areas to the regional economy is mostly underestimated. In addition, the utilisation of indicators which are highly aggregated is critical. Land rent and market value are indirectly contained in the standard ground value, in the calculation of which market-driven factors are also considered. The scores of table 1 reflect the

disproportionality of surface share and marketed economic value of LUTs dominated by agricultural or silvicultural use in comparison to built-up areas. This discrepancy is confirmed by sectoral accountings.

The use of modelled and measured indicators is very restricted, not only regarding economic aspects. Data about N-Export, soil sealing and run-off coefficient as estimated for different LUTs in other studies can be used in the evaluation matrix (table 3). N-export and soil sealing act as proxies for land-use intensity and the functioning of ecological processes. Soil sealing also has an impact on landscape aesthetics, assuming that a high share of sealed surface area causes a decreasing visual attractiveness. Run-off coefficient is connected to water retention potential which is important for the risk of flooding during heavy rainfalls. Therefore this indicator is considered as a criterion for CC mitigation. For assessing ecological functioning species richness, percentage of dead wood or other non-structural indicators are not convenient. Depending on environmental conditions and habitat composition, such indicators behave differently and are thus not appropriate to be assigned to LUTs.

The drawbacks and restrictions related to the integration of indicators of multiple scales and dimensions resulted in the consideration of stakeholder involvement to obtain a comprehensive evaluation. Participatory methods are often considered the most suitable approach in terms of landscape analysis (eg. de Groot 2006). They have been widely and successfully applied in landscape/ environmental modelling (Dai et al. 2001; Vacik and Lexer 2001). Due to weighting and aggregation issues, indicator-based approaches and collaborating techniques are both prone to biases. MCA approaches also suffer from concerns such as the selection of participants, their respective background and interests (Danae and Stelios 2004). We therefore intend to incorporate available indicator values as reference points for experts during the evaluation process.

4. Conclusion

Some pre-analysis in our work proved that a purely indicator based approach for a holistic landscape evaluation in Pimp your landscape will fail, because fitting indicators are rare and sectoral indicator approaches are not suitable for up-scaling the evaluation results (Fürst et al., subm.). A comprehensive evaluation of LUTs in the context of landscape management and planning was founded on several data sources. We suggest a mixed indicator-based and expert opinion evaluation approach.

Next steps are expert-evaluation which may be followed up by another round in order to estimate the performance of LUTs under future scenarios, which is important for the introduction of time slots. Thus, based on CC projections also ecosystem dynamics can be regarded. Since we *de facto* assess land-cover types as supported by CLC (2000) which are related to but not fully congruent with LUTs, an incorporation of land management types into PYL is planned in order to address the impact of adaptation options to CC at the farm level (irrigation, crop rotation, tillage, changing tree species composition etc.).

Despite several shortcomings and limitations inherent in the approach, we believe that comprehensive assessments are of great importance for environmental managers and for the consideration of ecosystem services in landscape planning processes.

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Tables

Table 1: Simple relational matrix of cross-linked indicators (vertical bars) for assessing the economic wealth. Quotients of initial indicator values (vertical column on the left) are depicted in the matrix. They are assigned to a limited number of LUTs. Quotients allow for comparison of land prices among LUTs. The mean value of each LUT was normalised to a score between 0 (least valuable) and 100 (most valuable) (grey row at the bottom).

	Initial Values [€/ha]	LUT	Urban fabric	Arable land	Deciduous forest	Conif. forest	Mixed forest	Rods	Pastures
Standard Ground Value[1]	458000	Urban Area		0,0	0,0	0,0	0,0	0,1	0,0
	6500	Arable land	70,5		0,7	0,7	0,7	6,2	1,0
	4300	Deciduous forest	106,5	1,5		1,0	1,0	9,3	1,5
	4300	Coniferous forest	106,5	1,5	1,0		1,0	9,3	1,5
	4300	Mixed forest	106,5	1,5	1,0	1,0		9,3	1,5
	40000	Roads	11,5	0,2	0,1	0,1	0,1		0,2
	6600	Pastures	69,4	1,0	0,7	0,7	0,7	6,1	
Lease[2]	143	Arable land	x		x	x	x	x	0,5
	72	Pastures	x	2,0	x	x	x	x	
Market value[3]	4858	Arable land	x		0,7	0,7	0,7	x	x
	3444	Deciduous forest	x	1,4		x	x	x	x
	3444	Coniferous forest	x	1,4	x		x	x	x
	3444	Mixed forest	x	1,4	x	x		x	x
		Mean	78,5	1,2	0,6	0,6	0,6	6,7	0,9
		Points	**100,0**	**0,8**	**0,0**	**0,0**	**0,0**	**7,8**	**0,4**

Data sources: [1]Advisory Committee on Property Valuation (Gutachterausschuss,2008), [2]Saxon State Ministry of the Environment and Agriculture (LfULG 2009), [3]Bodenverwertungs- und verwaltungs GmbH (BVVG 2008)

Table 2: Compilation of data derived from different studies with corresponding value points assigned to LUTs. LUTs for which no data were available are not depicted.

Land-use function (LUF) Associated indicator	Ecological Functioning		Ecological functioning/Aesthetics		CC Mitigation	
	N-export[1]		Soil sealing[2]		Run-off coefficient[2]	
	(kg N ha⁻¹ a⁻¹)	**Points**	(%)	**Points**	(Ψ)	**Points**
Continuous urban fabric	20	**0**	73	**0**	0.7	**13**
Discontinuous urban fabric	-	**-**	31	**58**	0.325	**59**
Road and rail networks	-	**-**	-	**-**	0.8	**0**
Mineral extraction sites	9.1	**98**	-	**-**	-	**-**
Non-irrigated arable land	-	**-**	0	**100**	0.15	**81**
Vineyards	11.2	**79**	0	**100**	-	**-**
Fruit trees & berry plantations	11.3	**78**	0	**100**	-	**-**
Pastures	-	**-**	0	**100**	0.1	**88**
Agro-forestry areas	-	**-**	0	**100**	-	**-**
Broad-leaved forest	8.9	**100**	0	**100**	-	**-**
Coniferous forest	13.7	**57**	0	**100**	-	**-**
Mixed forest	-	**-**	0	**100**	-	
Natural grasslands	-	**-**	0	**100**	-	**-**
Water bodies	15.9	**37**	0	**100**	0	**100**

[1](LfULG 2009), [2](Arlt 2001)

Table 3: Draft matrix for the assessment of regionally relevant land-cover types. Displayed indicator scores (light grey and grey fields) stand for an LUTs capacity to sustain specific ecosystem services. Original statistical and measured (modelled) data values were normalized to the scoring scale (0-100). For incommensurable criteria, values will be estimated and existing data gaps (dark grey fields) completed using expert knowledge. The weighted mean of criteria scores corresponds to the final evaluation and will be displayed in the black fields.

[1] LfULG (2009), [2,3] Arlt (2001), [4] Advisory Committee on Property Valuation (2008)

Assessing "spatially explicit" land use/cover change models

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Abstract

Spatially explicit land use/cover change (LUCC) models aim at predicting the location and pattern of LUCC. The simulation involves a spatial procedure which identifies the potential locations of change and eventually replicates the patterns of the landscape. Generally, evaluation is based upon the comparison of the simulated map and a true map of the same date. However, most of the evaluation techniques only evaluate the spatial coincidence between simulated and true changes and do not assess the ability of the model to simulate the landscape patterns. Simulated maps obtained by two models (DINAMICA and Land Change Modeler) were evaluated using a fuzzy similarity index and landscape metrics. Results show that more realistic simulated landscape are often obtained at the expense of location coincidence. When patterns of landscape is an important issue (e.g. Fragmentation), indices taking into account spatial patterns, and not just location, should be used to assess model performance.

Keywords:land use/cover change, modeling, landscape metrics, assessment

1. Introduction

Over the last decades, a range of "spatially explicit" computational models of LUCC have been developed for the projection of alternative scenarios into the future, for conducting experiments that test our understanding of key processes, and for describing the latter in quantitative terms (Veldkamp and Lambin 2001; Xiang and Clarke 2003). Among these models, process-based models, closely related with geographic information systems, view land use and cover changes as transition process from one state to other states. Typical examples are models based on cellular automata and Markov process models, such as the two models used in the present study.

2. Material

We used the programs DINAMICA EGO and Land Change Modeler in IDRISI for LUCC modeling. DINAMICA EGO is a cellular automata-based model which has been applied in a variety of studies, including modeling tropical deforestation (Soares-Filho et al. 2002 and 2006; Cuevas and Mas 2008) and urban growth and dynamics (Godoy and Soares-Filho 2008). Land Change Modeler (available in IDRISI) provides tools for the assessment and projection of land cover change, and their implications for species habitat and biodiversity (Eastman 2006; Gontier et al. 2009; Koi and Murayama 2010). Statistical analysis and graphs were created using R (R Development Core Team 2009).

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Modeling was carried out using the data set supplied with the IDRISI tutorial which consists of land cover (LC) maps and ancillary information from a rapidly changing area in the Bolivian lowlands (Eastman 2009). The data used in the present study are the LC maps of 1986 and 1994 and several maps used as explanatory variables (maps of distance from urban areas, distance from roads, slope, distance from disturbance, elevation).

3. Methodology

The present study aimed at: 1) creating modeled LC maps using DINAMICA and LCM; and 2) assessing these maps using two approaches, a) based on the spatial coincidence,, and b) computing landscape metrics.

3.1. LUCC Modeling

LUCC are modeled empirically by using past change to develop a mathematical model; and GIS data layers influence the transition potential. The simulation procedures can be sub-divided into the following basic steps:

1) Calibration: The model is calibrated using a map of LUCC obtained through the comparison of LC maps at two different dates (1986 and 1994 in the present case). The quantity of each type of change is computed from a Markov matrix, which is the standard procedure in DINAMICA and LCM. A spatial analysis allows the identification of more likely change locations using a set of explanatory variables. Based upon the relationship between the different transitions and the explanatory variables, maps of change potential are produced for each transition. In the present study, the DINAMICA model uses the map of probability elaborated by the LCM artificial neural network (ANN) in order to obtain comparable results.

2) Simulation: A prospective LC map is created based upon the expected quantity of changes (Markov matrix). DINAMICA and IDRISI use a cellular automata approach in order to obtain a proximity effect and eventually simulate landscape pattern. In IDRISI, the process involves a 3x3 filter which reclassifies pixels to incorporate the effects of neighboring pixels on a current pixel value and there is no option to control the CA behavior. DINAMICA uses two complementary transition functions: 1) the Expander; and 2) the Patcher. The first process is dedicated only to the expansion or contraction of previous patches of a certain class. The second process generates new patches through a seeding mechanism. The user can set parameters to control the size and shape of the simulated patches, such as mean patch size, patch size variance, and isometry. Additionally, a "prune factor" allows simulated changes to occur in less likely areas.

3.2. Model assessment

The evaluation of the LC prospective map was based on the comparison between the simulated and the observed (true) map using two approaches: a) the spatial coincidence between modeled and true change; and, b) the spatial pattern of modeled and true change patches.

In order to assess the spatial coincidence between simulated and true changes, we used the fuzzy similarity test based on the concept of fuzziness of location, in which a representation of a cell is influenced by the cell itself and by the cells in its neighborhood (Hagen 2003). Two-way comparison was conducted, applying the fuzziness to the simulated and the true maps of change in turn. As random maps tend to score higher, we picked up the minimum fit value from the two-way comparison. In order to assess the spatial configuration of simulated and true changes, we calculated, for each transition, the amount of change with respect to the map of change

probability. For this, a map of susceptibility categories was first obtained by reclassifying susceptibility maps into 10 categories and overlaying this with the maps of changes. Additionally, some metrics used to characterize landscape were computed, such as the number and the size of the patches (mean and standard deviation) and total edge (mean and standard deviation). In the present study, as we are interested in assessing landscape pattern simulation rather than predictive performance, we simulated a 1994 LC map from the model calibrated over the period 1986-94 (i.e. the simulation and calibration periods are the same).

4. Result

4.1. LUCC Modeling

During 1986-94, the main LUCC transitions were the conversion to anthropogenic disturbance of:

Transition 1:Deciduous mature forest.
Transition 2: Savanna.
Transition 3: Amazonian mature forest.
Transition 4: Woodland savanna.

Only these 4 principal transitions were modeled using as explanatory variables the distance from 1986 urban areas, the distance from roads, the slope, the distance from 1986 disturbance, the elevation and the 1986 LC map. The two programs were used to build 1994 simulated LC maps (Figure 1). In the case of DINAMICA, various settings of prune factors, patch sizes and isometry were tested.
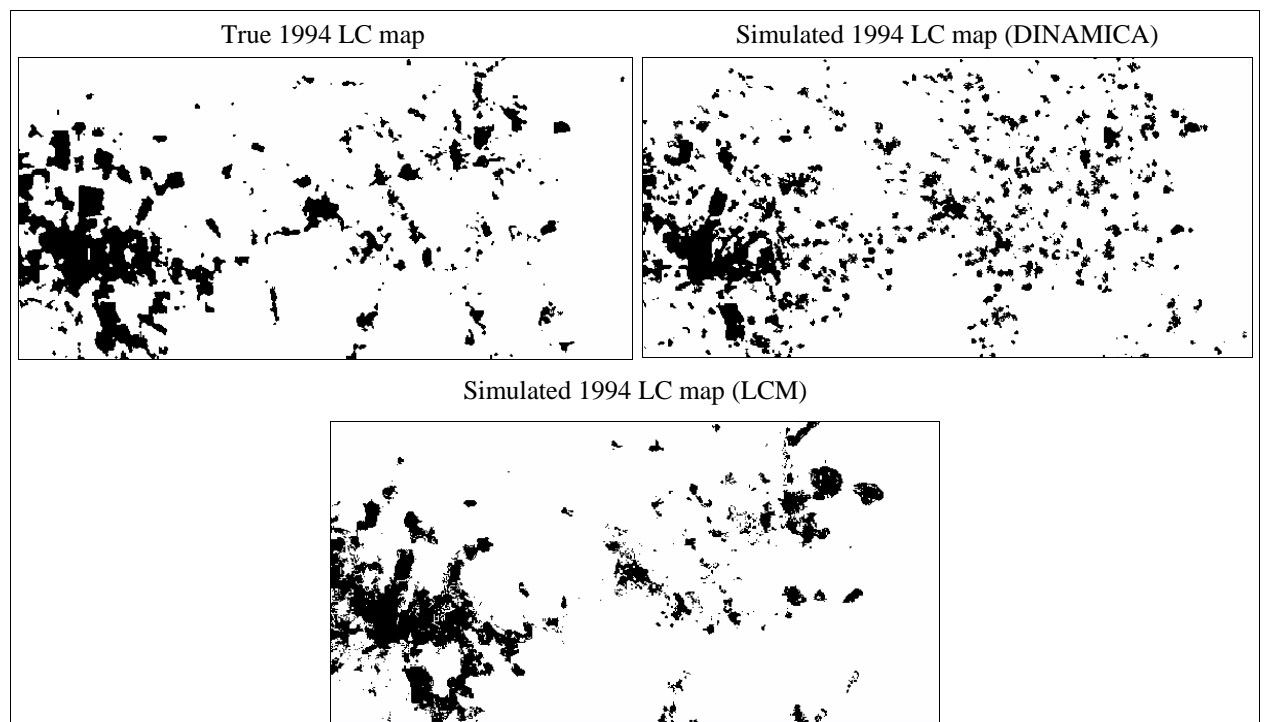
Figure 1: True 1994 LC map and modeled maps by DINAMICA and LCM (Zoom on the Southeastern part of the study area, only the category anthropogenic disturbance is represented)

4.2. Model assessment

The fuzzy similarity index indicates that coincidence between the true changes and the changes modeled by LCM is much higher than with DINAMICA using little tolerance (fuzzy tolerance distance < 1000 m). This result was expected as LCM tends to collocate simulated changes only in the areas with higher change potential. Since DINAMICA makes an attempt to create patches and simulates change in less likely areas (if the prune factor value is set high), the coincidence between the true and simulated changes is likely to be lower. However, with higher fuzzy tolerance values, DINAMICA presents a higher score because it has some (fuzzy) coincidence of simulated patches located in less likely areas. This does not occur with LCM that restricts the simulated change to the more susceptible areas only. Therefore, DINAMICA presents a better coincidence "as a broad picture" whereas LCM exhibits a better coincidence on a per-pixel comparison or with little fuzzy tolerance.

Table 1 shows that with DINAMICA it was possible to obtain for each transition simulated patches of change that present broadly the same size as true patches of change. In the case of LCM, the simulation produced some very large patches corresponding to the higher susceptibility areas, resulting in larger values for the mean and the standard deviation of patch size. A similar pattern can be observed for patch edge lengths. However, there are fewer patches on the true change map than on either of the simulated change maps. The map modeled with LCM has 47% fewer patches than the true map.

Table 1: Landscape metrics for true and simulated maps

Metric	Transition	True Changes	DINAMICA	LCM
Number of patches	Transition 1	332	204	192
	Transition 2	326	208	190
	Transition 3	666	615	299
	Transition 4	1017	804	547
Patch size (mean / standard deviation)	Transition 1	5.7 / 6.9	9.3 / 9.3	9.7 / 36.2
	Transition 2	9.8 / 18.4	15.4 / 21.3	
				16.7 / 41.7
	Transition 3	17.1 / 46.3	18.5 / 23.5	36.1 / 162.1
	Transition 4	19.4 / 45.6		35.4 / 151.6
			24.5 / 32.4	
Patch edge length (mean / standard deviation)	Transition 1	1058.1 / 802.4	1551.5 / 1262.8	1417.2 / 2936.7
	Transition 2		2097.1 / 2056.8	2133.2 / 3690.2
		1465 / 1835.6		
	Transition 3	1856.8 / 2604.1	2245.4 / 2240.3	3107.9 / 9325.7
	Transition 4	2233.2 / 3343.9	2889 / 3184.5	3240.2 / 9436.7

Figure 2 shows that true changes do not occur only in more susceptible areas and that this tendency depends on the transition. For example, transition 3 occurred mainly in the more susceptible area whereas transition 2 is frequent even in areas with medium susceptibility. The changes simulated by LCM are limited to the areas with higher susceptibility. The setting of the prune factor allowed DINAMICA to generate a map with a distribution of change closer to the observed change.
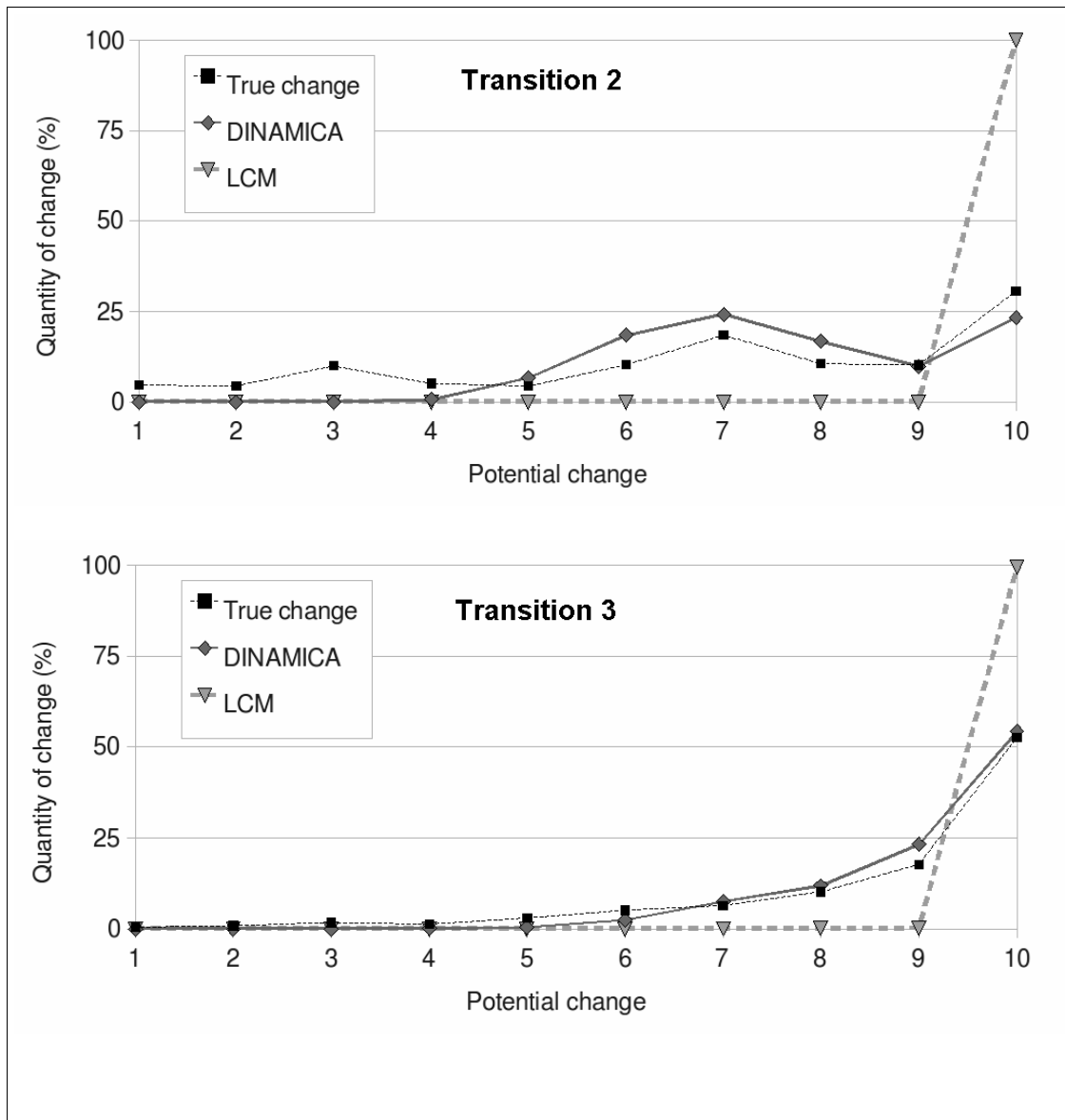
Figure 2. Distribution of change in categories of change susceptibility.

5. Discussion

DINAMICA was able to generate more realistic prospective LC maps with respect to landscape pattern because it provides parameters to control the CA behavior. However, the best manner of producing a prospective LC map, where simulated changes fit better with the true changes, is by thresholding the susceptibility map, because the majority of the changes occur in the more likely locations. The realism of the landscape pattern in the prospective LC map is obtained at the expense of the accuracy of the locations of the change. This is particularly obvious when models simulate the occurrence of changes in unlikely areas. The prune factor in DINAMICA also allows the occurring of change in less likely areas. When modeling aims at producing LC maps that can represent a possible future given a certain scenario, the accuracy of the spatial allocation of change is not necessarily a critical issue. For example, in the assessment of LUCC

on biodiversity, it can be important to know that homogeneous forest areas will be perforated by small agriculture fields although the exact location of the fields remain unknown.

However, the common procedures of assessment of a prospective LC map are based upon the spatial coincidence of the simulated map and a "true" observed map. Therefore, the modeling and the assessment procedures have to be adapted to the critical feature the model has to achieve. When landscape pattern is an important feature, the computing of landscape metrics can provide valuable insights to evaluate the model performance.

6. Acknowledgements

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Economic valuation of environmental goods and services

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Abstract

The economic valuation of environmental goods and services (EVEG&S) results of the increasing concern with the quality of industrial products and the reduction of social welfare. The EVEG&S presents the direct and indirect costs and benefits of quantitative and qualitative environmental changes in goods and services and corresponding impacts. This is particularly important in the valuation of investment projects and governmental policies. This study consists in a survey of environmental appraisal methods, focusing into the hypothetical and complementary market based ones. The review reveals that evaluation of environmental quality is very complex. In fact, for each criterion there are several assumptions that are inapplicable to all situations. Effectively, despite the evident complementarity of conventional goods environmental quality, the values attributed to these resources could be underestimated and complementary and substitute markets can be inefficient parameters.

Keywords: Economic valuation, natural resources, markets, environmental goods

1. Introduction

The economic growth is based on wealth creation, based on a process of dominance and transformation of the Nature. The modern society is guilty of wild exploitation of natural resources, neglecting the damages of productive activities. The demand and improper use of the natural resources increases daily. With this speedy environmental harm, environmental protection stands out as one of the current and future major challenges for humanity. The economic appraisal of environment results of the increasing concern with protection and preservation of natural resources and consumers' requests for quality industrial products, simultaneous with the reduction of social welfare, as consequence of the quality and amount of these resources. The economic appraisal emerges as a measuring tool of environmental goods and services and of the impacts of environmental degradation and depletion, determining the direct and indirect costs and benefits of qualitative and quantitative changes. It is gathering importance in the evaluation of investment projects, governmental policies and international trade. This paper focuses on this problematic. The paper consists of a critical analysis of the economic appraisal criteria of environmental goods and services. Particularly of the methods that make use of hypothetical and complementary market goods.

2. Economic Valuation of Environmental Goods and Services

Based on the externality notion, Foladori (1997) defends that negative trends inherent to free market can be beaten through environmental appraisal with the inclusion of prices in economic analysis, via policies that attenuate environmental problems. Schweitzer (1990) beliefs that environmental appraisal is fundamental to prevent the depletion of natural resources.
The environmental appraisal emerges as a set of techniques and methods to quantify the expectations of benefits/costs derived from the use of environmental assets, carrying out

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benefittings or infliction of environmental damages. The economic value of an environmental good consists of the estimate of a monetary value for this good, in opposition to other available goods. However, some times, it's difficult to aggregate all the effects in a single indicator.

The economic value of environmental resources (EVER) results from its attributes, and these can be associated to the use (direct, indirect and option) or non-use of the resource, i.e., its simple existence. EVER purposes a fee for environmental resources' use and/or preservation. The genesis is the protection of current and future generations' interests. Thus, use value (UV) is the value attributed by people who use or usufruct of the environmental good to satisfy their needs. The non use value (NUV) is dissociate of the use because it derives from a moral, cultural, ethical or altruistic position regarding the rights of existence of other living species or the preservation of natural assets although that do not represent current or future use for them.

While slightly different classifications exist, they result the same. Still, controversy subsists regarding existence (EV) and option (OV) values, since the EV represents the individual will to preserve a set of environmental resources for future generations' direct and/or indirect use. Thus, the conceptual question is if a value defined like so is closer associated with the OV or the EV. Equally, the legacy value (in this definition mixed with the EV) can be independent (Figure1). However, for EVER matters that the individuals point out the most trustworthy values possible, independently of the current or future use.
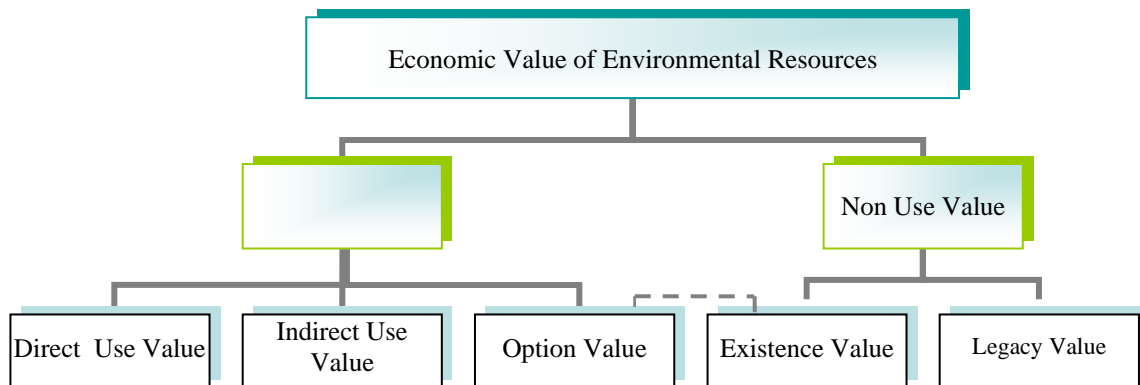
Figure 1: Different economic values of environmental resources

The environmental appraisal difficulty increases inversely as function of the resources' use. The choice of the criterion depends on the knowledge of the ecological dynamics of the study object, the purpose of the valuation, the availability of information and the hypotheses adopted.

Environmental economics classifies the valuation techniques in production function methods – marginal productivity method and markets of substitute goods method – and demand function methods – methods that utilize markets of complementary goods (hedonic prices and travel costs methods) and hypothetical markets (method of contingent valuation). May and Motta (1994) refer that production function methods analyze environmental resources associated to the production of a private good and, generally, assume that supply variations do not influence market prices. The demand function methods admit that changes in resource availability modify individual wellbeing and, therefore, it's possible to identify individual measures of Willingness to Pay (WTP) or Willingness to Accept (WTA) regarding to these variations. These are the methods under this study review.

2.1. Analysis of the Demand Function Methods

To Dixon *et al.* (2001), subjective valuation methodologies can assess consumers revealed or expressed preferences, in real or fictitious markets, relating it with individuals' utility functions. Mainly, these methodologies use substitute market prices or contingent values (Table 1)

Table 1: Subjective valuation criteria

Complementary Goods Market		
Hedonic Prices		
Property value	Revealed behaviour	Substitute market prices
Wages differential	Revealed behaviour	Substitute market prices
Travel Costs	Revealed behaviour	Substitute market prices
Hypothetical Markets		
Contingent Valuation	Expressed behaviour	Contingent value

Revealed preferences analysis is based on real markets of goods and services (MG&S) affected by environmental impact, in which folks pick between levels of environmental quality and other goods. When resources are not marketly traded, the economic analysis aims to estimate the economic value as if the market exists. The analysis of expressed behaviours is used when is not possible to valuate the environmental impacts, even dissimulatly, through real markets.

2.1.1. Markets of Complementary Goods

The urban amenities are not restricted to natural features, as green areas, beaches and climate. The concept also adds the goods (or evils) created by men, as traffic, pollution, recreation areas and safety. The study of these environmental attributes permits to understand the impact (and the changes) of the cities physical space on their inhabitants' wellbeing, as well as the effect on the real estate market value. To quantify urban amenities is not a simple task. Although the real estate market has supply, demand and an equilibrium price, it's not possible to visualize the market prices of environmental amenities, since trade of oxygen, landscape, recreation areas, or traffic, pollution and noise, does not exist.

The hedonic prices (MHP) and travel costs (TCM) models are the more adjusted criteria to decode this information. They are based in the preferences revealed by consumers in a substitute market, and use it to assess individuals' wellbeing, in view of environmental quality changes.

The MHP has been widely used in the real estate market to measure the marginal value of natural or structural attributes, and estimate the correlated social-environmental variables. This method is based on the recognition of the complementary attributes of a specific private composed good to environmental goods or services (Motta, 1998). This complementarity discloses the price of the environmental attribute implicit in the market price.

The method of property value (and wages differential method) solely valuates UV. It only looks into the appraisal of environmental functions/services that directly affect the market prices of related goods. The MHP considers a heterogeneous good as a closed package, with specific attributes, where the marginal price of each one is estimated, based on the analysis of the good observed value and attributes' respective amounts (Rosen, 1974). It presumes that families, when look for housing, are worried about what exists inside and outside (the amenities) of the property. These amenities (distance to workplace, proximity of parks, beach, schools, quality of air, water, sonorous pollution, landscape, etc.) will imply variations in the asset usufruct. Similarly, the price of a specific land does not depend solely on its patrimonial value, but also on the actual value of the net benefits generated by soil productivity over time. Thus, because productivity levels differ, different land fractions have different price levels. Additionally, the environmental features, as air quality, water disposal (for irrigation) or erosion, affect the soil quality for agriculture, and thus, its price. The MHP estimates the quantitative differences of the attributes, using market prices of goods or costs of services essentials in the formation of these prices/costs. These discrepancies are valued by individuals, reflecting their WTP when the environmental attributes vary. According to this paradigm, two houses with identical physical attributes, situated in different ecological and social contexts, will have different prices.

The MHP catches only the use values. EV is not catched because of the weak complementarity. When the demand for a specific environmental attribute is null, the demand for the composed

good is also null. Redondo (1999) refers that MHP reproduces the changes in the UV of a specific place inhabitants, but are merely informative in the "*passer-bys*" case (individuals that do not have fixed residence there, but sporadically travel to it) and reveal nothing about NUV (associated with individuals that do not use the place). The adoption of this criterion requires the existence of a reasonable mobility in real state market, so that folks can reveal their WTP in an environmental context where is possible to choose between houses with different attributes and without prohibitive transaction costs (costs of house search and changing, taxes and duties associated with the sale/purchase). The improve of life quality conditions in a specific neighbourhood, does not necessarily imply a change in housing prices, due to the people weak mobility to try another neighbourhood and their WTP for usufruct of it.

Dixon *et al.* (1994), Comune *et al.* (1995), Motta (1998), Redondo (1999), among others, emphasize that MHP efficient results require the assembling of detailed and faithful information on the characteristics of the asset under valuation. An exhaustive survey on the environmental indicators is crucial. Namely, the attributes that influence the assets price: property features (size, degree of conservation, benefittings); commercial, transport and education services; local community quality (neighbouring, criminality) and social-economic information of a sample representative of local owners. Additionally, the attribute under valuation must be clearly and precisely defined, in order to successfully isolate it from the subject other attributes. The same authors refer the operative difficulties in the econometrical estimation of the hedonic functions due to the omission of relevant variables, attributes' multicollinearity, and functional form identification, among others. Additionally, property prices can be underestimated due to minor property tax transfer or to attenuate the effect of patrimonial variations. The alternative would be to use leasing values. So, this method must only be used in case of high correlation between property price and environmental attribute, when is possible to catch all the attributes influencing the real estate market equilibrium price and when the hypotheses adopted for the estimate of the consumer surplus are realistic.

The TCM is used in the valuation of environmental resources as parks and recreational sites, but also to quantify externalities of urban collective transport projects. The TCM basic premise is that the costs of accessing to a place directly influence its visits number. This method associates the environmental resources value to its recreation value. The benefits of a specific investment are quantified in function of the (estimated costs by the) curve of demand of the activity, based on the study of their users' expenditures (in time and transportation costs).

The TCM is based on a preferences approach. The individual reveals his choices buying specific goods associated with the use of an environmental good. This approach requires interviews to the visitors in order to determine their standard use and to gather information on the number of visitors; visitors' geographic, social and economical characteristics; motive, duration and frequency of the visit; transportation mean and costs associated to the trip... The data collected will be used to estimate a visitation rate by region of origin, the total travel costs and link it with the visits frequency, establishing a demand correspondence. Each individual income matches a demand function, given that each person is WTP a determined price in exchange for an amount of the product. The curve of demand for visit for each region and the aggregated demand curve are determined. Then, visitation demand function is used to estimate the consumer surplus, which represents the economic value of the recreational site.

The disadvantages of the TCM application are related with the individual visits' duration, the possibility of resources deterioration, the distance (it's expected that distant residents visit less the recreational site, while they can actually have longer visits), the difficulty in the exclusion of services not associated to the site (multiple trip objectives and destinations), the merely capture the visits direct and indirect UV and the monetary value of the time spent by the visitor (overvaluing the recreation cost, due to price distortions in the labour market). Other disadvantages are related with the premises assumed in the estimation of the curve of demand; the need of reliable data; high application costs; dependency of statistical methods; and the no consideration of NUV components.

2.1.2. Hypothetical markets

To Hicks (1939), the estimation of a change in consumer wellbeing can be carried out by its income variation, introducing two measures of value that support the economic valuation of environmental impacts. The measures are compensatory and equivalent variations and are linked with variations in consumers' utility and preferences (WTP and WTA).

According to Comune *et al.* (1995), the Method of Contingent Valuation (MCV) aggregates a set of techniques used in research to estimate the EVEG&S, based on consumers' preferences. These techniques are based on individual budgetary evaluations, given an increase or decrease in the quality or amount of an environmental good or service, in a hypothetical scenario. This is the only method that allows valuating the UV and NUV of environmental resources. Its domain of application is the valuation of wildlife, protection of *habitats* and measurement of the UV of leisure and recreational sites. According to Dixon *et al.* (1994), the MCV constitutes the only alternative to attain economic value estimates when in presence of distortions in environmental MG&S, there are no effective market nor substitute markets for it. Walnut *et al.* (2000) explain that the theoretical concept of MCV is consumer theory (consumer choice and consumer surplus). The individual WTP discloses, through the graduation of the marginal utility, the best estimate of its demand scale, and thus, quantifying social welfare measures. The consumer choices are based on the utility maximization premise, under budgetary restriction. The consumer surplus valuates the different degrees of individuals' preferences for various goods and services revealed when consumers go to the market and pay a specific amount for them.

The MCV uses questionnaire techniques to valuate consumers expressed preferences, and clearly describe the good to quantify. In order to the respondents declare and quantify their real preferences, this method simulates scenarios with characteristics analogous to the existing in the real world. Based on personal opinions, constructs a hypothetical market and quantify WTP (payment for a wellbeing improvement) and WTA (reimbursement for a wellbeing loss) according to variations in the availability of environmental resources. The intended result is to reach maximum WTP for a given benefit, the minimum compensation to abdicate of the benefit or WTA for environmental damage. Finally, average WTP/WTA is calculated, the populations are added and thus obtaining the estimates of the value attributed to the environmental good.

Comune *et al.* (1995: 64) point out that one of the advantages of this type of methodology consists, precisely, of producing estimates of values that could not be obtained by other ways. To Macedo (2002), the limitations of these methods derive from individuals apparently contradictory behaviours, according with the roles adopted in face of the environmental good. The author refer that most of the folks is propense to establish extremely high values to admit the loss of a natural resources and excessively low values in the hypothesis of having to pay to assure the it protection.

The MCV can bear ambiguous results due to bias, resulting from the market fictitious feature and from quality of the individuals' information. The respondents can not reveal the real WTP or WTA due to their reduced experience, mostly for the WTA case. Moreover, the interviewer can induce answers. And, having no commitment with an effective payment, the vehicle used can affect the result.

3. Final remarks

This paper describes several methodologies of evaluation of environmental goods, showing that the quantification of environmental quality is not simple to get. None of the different existing methods adjust to all situations. Each criterion is limited to specific conditions, and therefore unacceptable and inapplicable in others.

The economic indicators are precious tools for unique decision making, however, as society general knowledge of ecosystem functions is reduced, they become limited, consequently overvaluing individual preferences, that is, overvalue a subsystem in detriment of another possibly more valuable for the project. Therefore, the EVEG&S incurs in an implicit

subjectivity of the importance of the scale and the definition of object of study. With the existing subjectivity, we can argue about the multiplicity of the value, since different exercises of quantification origin distinct results, according to the purpose and the methodology applied. Such multiplicity does not reduce the importance of the valuation as an analysis technique, but, each result can be influenced by different perspectives, and, thus alerting to the values' partiality. The EVEG&S should be executed in partnership by environmental, social scientists and economists, with inter, trans and multidisciplinary dimension to avoid the risk of indiscriminately choose methods inadequate to the reality in study. The EVEG&S is of extreme utility for the decision making, but has limits of scientific uncertainty that go beyond economic science. Therefore, it would be of all interest a bigger scientific cooperation in this area, in order to increase quality to the current state of the art, since the resources' values can be underestimated and the complementary or substitute markets can be inefficient parameters.

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Land-use management and changes in Campania Region (Southern Italy): examples from ten regional State Forests

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Abstract

In the last 50 years the Italian territory has undergone a remarkable transformation as a consequence of anthropogenic activity . In the Campania Region, the main causes of change are urban expansion, abandonment of mountainous and marginal agricultural areas and expansion of industrial settlements. We document land use variation during the last 50 years and the changes occurred in ten Regional Forests which contain mainly natural land use patches

The main problems of land and forest management are discussed in the light of actions promoted by the promulgation of two important legislative instruments, the "Piano Territoriale Regionale (PTR)" and the "Piano Forestale Generale (PFG)", for the socio-economic revitalization of rural areas and for the sustainable management of agro-forestry systems.

Keywords: Systems of Lands, Urban Sprawl, Forestry, GIS

1. Introduction

In the last fifty years the agro-forestry landscape of the Campania Region (Southern Italy) has undergone a remarkable transformation under the pressure of two opposing forces: urban sprawl (almost fivefold) and intensification and specialisation of agriculture in the coastal plains and hills, contemporary to land abandonment in the mountain areas and in the inland hills (Di Gennaro and Innamorato, 2005, Mazzoleni et al. 2004, Motti et al.2004, Migliozzi et al. 2001). The key areas of major landscape transformation are situated along the sea coast, where the rapidly increasing urbanisation eroded the cultivated land areas and the residual plain forests. The consequent congestion of the flat areas is a completely unbalanced use of soil, water and land resources. This is highlighted by the centrifugal expansion of urban areas at the expense of cultivated fields and natural vegetation and the contemporary centripetal recolonisation by wildland vegetation of the abandoned cultivated land.. The soil loses its primary function and becomes a free building space. The areas recolonised by natural vegetation, tends to interface directly with the expanding urban areas. Therefore water supply, pollution, management and transport of solid and liquid waste increase. Furthermore natural vegetation dynamics on the abandoned crops determines a homogenisation of the landscape and modifies of the hydrological processes, leading to an increase of the hazard management issues (fire and landslide) at the urban-forest interface (Mazzoleni et al. 2004). The epochal dimension of this change, is the following: from 1960 to 2000 the urban space has increased from 20,000 ha to about 93,000 ha and the LUW (Land Used Wholly) has decreased by 16%.

The urban centers of the coastal strip has welded together in a metropolitan continuum that extends to approximately 15% of the region, from Caserta (North Campania) to Battipaglia (South Campania), but hosts 72% of the population of the Campania Region. The result was the abnormal consumption and waste of soil in the more fertile areas, as well as the loss of rural landscapes of inestimable value. Several factors contributed to this unbalanced outcome: the inadequacy of public policies, a lack of participation of the public opinion, the influence of organized lawlessness (Totò 1952; di Gennaro, 2005).

Since 2004 a series of legislative measures have outlined the regional legal instruments capable of inverting this trend by offering an integrated strategy for the management and restoration of the urban, rural and forest ecosystems,. Within the framework of the landscape restoration the *Piano Territorale Regionale* (PTR) and the the *Piano Forestale Generale* (PFG) was promulgated. Among the   objectives of the latter are the protection, conservation and enhancement of ecosystems, forest resources and hydro-geological aspects, and theimprovement of the socio-economic conditions for the populations of the hill and mountains areas.

The study of 10 state forests in the Campania Region was an applied research aimed to highlight both local and regional landscape changes, for a more appropriate definition of the PFG recently approved by the Regional Council of Campania.

In a first step the present work focuses on the change at landscape scale occurring in the last 50 years in Campania. Then, physiographic units were employed as a basis to describe the 10 state forests of the Campania Region. The main problems of sustainable forest management and agro-forestry in Campania are highlighted in relation to actions proposed by the PRT and PFG.

2. Methodology

Two different approaches were followed: At a landscape level, carriers responsible for the transformation of Campania's landscape agroforestry were identified, covering the last fifty years. A land-systems map was used as background to focus on ten different forests, highlighting their status and management perspectives.

2.1 Landscape changes towards 40 years

The analysis of land–use changes was carried out comparing, in GIS environment (ArcGIS - ESRI inc.), the land-use map of ltaly (CNR TCI 1956-1960) with the Corine land cover map (level IV – 2000 EU) integrated by the map of rural soil use, edited by the National Institute of Agricultural Economics (INEA CEC-2001), which allowed a more accurate cartographic restitution of farmland. Comparison was made with reference to physiographic areas (Lands systems) characterised by a particular combination of environmental factors (climate, morphology and soil) which can influence at the medium and long term sustainable use of resources by the man.

Finally, the cartographic analysis data was integrated with socio-economic statistics and census (a more accurate description of the used approach is available at www.risorsa.info). The implementation of geographic database in GIS environment, has assumed the reference of all cartographic documents to a single geographic projection system (Gauss Boaga for Italy – Zone 2).

2.2 State Forests characterisation

A detailed survey of forest types was conducted within the 10 State Forests of the Campania Region (Figure 1).

State of art and bibliographic acquisition
All the existing bibliographic and cartographicinformation on flora and vegetation and forest management plans related to the geographical areas where forests are located, was acquired and archived according   the guidelines for the sustainable management of forest and pastoral resources in Protected Areas. To assess the constraints on the management of the habitats of these areas, overlaps with the Site of Community Importance Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), included in the network "Bioitaly-Nature 2000" were considered.
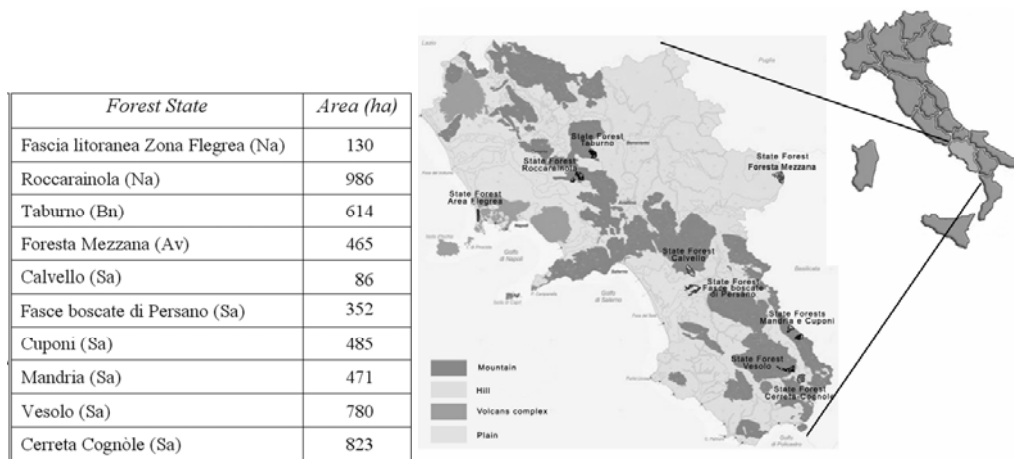
Figure 1: Location and list of the 10 State Forests in Campania Region (Southern Italy)

Forest State	Area (ha)
Fascia litoranea Zona Flegrea (Na)	130
Roccarainola (Na)	986
Taburno (Bn)	614
Foresta Mezzana (Av)	465
Calvello (Sa)	86
Fasce boscate di Persano (Sa)	352
Cuponi (Sa)	485
Mandria (Sa)	471
Vesolo (Sa)	780
Cerreta Cognòle (Sa)	823

Ortho-Photo interpretation and mapping of the forest types
The main forest formations were identified through the interpretation of digital orthophotos (1px / m resolution; max strain = 2m).It was possible to obtain a more precise classification of forest types in relation to the tone and texture of the pictures. The forest polygons were acquired directly from georeferenced digital orthophotos in a GIS environment (ArcView 3.2 ESRI inc.). Contextually, a geographic database for further processing was built. The polygon video scale capture was not less than 1:3,000 scale ratio.

Field investigations
In order to determine the main structural aspects of each forest type found on the digital orthophotos, a combined approach based on floro-vegetational, phyto-sanitary, phytosociological and physiognomical characteristics was carried out. Measurement on sampling areas, also documented by a detailed photographic survey, was performed by targeting plots, which allowed the compilation of field data sheets, useful for subsequent phases, and for outlining the current woodland management .
Field investigations regarded: 1) Biotic and abiotic environmental characteristics (stand site analysis); 2) Qualitative and quantitative features of the stand; 3) Productivity and non-productivity functions of the woodlands .

3. Results

Landscape changes through 40 years
Land cover changes at regional scale can be summarized through a model based on three compartments (Figure 2):
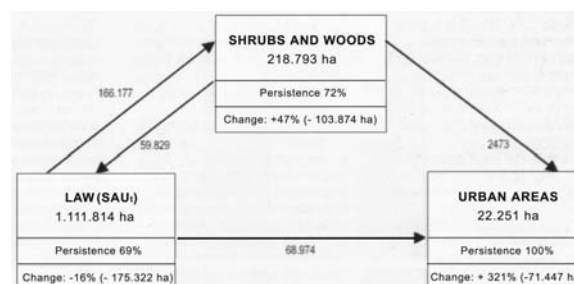
Figure 2: Land cover changes through 40 years in Campania Region. LAW (Land Used Wholly) contributes to almost all of the increase in urban areas

The figure shows that LAW is affected by a net decrease of 175,322 ha, corresponding to 15.8% of the agricultural area used in 1960. This trend is opposed by the increase of 103,874 hectares of forest and shrub area (+43%), and of71,447 ha of urban areas (+321%).

The overlay operation between land-use dynamics maps and land-systems map allowed to analyse the geographical distribution of land cover dynamics in relation to: a) differences between the great systems of land and the general physiographical partitions; b) differences within the major land systems.

Figure 3 shows a summary of these findings. 40% of LAW decrease is found on mountains, 28% on hills, 10% in the volcanic complexes, 22% on plains.
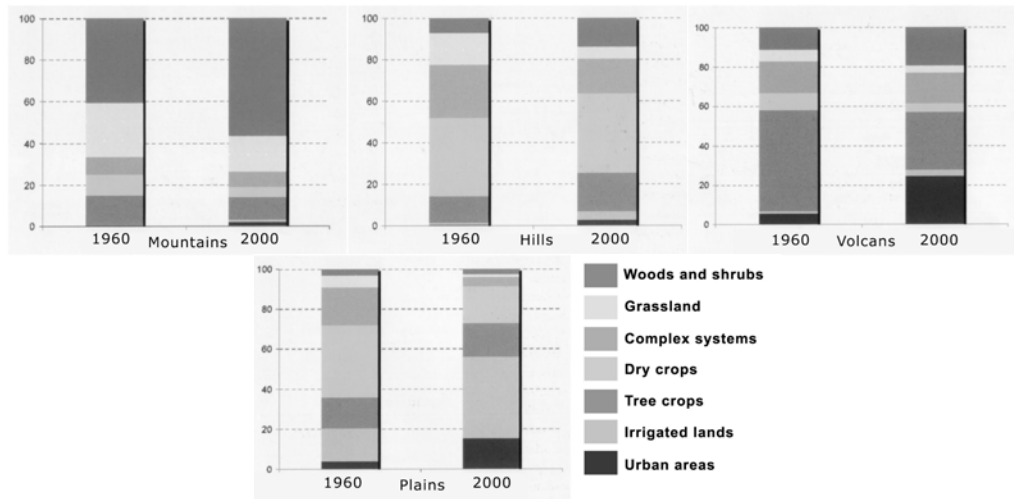
Figure 3: Result of the intersection between land-systems and land-use dynamics maps

The net loss of LAW accounted 40% for urbanization and the remaining 60% for the recolonisation of natural vegetation by agricultural areas and grasslands.

Forests State characterization

The Forests State of Campania are distributed in environments with different climate and vegetation, between the the sea coast and the mountain belt (Figure). The territorial districts fall within both SCI and SPA areas of Natura 2000 network in the Regional Parks of Picentini, Partenio and Campi Flegrei and in the National Park of Cilento and Vallo di Diano.

The forest type of the Forests State consist in:
1. coppices mostly exceeding the usual coppice cycle or on the way to conversion into high forest. They are classified into monospecific coppices of *Quercus ilex*, *Q. pubescens Q. cerris* and*Castanea sativa* coppices pure or mixed with oak, hornbeam, maples and ash trees;
2. high stand forests consisting of deciduous trees (*Fagus sylvatica*, *Quercus cerris* and other mesophilous species) and conifers such as *Abies alba* with groups of deciduous pioneers such as *Betula pendula*, *Populus tremula* and *Alnus cordata*.) are introduced in different periods. Plantations of native woody species (*Q cerris*, *Q. pubescens*, *Prunus avium*) and alien species (e.g. *Eucalyptus* spp. *Pseudotsuga menziesii*.) were realised during the last 50-60 years ;
3. coastal plain forests with extrazonal broadleaved species and riparian woodlands dominated by willows and poplars.

Due to the previous intensive forest management and grazing in the forest these stands needs different sustainable management options. To each forest one or more functions (scientific, educational, touristic and recreational, protective and productive) can be assigned .

The forest types identified refer to the following Categories and Types for Sustainable Forest Management, Reporting and Policy (European forest types - EEA Technical Report No. 9/2006):

Table 1: Sustainable Forest Management types found in the Regional State Forests

7. Montane beech forest	7.3 Apennine-Corsican montane beech forest
8. Thermophilous deciduous forest	8.2 TURKEY OAK, HUNGARIAN OAK AND SESSILE OAK FOREST 8.7 Chestnut forest 8.1 Downy oak forest 8.8 Other thermophilous deciduous forests
9. Broadleaved evergreen forest	9.1 Mediterranean evergreen oak forest 9.5 Other sclerophlyllous forests
10. Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	10.6 Mediterranean and Anatolian fir forest
12. Floodplain forest	12.1 Riparian forest 12.2 Fluvial forest
13. Non riverine alder, birch, or aspen forest	13.2 Italian alder forest 13.4 Southern boreal birch forest 13.5 Aspen forest
14. Plantations and self sown exotic forest	14.1 Plantations of site-native species 14.2 Plantations of not-site-native species and self-sown exotic forest

4. Discussion

A sustainable forest management of the 10 Regional State Forests could be implemented also in the other forested areas. Among the factors of the degradation are   the pressure of urbanization on environment and landscape, pollution, widespread vulnerability of the soil (erosion and geological instability), coastal erosion and desertification, the increasing fire frequency, unsustainable touristic activities, lack of plans and forestry regulations at municipalitiy level, lack of forest grazing regulations, poor dissemination and applications of technological innovations in forestry. Nevertheless in these areas forested surfaces increased in the last years. They are located within protected areas (Natura 2000, Regional and National Parks, Marine Reserves andother Protected Areas) with high values of biodiversity (Figure 4) in relation to the variety of habitats.

The main objectives to be pursued in the management of the State Forests, contained in the PFG, concern the protection and improvement of biodiversity, in order to increase the stability and bio-ecological features of the forest stands and to preserve the soil from erosion and degradation.
The approval of the PTR and PFG provides the government of the Campania region the tools for a sustainable management of urban, rural and mountain areas according to guideline aimed at the protection of the landscapes. Sustainably managed State Forests could be used as pilot areas for monitoring natural forest processes, testing different management options and disseminating the results. Their geographic distribution makes these areas representative of the major physiographic and ecological features present in the Campania Region.

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Acknowledgments

Naturalness and diversity of biotopes: their impact on landscape quality-a mathematical model

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Abstract

A novel mathematical tool serves to quickly grading landscapes from the point of view of environ-mental value. Model is founded on five building blocks: (i) A landscape is considered to be mosaic of biotic patches; (ii) each patch displays the characteristics of a single representative biotope out of a finite set of generic biotopes; (iii) generic biotope´s environmental value depends on its degree of na-turalness (flora, fauna) and diversity which are determined in field surveys; (iv) a landscape´s environ-mental value is a simple function of the environmental values of its constituent biotopes; (v) the influence of shape and corrugated surface of a patch on the environmental value of the associated landscape is reflected by an amplification factor. By accounting for the biotic properties (naturalness / biodiversity) and for the structure of the landscape the model lends itself to comparative and trade off analyses in land use management and urban development projects.

Keywords: modelling, indices, naturalness of biotopes, diversity of biotopes, landscape valuation

1. Introduction

According to Farina & Belgrano (2004), landscape is the cognitive dimension of ecological complexity: Patterns and processes are distributed in a cognitive geographic space, the "eco-field". The new paradigm allows to describe the biotic and abiotic characteristics of the physicoecological space. To understand its foundations the notion of biotope is most helpful.

Commonly conservational recommendations are based on a landscape´s naturalness and biodiversity. In view of what was said above this approach must be rolled out to its constituent biotopes.

Efforts in describing landscape´s naturalness and biodiversity were carefully reviewed in a recent paper of ours (Porto et al., 2010). Especially we pointed out that up to now theore-tical

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models focused on structural aspects only (Papadimitriou, 2002, 2009). They did not link to the biota of the landscape.

Here we present a simple mathematical model which avoids the deficiencies stated above. It calculates one index only and thus lends itself to quick preselective landscape assessment. Model uses empirical data and determines the ecological value of a landscape through the degree of naturalness of its biotopes, i.e. structure and composition of their plant communities and structure and composition of the assemblage of their epigeic fauna. It accounts for indicators of disturbance, for the diversity of fauna and flora, and area and shape of the patches constituting the landscape.

2. Methodology

In general a landscape X is a cluster of patches distinct from the point of view of fauna and flora. Mathematically the patches make up for a partition $\mathbb{P}$ of the landscape X

$$\mathbb{P} = \{X_i, i = 1,2,\ldots, n/Xi \subset X; Xi \neq \emptyset; X_i \cap X_j = \emptyset, i \neq j; X_1 U X_2 U \ldots U X_n = X\} , \tag{1}$$

where, $\cap$ is the intersection of two patches, U their union and $X_i \subset X$ indicates that X_i is a subset of X. Each patch X_i has an area A_i and a perimeter P_i. The sum of all subset areas is equal to the area of the landscape,

$$A_{tot} = \Sigma A_i . \tag{2}$$

In order to express the degree of naturalness of a biotope our model introduces an index of naturalness associated with that biotope. The part INT_{flor} due to the flora prevailing in that biotope follows the equation

$$INT_{flor} = ((1 - IVI/IVI_{max}) + (1 - DR_{exot}/DR_{maxexot})) . \tag{3}$$

IVI is the index of value of importance (Curtis and MacIntosh, 1951), for the species of the plant communities of the patch. DR_{exot} is the relative density of exotic species of the biotope.

In order to obtain the index of environmental value of the biotope as a function of its naturalness and its diversity, its index of naturalness is multiplied by the Shannon measure of diversity H', i.e. Peet (1974).

$$IVA_{flor} = INT_{flor} * H'_{flor} , \tag{4}$$

$$H'_{flor} = -\Sigma (p_i * \ln p_i)_{flor} . \tag{5}$$

$(p_i)_{flor}$ is the probability of occurrence of species i and ln denotes the natural logarithm. Eq. (4) is derived by pure arguments of mathematical plausibility: naturalness of a biotope whose species were planted is zero by definition and thus its environmental value equals zero. Nevertheless it still may exhibit a nonnegligible diversity, i.e. H'> 0. A good example for this is man-made soils where for purposes of restoration different species of herbs were planted. Equ. (4) accounts for this scenario.

Design of the index of environmental value due to the biotope fauna (IVA_{faun}), follows a track similar to the one for deriving (IVA_{flor}): index of naturalness of the fauna of the biotope (INT_{faun}), thus is

$$INT_{faun} = ((1 - DR/DR_{max}) + (1 - DR_{spider}/DR_{maxspider})) \tag{6}$$

DR is the largest relative density of the epigeic fauna of a specific biotope and DR_{max} its maximum value across all biotopes of the landscape under consideration. DR_{spider} is the relative density of spiders in a biotope. $DR_{maxspider}$ is the maximum relative spider density across all biotopes of the landscape

As before multiplication of Eq. (6) by the diversity H' yields the index of environmental value of a biotope due to its fauna.

$$IVA_{faun} = INT_{faun}*H'_{faun} .\qquad(7)$$

The index of environmental value of a circular biotope X_i based on its naturalness and diversity, IVA_{oi}, is the sum of its values IVA_{flor} and $IVA_{faun.}$

$$IVA_{oi} = IVA_{flor}(i) + C*IVA_{faun}(i).\qquad(8)$$

C is the relative weight with which fauna and flora, respectively, contribute to the total environmental value of biotope i.

To account for the fact that in general biotope Xi has a non-circular shape we introduce the factor

$$(K_F)_i = 2*(\Pi * A_i)^{\frac{1}{2}} / P_i\qquad(9)$$

$(K_F)_i$ varies between 0 (biotope with extremely corrugated edge) and 1 (circular biotope). With this factor we define the index of environmental value of a biotope Xi to be

$$IVA_i = ((2 - (K_F)_i) * IVA_{oi}\qquad(10)$$

The index of environmental value of a landscape based on the naturalness of its constituent biotopes, IVA_{tot}, corresponds to the weight average of the environmental values of the biotopes:

$$IVA_{tot} = (A_{tot})^{-1} * \Sigma A_i * IVA_i = (A_{tot})^{-1} * \Sigma A_i*((2 - (K_F)_i) * IVA_{oi}\qquad(11)$$

The weight with which biotope i enters this equation corresponds to its relative biotope area $A_i*(A_{tot})^{-1}$. $(K_F)_i$ is defined by Eq. (9), IVA_{oi} through Eq. (8), and Σ represents a sum over all *n* biotopes that shape the landscape.

3. Result and Discussion

We applied the model to a circular test sample of 200 m radius. Sample was chosen out of an area of survey located in the city of Treviso, State of Santa Catarina, southern Brazil. Its covering is hetero-genous: remnants of original vegetation (humid atlantic coastal forest), areas used for agriculture (livestock, fruit plantations), large waste deposits of coal mines and areas reforested with Eucalyptus. The area was found to be describable on the basis of five resilient natural biotopes: climax forest (GB1), early secondary forest (GB2), late secondary forest (GB3), eucalyptus plantation with forest regeneration (GB4), anthropogenic grasslands (GB5), Fig 1. For each generic biotope we carried out phytossociological surveys and calculated the appropriate indices of importance, relative densities, and Shannon´s indices of diversity (Porto et al.. 2010) needed for executing Eq.(11). Structural information such as area and circumference of the patches constituting the test sample was extracted from the digital image of the area of investigation. The resulting indices of environmental value, IVA, for the generic biotopes are shown in Fig. 2.

According to our model, assumption of high diversity implying automatically high environmental quality is not valid (Fig. 2). On the scale of biotope for example, generic biotopes 4 and 5 exhibit relative high values of diversity both in fauna and flora. Their respective indices of environmental value though are lowest in the set of the five generic biotopes. This is because the corresponding indices of naturalness compensate the high values

of diversity, in our model. As a matter of fact our data revealed specific areas which originally were areas of native forest but now after reforestation represented Eucalyptus monocultures. In addition undergrowth had developed which showed a high degree of species diversity. For sure these areas show high diversity but are of low environmental value.

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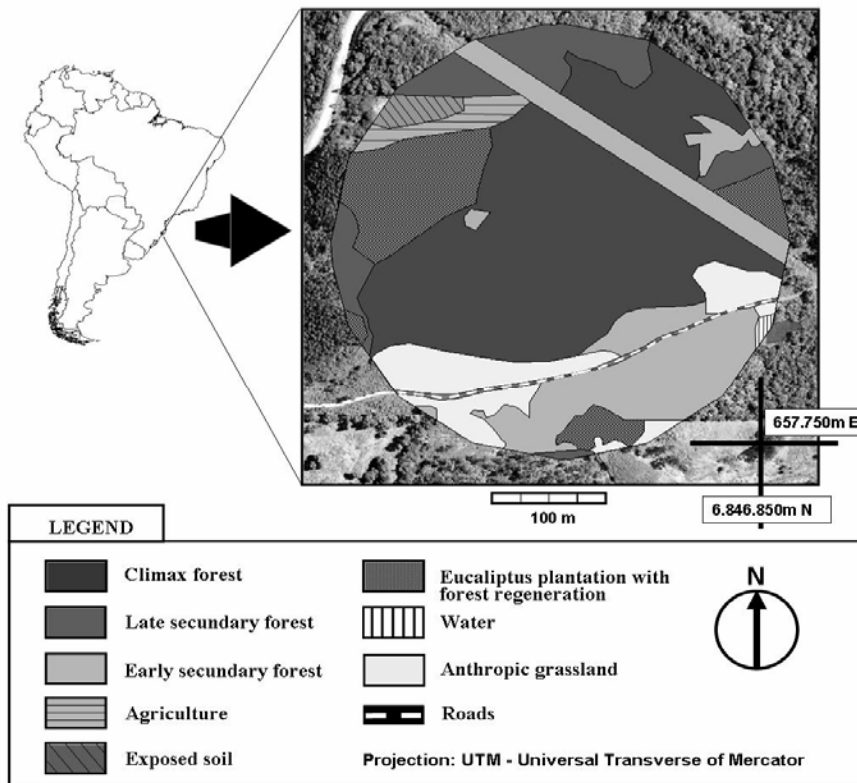
Figure 1. Part of the landscape for which empirical data were collected. The circular area represents the sample of diameter of 400 m used to test the mathematical model. Indicated are also the different types of soil covering of the 27 biotopes of the sample.
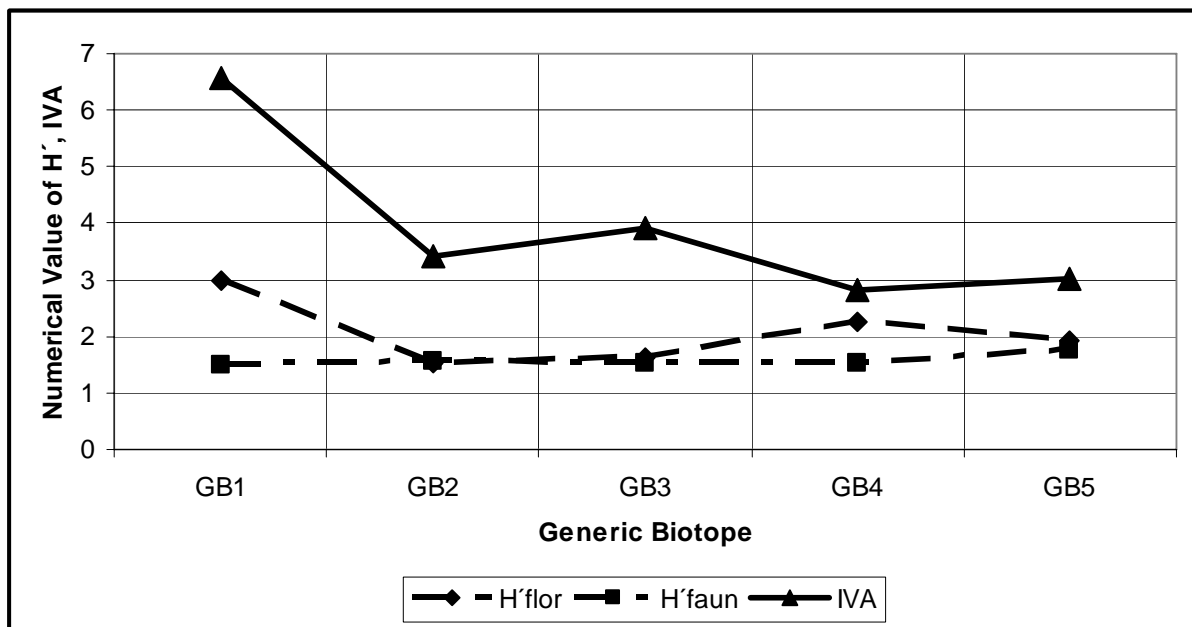
Figure 2. Indices of environmental value (solid line) , IVA, Shannons´s diversity index of the fauna (dash-dotted line), H´$_{faun}$, and the flora (dashed line), H´$_{flor}$, respectively, for the five generic biotopes of the sample of Fig.1.

Application of modern, non traditional restoration methods on brown coal localities of Czech Republic

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Abstract

Over 70% brown coal reserves have been exploited in the North-Bohemian Basin today. Opencast mining of brown coal naturally led to vast landscape damages. Therefore reclamation work has acquired a great significance. The research methodology of the areas of interests and the reclamation works themselves described in this article arises from North Bohemian Mines locality reclamation philosophy. Apart from the earlier published methodology of fertilizable soils application used today in operation, experiments with filling areas left for natural succession and pilot application of power plant stabilizer and ash in phyto-toxic areas. The results are stated in the paper.

Key words: Restoration, dump, geology, methodology

1. Introduction

The North-Western Bohemia region takes a unique position in the history of mining in the Czech Republic. Several ore districts are situated here, the welfare of which influenced the development of the Czech state in some periods. Some precious stones mining was also significant. Today the North-Bohemian Basin area is known for its largest Czech brown coal deposit. Whereas ore mining in the region extinguished and the other raw materials mining has relatively small significance, coal mining and the restoration of damages caused by mining activity still have an essential meaning.

Severoceské doly, a.s. Chomutov (North Bohemian Mines, j.s.c. Chomutov), the greatest mining company of the Czech Republic, was founded within the privatization of the North-Bohemian Brown-Coal Mines concern privatization on 1.1.1994. Today the allotments of the share holding company include geological reserves of about 1200 million tonnes and the recoverable reserves amounting 700 million tonnes. The annual production amounts to ca 22 million tonnes of brown coal representing almost 50% Czech market with this coal, and the annual volume of overburden stripping is 100 million m^3 of clayey rocks. This is currently the largest mining company in the Czech Republic. The reclamation of vast areas affected with brown coal mining is, of course, an important part of its activities.

Current task of Severoceské doly, a.s. reclamations is to make reclamation works more efficient using locally available fertilizable rocks and other materials, and to be maximaly environmentally friendly. The core of the article is the characteristics of new reclamation methods used mainly for reclamation of sterile and phyto-toxical areas of both localities of Severoceské doly, a.s. and for the protection, research and relevant development of remarkable ecosystems arising in the dumps.

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2 . New Concept of Technical Reclamation in the North Bohemian Brown Coal Basin

Mining and reclamation works of Severoceské doly,   a.s. proceed in two considerably different geological areas. It concerns Nástup Tusimice Mines with the mining locality of the Libous mine and the Bílina Mines with the mining locality of the Bílina mine. Based on the different type of overburden rocks in both mining localities different requirements for the areas reclamation appear. In case of the Bílina Mines the main issue is the occurrence of extremely acid phyto-toxical areas (high contents of coal – ca 5%), in the case of the Nástup Tusimice Mines the main issue is the occurrence of sterile areas (high content of physical clay). The research methodology of the areas of interests and the reclamation works themselves described in this article arises from Severoceské doly, a.s. locality reclamation philosophy. It is based on the knowledge of overburden minerals properties and detailed survey of each reclaimed sites provided in co-operation with the Severoceské doly, a.s., Výzkumný ústav pro hnedé uhlí, a.s. (Research Institute of Brown Coal, j.s.c. Most), Výzkumný ústav meliorací a ochrany půdy Praha (Research Institute of Ameliorations and Soil Protection Praha) and Zemedelská universita Praha (Agricultural University of Prague). Experiments have been started recently with areas left for natural succession, with application of power plant stabiliser (this product is described in greater detail in chapter five) and power plant ash in phyto-toxic areas apart from the methodology of fertilizable soils application earlier published by (Ondrácek 2003), (Safárová 2003) and being used in operation today.

3. Application of Fertilizable Rocks in Reclaimed Localities of the North Bohemian Brown Coal Basin

Top soil, loess and loess loam, marlite and bentonite are the most important rocks used for reclaimed purposes in the localities of Severoceské doly, a.s.

The application of fertilizable rocks is the most efficient in areas consisting of highly arenaceous to phyto-toxical rocks. In this case marlaceous minerals or bentonite minerals are applied in the amount 3000-3500 $m^3.ha^{-1}$ with the following homogenation (inmixture) or cross ploughing from 0,5 to 0,6 m. Surface overlay in the area of interest with loess loam and the thickness to 0,5 m is an option of this procedure. The application of organic substances (composts) with the adjusted ratio C : N (25) in the amount 400 $t.ha^{-1}$, embedded into 0,30-0,50 m reclaimed surface of the dump and the follow-up two-year preparatory agricultural cycle (growing plants for green manure) is requested as an additional measure.

The stated methodology was successfully used in a lot of sites of the Bílina Mine. Anthropogenic soil profile created by bentonite application in the Strimice dump, an anthropogenous soil profile created with the application of marl in the Radovesice dump and the anthropogenous soil profile created with the application of loess loams at the inner dump of the Bílina Mine can be used as an example. Several results are shown in the table No. 1.

4. Filling Areas Left for Natural Succession at Radovesice Dump

The areas left for natural succession have been tentatively filled in the areas where functional ecosystems spontaneously started to develop under specific conditions where protection and research of some biological, geological and paleontological phenomenon is necessary and where future access to public may be assumed within the overall concept of the locality reclamation. The selection of these areas proceeds based on the research of dumps. After the area is filled and plotted into the planning maps detail research is provided based on which entry documentation is created. Thus long-term research of the area starts evaluating its

pedological and biological development. The article briefly characterizes the areas filled at the Radovesice dump which is the largest reclaimed dump of the Bílina Mines and also the largest dump in the Czech Republic.

Based on the extended survey of the non-cultivated part of the dump (ca 670 ha) consisting of terrain mapping, evaluation of top soil profile sampled with a boring bar and laboratory analyses of the selected samples two quite large areas were selected to be left for natural succession in the year 2004.

Succession area 1 (32 ha) was selected in the southern part of the dump. Heterogeneous dump mixture of brown clay, grey claystone and grey sand claystone with higher content of brown clay was a prevailing mineral type. Brown-grey kaolinitic- illitic clays appear. In the eastern part of the area sandy minerals are more significantly represented creating natural border of the area. A lot of natural water bodies and wetland occur here (see figure No. 1).

Succession area 2 (20) ha was selected in the northern part of the dump. The mineral consumption of the upper horizon is similar as in case of the area No 1. Southern border of the area is created with "sand dunes". Two large natural water bodies and several small water bodies and wetlands occur here. Some small water bodies verge in the wetland during the year.

Plant and animal species composition was evaluated in both areas. It is recommended to leave the area for natural development without reclamation impacts. The area should be monitored in the future and serve for research purposes. It is interesting to monitor the way how several kinds (mainly from plant land) comply to a certain, not very typical environment for these species. With respect to the area situation it will also serve as a natural corridor for the animals movement in necessary technical works in the surrounding part of the dump. Pedological properties of the prevailing mineral type are shown in the table No. 2.

5. Experimental Application of Power Plant Stabilizer in Inner Dump of Bílina Mine

In the year 2006 the application of power plant ash application to various types of dump soils was tested in the inner dump of the Bílina mine. Extremely acid (sterile from the reclamation point of view) coal claystones from the Ledvice preparation plant which created large phytotoxic area was one of these types. Stabilizer from the Ledvice power plant was used for the experiment (the desulphurization product here). The objective of the work was to evaluate the chances to make the technical reclamation of phyto-toxic area more efficient – see (Rehor 2004).

The used stabilizer is the product of desulphurisation in Ledvice plant. It contains $CaSO_3$ (cca 50%), $CaCO_3$ (cca 25%), $Ca(OH)_2$ (cca 20%), and others less significant components. Dangerous contents of risky trace elements were not found out. It is very alcalic, that is why the possibility was tested of its application on extremely acidic phyto-toxic area of coal claystones.

The values of the soil reaction in the water extract were, for the above stated coal claystones, usually about 3,8 – 4,5. After the application of power plant stabilizer in the amount 600 t.ha^{-1} soil reaction of the resulted mixture was about 9-10. From whence it followed the need to optimize the stabilizer doses to reach the soil reaction of the resulted mixture ca 6,5 – 7,5.

In the task solution first samples of clean power plant stabilizer and coal claystone in which the value of soil reaction in soil extract were taken. Then an experimental area with the dimensions 0,5 x 0,5 m was established to which various doses of stabilizers were embedded and then the soil reaction of the mixture detected. The embedded dose of stabilizer was calculated per 1 hectare of the area. The results are stated in the table No. 3 below. The samples were taken immediately after the application of stabilizer and after every 2 years.

Optimum dosing ranges between 100 – 300 t.ha^{-1}, for further application the dose 200 t.ha^{-1} can be recommended. The mixtures A-F were tested for the presence of risk trace elements, all samples comply with the valid legislation of the Czech Republic. The experiment proved substantial improvement of the sterile coal claystones properties and the method is, with respect to great production of stabilizer, very prospective. Before its practical use other tests in larger areas will be necessary.

6. Experimental Application of Power Plant Ash in Brezno Dump

Application of power plant ash from the Tusimice power plant was tested in the experimental areas of the Brezno dump. It concerns the external dump of the Libous. mine. Experimental areas were found on the yellow overburden clays from the Libous mine. Some other details are stated by (Rehor 2004).

These rocks are homogeneous, strongly viscid and cast. With respect to extremely unfavourable physical properties and water regime they are not suitable for reclamation use. Their hydrophysical soil properties do not change even after longer period of depositing on the surface of the dump. They create permanently strained soil structure with unfavourable infiltration capabilities.

The target of the experiment was to improve grain composition of the upper horizon of the tested areas. Power plant ash in the amount 200 t.ha^{-1} was put on three areas with the acreage 1 ha and embedded with cultivator to the top horizon. Then the grain composition of the former yellow clays and the generated mixture was detected. The results of the grain analyses are stated in the table No. 4. Apart from that the sample with the applied ash was tested for the presence of risky trace elements. It has been confirmed that it complies with the valid legislation of the Czech Republic.

The results show significant improvement of the grain compositions of the mineral after the application of power plant ash. While former yellow clay can be ranked, from the grain size point of view, to the clay category, the mixture with power plant ash can be ranked as a clayey soil. But equal embedding of ash into clay is an issue. Gross description of samples however showed that ash creates rather single isolated clumps.

Despite of these issues the method is prospective, further research will focus on preparing optimum methodology of embedding power plant ash into the upper horizon of the reclaimed localities.

7. Discussion

The shareholding company Severoceské doly, a.s. Chomutov is today the largest mining company in the Czech Republic. Big volumes of stripped rocks and the extent of areas designated for reclamation require the application of new, efficient reclamation methods.

The application of fertilizable minerals remains the basic methods of technical reclamation proving its success at the localities of Strimice, Radovesice and the inner dump of the Bílina mine. But the first attained results of the research prove that some new progressive methods can become a significant complement of this method. Application of power plant stabilizer into extremely acid phyto-toxic minerals in Bílina Mines could be a prospective method where some non-traditional erosion control measures applied well. In the Nástup Tusimice Mines areas of interest, in case of resolving the issue of homogenation, the application of power plant ash into the heavy grain clays can be significant. Thanks to great morphological and geological variety of non-reclaimed areas of the Severoceské doly, a.s. there is enough space for filling the areas left for natural succession the target of which is the protection of unique ecosystems developing in the dumps.

The conclusions stated in this article are documented with the results of samples taken in Strimice, Radovesice, inner dump Bílina, Brezno and the overburden cuts of the Bílina Mine.

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Table No. 1: Features of Reclaimed Soil Profile after Application of Fertilizable Rocks

Taking interval (m)	N	C_{ox}	$CaCO_3$	pH/ H_2O	Acceptable nutrients (mg.kg^{-1})			Adsorbing capability mmol/100 g (%)		
	(%)	(%)	(%)		P	K	Mg	S	T	V
Strimice locality										
0,00-,60	0,07	1,24	0,98	6,79	10	190	102	13,4	19,7	68
0,60-0,90	0,07	0,68	9,93	8,23	1	218	949	36,3	36,3	100
0,90-1,10	0,05	2,94	0,24	4,50	1	103	304	3,1	8,2	39
Radovesice locality										
0,00-0,30	0,12	0,83	9,41	7,93	1	148	96	16,8	16,8	100
0,30-0,90	0,09	0,44	39,42	8,25	0	112	26	15,6	15,6	100
0,90-1,10	0,10	1,03	1,068	7,90	0	196	269	7,9	7,9	100

Table No. 2: Pedological Properties of Upper Horizon of Area Left f or Natural Succession

Taking interval (m)	N (%)	Cox. (%)	CaCO$_3$ (%)	pH/ H$_2$O	Acceptable nutrients (mg.kg^{-1})			Adsorbing capability mmol/100 g		(%)
					P	K	Mg	S	T	V
0,00-0,90	-	5,6	0,1	2,5	2	11	27	0	12	0

Table No. 3: Recommended Doses of Stabilizer and Final Values of Soil Reaction

Sample	Stabilizer dose / 1 ha (t)	pH/H$_2$O - after application	pH/H$_2$O - after 2 years
Clean stabilizer	-	12,1	
A	600	9,63	8,52
B	500	8,86	8,00
C	400	8,57	7,80
D	300	8,12	7,50
E	200	7,25	7,20
F	100	7,00	7,00
Coaly clay	0	4,11	

Figure 1:   Demonstration of Small Water Bodies and Wetland Spontaneously Developed in Successive Areas of Radovesice

Developing models and processes to aid decision support for integrated land management in the Canadian boreal forest

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Abstract

Forested lands encompass nearly half of the surface area of Canada and are exposed to demands from a growing human population. Industrial forested lands support multiple uses (e.g., forestry, oil and gas and urban development) within the same space and time. Planning processes need to consider these cumulative, long-term impacts. A novel forest management planning initiative is presented that considers forested landscape conditions within the context of climate change and cumulative impacts from forestry related and non-forestry related disturbances, as well as habitat supply and water quantity and quality. These measures are analyzed under various models to produce an optimum long-term forest strategy that satisfies current economic drivers and the new paradigm of intrinsic values that are naturally contained within the forest.

Keywords: integrated land management, cumulative effects assessment

1. Introduction

Canada is approximately 10 million km^2 in area, of which >30% is boreal forest (Fig. 1). More than 90% of the boreal forest is classified as Provincial Crown Land (under the jurisdiction of Provincial Governments in the name of the Crown) (NRC 2009). Within provinces, mechanisms exist to develop ~20-year leases on Crown Land to allow forest products companies to establish, grow and harvest timber. Forest Management (FM) plans must be developed by the companies and approved by the Province (usually every 10 years), with a 200-year forest harvest volume projection. There is usually a specific spatial harvest sequence for the first 5-10 years, which details where forestry operations will be undertaken. In Alberta (Fig. 1), the FM planning process, managed through the Ministry of Sustainable Resource Development, is centered on timber supply analysis and has a limited focus on issues like water, wildlife and the physical environment. Further, it virtually ignores the issues of Integrated Land Management (ILM) and Cumulative Effects Assessment (CEA), as well as oil and gas activities, which can have as big a footprint as the forest industry. Forest operations on adjacent FM areas are also not considered, eliminating any potential to mitigate large landscape issues that encompass multiple FM areas. This study is based primarily in the FM area (productive land base 2950 km^2) leased by Millar Western Forest Products Ltd., a small pulp and solid wood products company. The research group embarked upon a process that would help push the intent of FM planning by engaging the company, government and researchers in an ILM approach (Russell et al. 2008). This FM plan would be based on science, data and state-of-the-art modelling and would address issues like

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ILM and CEA. The plan would demonstrate that it was feasible to produce an ILM/CEA structure, models could be developed or adapted, and outcomes could be tested over time.

2. Methodology

In 1995, Millar Western developed permanent vegetation sample plots that focused on tree growth, as well as free-to-maneuver flying space, bat crevices, tree lichen cover and downed woody debris. Additional research included creel censuses, thinning trials to evaluate tree growth and habitat use, tree retention in clearcut stands, animal surveys and habitat supply model verification. In 1997, expert panels were assembled to develop models for: landscape projection under various climate change scenarios; coarse and fine filter habitat supply and; surface water quantity and quality. Research outcomes and the mechanisms developed would be incorporated into a timber supply model as constraints against the allowable cut.

2.1 Landscape Projection

The Landscape group used the Special Report on Emissions Scenario A1 (IPCC 2001) to predict impacts on the forest of climate change, namely a doubling in atmospheric CO_2 concentrations, and an increase of 7ºC in temperature and 8% in precipitation between 1999 and 2100 (Millar Western Forest Products 2007). To project climate conditions, the CCSR-NIES Global Circulation Model (Ozawa et al. 2001) was selected. To downscale climate data, local weather was adjusted with global circulation model data. The FORECAST model (Kimmins et al. 1999) was used to predict forest growth and the Athabascan Plains Landscape model was used to predict forest succession changes (Yamasaki et al. 2008). Nine scenarios were tested and biodiversity and productivity were evaluated within these landscape projections (Yamasaki et al. 2008). The study area sits at the northern limit of the Aspen Parkland ecoregion and research has suggested that climate change may result in the conversion of forested land to aspen parkland (Hogg and Hurdle 1995). Therefore this analysis included prediction of how much forested land would shift to aspen parkland under climate change Scenario A1 (IPCC 2001).

Daily fire weather indices were calculated once weather streams under historical and climate change conditions were obtained. The Fire Behavior Prediction System (Forestry Canada Fire Danger Group 1992) was used to derive daily values for the Fine Fuel Moisture Code, Build Up Index and Fire Weather Index for the period 1 January 1961 to 31 December 1990 and the corresponding 30-year period under climate change. This fire record, which corresponds to the 30-year baseline most commonly used in climate research, serves as the basis for fire modelling with the Athabascan Plains Landscape Model. To simulate 200 years of fires, the model cycles through this 30-year record almost seven cycles. Fire duration, extent, frequency and seasonality were all statistically modelled as dependents of the Fire Behavior Prediction indices above and annual, seasonal and daily measures of temperature, precipitation and wind. A link detected among fire occurrence, weather and human population was also included in the analysis.

As an example of a dominant non-forestry related human disturbance in the FM area, patterns of oil and gas development were analyzed and future developments were simulated. The number of current wells was determined from the forest inventory. It was also possible to generate a time series of number of new well sites annually, and the area each represents. This was also completed for pipelines and seismic lines that are projected to being developed in the FM area.

2.2 Habitat Supply

Coarse filter analysis was divided into two areas within the Biodiversity Assessment Project (BAP): ecosystem diversity and landscape configuration (Van Damme et al. 2003). Ecosystem diversity analysis assumes that silvicultural practices will modify the distribution of ecosystems

across space and time. To monitor changes in the composition of the forecasts, BAP tracks the proportion of habitat types and diversity of the forest using the following metrics. 1) Area-weighted age is a single value at each time step during the simulation, indicating the average age of the entire forest. 2) Tree species distribution separates the forest into hardwood stands, hardwood-dominated mixedwood stands, softwood stands and softwood-dominated mixedwood stands. It provides an indication of the proportion of the FM area expected to support each habitat type at each time step. 3) Species presence indicates the extent of coverage of each tree species over the landscape. 4) Species dominance takes into account both tree species presence and relative dominance. 5) Habitat diversity was computed using a matrix showing similarity between habitat types as a weighting factor. The habitat diversity index considers the relative position of broad habitat types using a rating of similarity between the habitat types as a weighting factor. The diversity equation generates a single unitless value between 0 and 1 at each time step; 0 represents a very uniform landscape and 1 indicates the most diverse landscape possible. Incorporated into the index are both the number of habitat types present within the FM area and the proportion of the landscape covered by each habitat type. Landscapes containing many habitat types distributed evenly across the area are considered more diverse than those dominated by one habitat type, yet containing small portions of others.

Within the landscape configuration analysis, habitat types were used as class attributes because they can be weighted by contrast. As well, different levels of distinction among habitats can be used following the classification hierarchy. The landscape configuration analysis was comprised of several types of biostatistical analyses:

- Patch – areas of similar characteristics based on age and species composition.
- Edge – mean edge contrast index and contrast weighted edge length.
- Core area – The impact of edge on wildlife was expected to be linearly related to the abruptness of the habitat structure change at the edge and therefore the buffer width would change with contrast between adjacent habitat patches.
- Adjacency – It was expected that the spatial distribution of habitat types would differ in a managed scenario relative to a natural scenario. Consequently the proportion of adjacencies might be different. Many species use a combination of different habitats to fulfill their needs; therefore the adjacency of these habitats is important.
- Nearest neighbor – It was understood that a population using an isolated habitat is highly prone to local extinction. In addition, an organism using dispersed habitat patches may not be able to defend a sufficiently large territory from which to extract its needed resources. The nearest neighbor metric gives an indication of the dispersion of similar habitat types.

Fine filter analysis was undertaken by developing species-specific habitat supply models. It was recognized that the species selected would comprise an imperfect representation of the large array of species that occupy the FM area. The selection process was based on the following premises. 1) It is not possible to create models for all species. 2) Coarse filter analysis can account for habitat requirements for many species. 3) Models created for a carefully selected list of species will adequately represent the habitat needs of many other species. 4) Terrestrial vertebrates will be selected because: they use a large range of forest features; are good indicators of change; are the subjects of concern by the public and; approaches for analyzing forests in terms of vertebrate habitat potential are relatively well developed. Species were selected that represented the following classes: large terrestrial carnivorous mammals, large ungulates, medium-sized herbivores/omnivorous mammals, medium-sized carnivorous mammals, small mammals, raptors, birds in the order Gallinaceae and passerines (perching birds). The following criteria were used, with the numbers relating to the weighting scheme for each element: sensitivity to disturbance – 4; species status – 3; ability to monitor the species – 3; habitat specificity – 2; special habitat elements – 2; functionally essential species – 2; landscape configuration – 2; socioeconomic value – 2 and; available information – 1.

Habitat supply models were developed for each of 17 species selected to evaluate the potential of the FM area to provide suitable habitat (Van Damme et al. 2003). The models define habitat suitability based on the provision of habitat elements required for survival and reproduction. Within the models, special habitat element models were developed to characterize changes in condition (i.e. abundance, density) of habitat elements through forest succession and disturbance. Specific (i.e. canopy closure, tree height), general (i.e. perches, hiding cover) and habitat uses (i.e. food) were included in the analysis. Habitat supply models projected suitability based on home range size for each species and were used to assess each forest harvest scenario at 5-year time steps. Additionally, the special habitat elements were analyzed within the habitat supply model to determine a subset of elements that were most critical for the 17 species. These were then associated with silvicultural practices, seral stages and dominant species groups and embedded within the timber supply model as constraints.

2.3 Water

The Forest Watershed and Riparian Disturbance (FORWARD) project developed hydrologic models at two spatial scales (first- and third-order watershed) to predict how forest harvesting would change precipitation-normalized stream runoff at the watershed outlet (i.e. corrected for both watershed area and precipitation inputs). This variable, termed a runoff coefficient, was predicted for a given set of watershed attributes under forested conditions using a variant of the Soil and Water Assessment Tool (SWAT) (Arnold et al. 1998). The data to populate these runoff coefficient models were collected before and after experimental harvest from treatment and reference watersheds. Data included streamflow at a high temporal resolution, as well as improved digital elevation model, slope, soil and wetland coverage, and watershed boundaries. SWAT simulations are still underway to compare measured to predicted runoff coefficients with time after harvest and to calibrate the model for future FM planning cycles (Watson et al. 2008). Water quality is being incorporated into SWAT modelling, as well as artificial neural network modelling (Nour et al. 2006). The FORWARD project established indicators and ranges of acceptability in changes in streamflow based upon changes in runoff coefficients (Prepas et al. 2008). Thus, potential changes to streamflow could be given equal or varying weight as compared to other forest values during the development of a FM plan.

3. Results and Discussion

The structure of the FM planning analysis is hierarchical. The first task was to set the future landbase condition that included climate and vegetation change, human population change, wildfire response to these two conditions and oil and gas activities (Fig. 2). This produced a landscape change outside the normal projection (i.e. these issues are not included in a standard timber supply model). These conditions act as forest landbase constraints: over the standard planning period of approximately 200 years these conditions enact significant changes in the forest land base and forest growth patterns. This then produced future land base series on which we could overlay a timber supply analysis. This analysis includes the constraints of biodiversity (BAP) and water (FORWARD) (Fig 2). This was conducted for multiple future scenarios at two basic levels of projection: multiple scenarios of each component part (e.g., different oil and gas scenarios could be incorporated into the model leaving all other components static) and projections with various elements turned on or off, dependent upon what multiple effects needed to be focused upon for analysis. In this manner any number of iterations could be undertaken to arrive at an understanding of how each element affects the system at certain levels or how various combinations of elements can affect the system based on projected future scenarios.

The system described above is a logical evolution from the standard timber supply analysis employed in much of Canada to a more holistic model concept that looks at all issues facing a forest state. It is critical to model elements of varying forest values outside of traditional

economic considerations when developing a timber supply analysis, because these cannot alone be addressed by best management practices that are based on good intentions, with little data, science or modelling expertise behind them. It was found that these values can be incorporated into the process as post-projection analyses of the scenarios. However, the optimal approach is to include the elements as constraint conditions within a planning system that weighs and analyzes all elements at the same time. This approach demonstrates that the technical capacity is readily available to produce a true ILM/CEA plan. With all the pressures facing the forest land state, there is a definite need to produce plans such as these and what is needed now is the political and industrial will to carry such endeavors forward.

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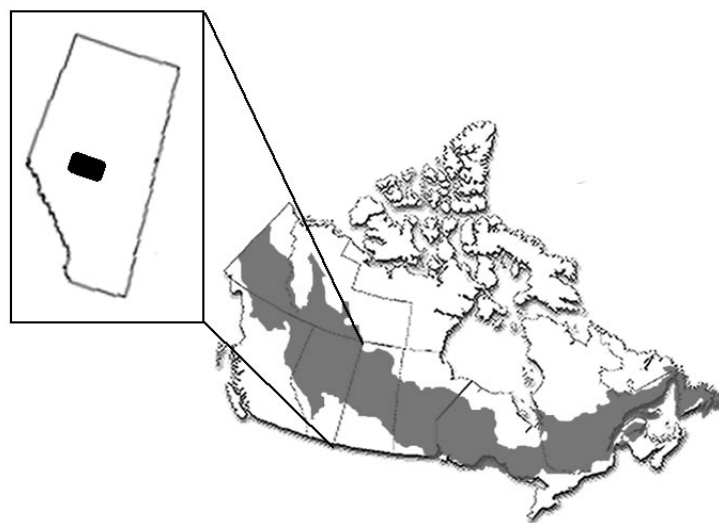
Figure 1: Map of Canada showing the approximate location of boreal forest and the location of the study area in the province of Alberta (inset).
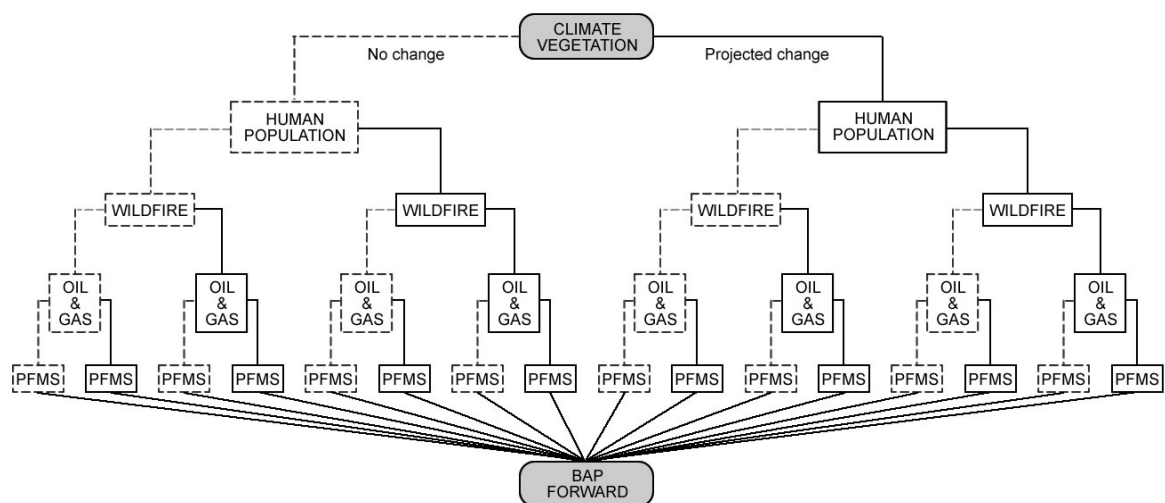
Figure 2: Schematic of the hierarchical Forest Management planning analysis. PFMS: Preferred Forest Management Strategy.

Section 7
Management and sustainability of changing landscapes

Sustainable forest management requires multi-stakeholder governance and spatial planning: Kovdozersky state forest management unit in northwest Russia

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Abstract

Large-scale clear-felling of naturally dynamic forests during the Soviet period has left many remote forest landscapes in the Russian Federation with limited wood resources for decades to come. Ideas about rural development based on forest non-wood goods, ecosystem services as well as natural and cultural landscape values are thus emerging. To understand stakeholders' needs for regional development based on both use and non-use values of forest landscapes we interviewed 31 stakeholders from private, public and civil sectors in the Kovdozersky state forest management unit in southernmost Murmansk oblast. While about half of the stakeholders were confined to the Kovdozersky forest management unit (~500,000 ha), the spatial scales of stakeholder activities ranged from local villages to the entire catchment of Kovda River in the Russian Federation and Finland (~2,600,000 ha). To avoid future negative externalities and risks for conflicts there is a need to (1) communicate the state and trends about sustainability dimensions of forest landscapes at multiple levels, (2) encourage collaborative learning processes about natural resource management based on principles of adaptive governance and adaptive management, and (3) plan at multiple spatial scales to satisfy and reconcile the needs and interests of different landscape stakeholders. The development of traditional and new products from forest landscape's goods, ecosystem services and values, and of local and regional forest governance requires exchange of experiences with development initiatives toward an integrated landscape approach in other regions and countries.

Keywords: spatial planning, natural resource governance, rural development, boreal forest

1. Introduction

The circumboreal boreal forest ecoregion is an important provider of natural resources in terms of wood, minerals and hydroelectric energy supporting human welfare and quality of life. Being relatively little impacted by anthropogenic change, there is opportunity for biodiversity conservation including viable populations, ecological integrity and resilience (Angelstam et al. 2004). Northern forest ecosystem also form a biomass sink (Myneni et al. 2001).

According to international and national policy documents sustainable forest management (SFM) aims at satisfying economic, ecological and socio-cultural values, and should be based on the principles of sustainable development as good governance including representation of actors and stakeholders (Lammerts van Buren and Blom 1997; Mayers and Bass 2004). The effects of multi-level external factors from local and regional to national and global levels that affect ecosystems, including climate change, and social systems, need to be understood (Angelstam et al. 2005). Finally, the actors, stakeholders and organisations exercising government and governance need to be well informed to connect forests and markets.

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A framework for building capacity for multi-level governance and planning towards sustainable forest landscapes is to view landscapes as interconnected social-ecological systems. This is often termed "landscape approach", meaning that that there is a need to expand the area for planning from stands and local areas, and to support participation of representative stakeholders (World Forestry Congress 2009). The social dimensions involve the institutions and all stakeholders involved with the use of natural resources. Thus, sustainable landscapes are integrated systems encompassing diverse cultural, natural and social functions through balanced governance empowering the involvement of all actors and stakeholders (Norton 2005; Baker 2006). To describe the ecosystem providing renewable natural resources, its composition, structure and function at multiple scales need to be understood. Similarly, the actions of the social system's actors and stakeholders from different sectors and governance levels should be mapped. Angelstam et al. (2003) coined the term two-dimensional gap analysis to better understand policy implementation processes in integrated social-ecological systems.

Many special initiatives have appeared globally that aim at implementing sustainability and sustainable development on the ground (Axelsson et al. 2008). The Model Forest (MF) concept, which originated in Canada in the beginning of the 1990s, is one example (IMFN 2008). A MF can be seen as a social process aimed at forming a partnership and a platform for discussing and solving a wide spectrum of issues related to sustainable management in a forest landscape by implementing new ideas approved by MF partners, and thus developing the adaptive capacity in an area to deal with uncertainty and change (LaPierre 2002).

This study focuses on the southern part of the Murmansk region in the northwest of the Russian Federation. Mining and forest logging began in the late 19th century and hydro-electrical power stations were built from the 1950s. While mining and hydropower production continues, forestry has declined dramatically (Elbakidze et al. 2007). As a consequence, rural settlements are declining, and people rely on local use of a wide range of wood and non-wood resources, and emerging tourism based on natural and cultural values (e.g., Lehtinen 2006). To adapt governance and management of forest landscapes to this situation a partnership of stakeholders was created in 2006 in the Kovdozersky forest management unit in the southernmost part of Murmansk region termed the Kovdozersky Model Forest (MF) (Elbakidze et al. 2007). We mapped landscape stakeholders and their use of landscape goods, services and values in the MF area. Our study shows the need for spatial planning at four spatial scales to communicate the present, past and future states and trends of forest goods, ecosystem services and values to different stakeholders at multiple level of organisation. We discuss the need to promote new forms of forest landscape governance promote collaboration among stakeholders.

2. Methodology

2.1. Study area

The Kovdozersky state forest management unit (400,626 ha) is located in the southern part of the Murmansk region in the north-west of the Russian Federation (Elbakidze et al. 2007). Geographically, it occupies the lower part of the Kovda river catchment, which has its headwaters on both sides of the Russian-Finnish border, and flows to the Kandalaksha Bay of the White Sea, and borders with the Karelian Republic in the south. Forests are dominated by Scots pine *(Pinus sylvestris)* at lower altitude and Norway spruce *(Picea abies)* on higher hills. There are eight settlements and many abandoned logging villages from the period of exploitative logging in the area. Local people in rural settings have retained their traditional land-use practices, which are based on forest resources. In 2006 the total number of people living in the area was about 15,000, and the population density was 3.7 people sq. km (Elbakidze et al. 2007).

2.2. Methods

To identify the stakeholders of the Kovdozersky MF and their use of forest landscapes, both qualitative and quantitative methods were used 2006-2008. A total of 36 open-ended qualitative interviews were conducted with stakeholders in the Kovdozersky MF. All interviews were taken face to face and lasted between 60 and 180 minutes. The interviews focused on the natural resource use profiles of stakeholders from civil, private and public sector actors, trends in forest management and transport logistics, as well as economic and social development in the area of the Kovdozersky MF. To quantify the state and trend of economic, ecological and socio-cultural dimensions of SFM in the Kovdozersky MF the interviews were complemented with analyses of socio-economic statistical data from the All-Russian Population Census (2002), and archives of local and regional administrations. To make a survey of the products derived from different kinds of natural resources we divided them into use values and non-use values (Merlo and Croitoru 2005). Direct use values include (1) consumptive (e.g., wood and non-wood goods) as well as (2) non-consumptive direct use values in terms of landscape quality for recreation and tourism. Indirect use values include ecosystem services such as watershed protection, water purification and carbon sequestration. Non-use values are closely linked to conservation interests of the landscape.

3. Results

3.1. Landscape stakeholders

In total we identified 31 stakeholders operating in the area of the Kovdozersky management unit. There were 13 land leasers, 9 forest contractors, 6 other forest users, and 3 potential forest contractors whose rights to use forests was under negotiation with the state as a main land and forest owner (Figure 1). Stakeholders from all societal sectors used landscape goods, services and values to create products through different kind of activities. However, private sector stakeholders were the main group (55% of the total number of stakeholders in the area). The representatives of the private sector were mainly small-scale forest logging companies, tourist enterprises, and an agricultural company. The smallest group was civil sector stakeholders, represented by the local gardening society. Stakeholders from the public sector managed the most of the land, forests and water in the area of Kovdozersky MF. This group included the Kovdozersky state forest management unit, the hydropower stations, and the protected areas. The distribution of stakeholders among different groups indicated that it was an interest from the private sector to develop business. According to the interviews with the stakeholders, we concluded that the business interests were very diverse, ranging from small-scale forest industry based on local forest resources, tourism (nature-based, sport, fishing and hunting), maintenance and restoration of fish population, small scale farming and fisheries, and construction of bio-energy production facilities.

3.2. Spatial planning scales

The spatial levels of stakeholder activities covered a wide spectrum, from international to local. However, almost 50% of all stakeholders focused their activity in the Murmansk region, i.e. the regional level. Based on interviews we found that four spatial scales of stakeholders' activities need to be considered in different types of spatial planning (Table 1). This means that although the different stakeholders which leased or used forest land in the same forest management unit, the creation of products from landscapes' goods, services and values took place at different spatial scales.

4. Discussion

4.1. Spatial planning at multiple scales

Today the main planning unit in the Kovdozersky MF is the 400,000 ha state forest management unit. An important task is to support co-existence of forest land leasers operating at different spatial scales with planning for multiple uses within and among leasing areas. A total of 17 stakeholders lease parts of this management unit for wood harvesting, hunting and recreation businesses. To secure sustainable use of forest landscape goods, ecosystem services and values their spatial distribution needs to be mapped. Assessment is needed of wood resources for timber and bioenergy, habitat suitability for game and fish, nature and culture tourism, hydro-electric development and for nature conservation. Some users have also a need for regional trans-boundary planning at the scale of the entire Kovda river catchment (2,610,000 ha) in Murmansk oblast, Republic of Karelia and Finland. Three examples are hydro-electric development, conservation of the last intact forest areas in Fennoscandia, as well as tourism linked to the Finnish and Russian cultural heritage. Given the importance of hydroelectric development for landscape stakeholders and fish populations a catchment perspective is logic. It would be appropriate to include the entire Kovda river catchment into the Kovdozersky MF.

4.2. Need for multi-stakeholder partnership for sustainability

Implementing policies about sustainability on the ground is highly dependent on biophysical conditions, the environmental history, and the systems of government and governance. Stakeholders and actors at multiple levels use goods, services and values of forest landscapes to develop products at several temporal and spatial scales. Consequently, when developing local and regional governance arrangements towards SFM policy implementation on the ground, stakeholders have to collaborate and develop capacity for learning to deal with uncertainties and risks in governance and management of forest landscapes. The development of collective action towards sustainable forest landscapes differs in different situations and places. Different stakeholders may also have different interests and needs for taking part in collective action (Elbakidze et al. 2010). In the Russian Federation the first MF initiative appeared in 1994, and in 2006 there were already five MFs. According to the "Initiative Network of Russian Model Forests", the Russian MFs are long-term projects, which develop on the basis of generally recognized international and Russian principles of SFM (Elbakidze and Angelstam 2008). At the end of 2007, the Russian Federation's Forest Agency, inspired by the MF concept, planned to create 31 Model Forests in addition to the five existing ones (Zheldak 2008). The vision was that the suite of MFs should represent all forest zones in the Russian Federation, and would become examples of SFM based on Russian and international experiences (Elbakidze and Angelstam 2008). However, since then no official information has been provided about any governmental actions towards development of a MF network in Russia. Nevertheless, given the interest to base regional development on forest resources in Russia, applying integrated landscape approaches, such as the MF concept, to support SFM implementation remains is an urgent task (World Forestry Congress 2009).

4.3. Knowledge production using transdisciplinary approaches

To realise the vision of SFM a societal learning process it is crucial to explore different landscape approaches in order to develop (i) an accounting system as a "map and a compass" that tells natural resource managers, policy-makers, media, authorities exercising governance, and the general public where we are going, and (ii) ways of establishing societal arenas for local and regional governance as a "gyroscope" that allows us to make informed decisions based on knowledge. This requires new forms of knowledge production that integrate different disciplines as well as academic and non-academic actors, i.e. transdisciplinary approaches (e.g., Gibbons et al. 1994).

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Table 1: Spatial scales for different types of spatial planning identified from interviews with 31 users of forest landscapes' goods, ecosystem services and values in the Kovdozersky Model Forest landscape as determined by the stakeholders' use profiles.

Spatial scale	Type of planning	Landscape actor
Trees in stands (~1-100 ha)	Operational planning (e.g., general considerations in forest management, stream and riparian management)	Forest leasers that harvest wood
Stands in management sub-unit (=landscape, old lesnichestvo, leasing area) (~2,000 to 100,000 ha)	Tactical planning (e.g., forest management, landscape planning for game species)	Kovdozersky forest management unit, nature protection units
Landscapes in a management unit (lesnichestvo under the 2007 Forest Code) (~500,000 ha)	Strategic planning in the Kovdozersky MF (e.g., to assure co-existence of use of wood, non-wood goods, energy, tourism)	Kovdozersky forest management unit
River catchment in the boreal forest (~5,000,000 ha)	Regional planning for sustainable development (e.g., hydro power, tourism, conservation of "green belt" forest)	Hydroelectricity production, authorities working with nature conservation
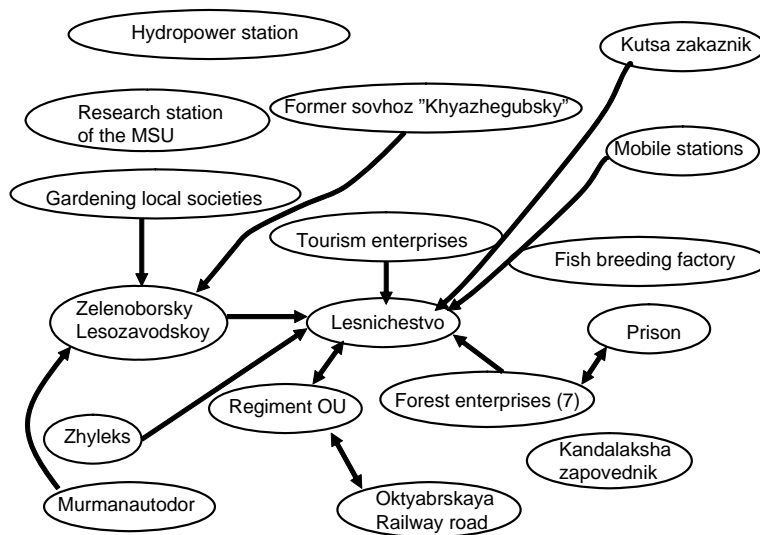
Figure 1: Management interactions between landscape stakeholders in the Kovdozersky Model Forest in the summer of 2008. Arrows show management interactions among different landscape stakeholders.

Relationship between small ruminants behaviour and landscape features in Northeast of Portugal

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Abstract

The small ruminant production systems in Northeastern Portugal are mainly based on the extensive exploitation of the spontaneous plant production. The shepherds direct their flocks on daily grazing itineraries across different patches of land use.

Sheep and goats flocks were monitored monthly for a year. Data collected consists of geographical position and the type of land use crossed. Also, essential livestock activities were monitored.

The corrected frequencies (preference indexes) approach was used for the data analysis.

The principal aims were to examine the relationships between livestock behaviour and land use types, and to check how they change throughout the year and the time of day. Our results showed a strong dependence between land use types and livestock activities and suggested a considerable coherence between human management, the spontaneous behaviour and physiological needs of animals and the agroecosystems capacity to supply the livestock needs.

Keywords: preference indexes, sheep and goat, livestock behaviour, land use types

1. Introduction

The small ruminant production systems in Northeastern Portugal are mainly based on the extensive exploitation of the spontaneous plant production. The shepherds direct their flocks on daily grazing itineraries across different patches of land use (Barbosa and Portela 2000; Castro et al. 2004). These circuits strongly differ throughout the year in duration and design. The places visited and the time spent in each one depends on the natural conditions and nutritional needs of the animals.

The relationship between environmental factors and animal-behavior was studied by various authors (De Miguel et al. 1997; Oom et al. 2004; Horne et al. 2008). Most of them are focus on wild ungulate herbivorous or free-ranging domestic herbivorous. Livestock systems with human control such as itinerant shepherding haven't been to a great extent studied from these point view. However, according (Baumont et al. 2000) shepherding consists in interacting with spontaneous animal's decisions and the herder's interventions could be considered simply as new constraints to the expression of the behavioral trends of the flock. As a result, in this feature,

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a study of livestock activities or movements across the landscape permits understanding the animal's perception of landscape.

Several animal attributes and environmental characteristics affect livestock movements, for instance, species or breed (Bailey et al. 2001), prior experience with a landscape(Bailey et al. 1996), degree of slope (Ganskopp and Vavra 1987), diurnal temperature dynamics of the landscape(George et al. 2007), presence of trails (Ganskopp et al. 2000), resources availability and quality.

Animal activities (grazing, resting and walking) were also affected by landscape attributes (Ganskopp and Bohnert 2009). The research provided an understanding of how to animals use the landscape, what kind of requirements they search when they visit a particular land use type. Having an understanding of animal landscape use could help to develop strategies to better management the landscapes and its temporal changes.

In this paper we show that relationships between animal behavior and environment can be easily highlighted by preference indexes values (Godron 1965). This method produces a general descriptive overview of the environmental factors associated with each type of behavior, and provides information about the importance of each factor in conditioning animal activities.

The principal aims were to examine the relationships between livestock behavior and land use types, and to check how they change throughout the year and the time of day (temperature and vegetation moisture effect). Our results showed a strong dependence between land use types and livestock activities and suggested a considerable coherence between human management, the spontaneous behavior and physiological needs of animals and the agroecosystems capacity to supply the livestock needs.

2. Methodology

The experiment was carried out in Trás-os-Montes region; from May 1999 to May 2000. Fieldwork was conducted over the territory of four villages located near Bragança, northeast Portugal (41°46'N latitude and 6°45'W longitude) at 700 to 1000 meters above sea level. The climate is humid Mediterranean with yearly mean temperature of 11.6°C and precipitation of 972.1 mm, which occurs mainly from October until May (INMG 1991). The dominant soils are umbric leptosols and dystric leptosols, depending on the land use.

Four flocks (two of goat and two of sheep) were monitored every month for a year. Each flock was observed for a complete day by an operator using a GPS. Data collected consists of geographical position and type of land use crossed (annual and perennial crops; meadows, forestlands and scrublands). Also, animal behaviour was monitored.

Behavioural activities (grazing, browsing, resting and walking) and the grazed species were noted every 15 minutes by direct observation (instantly recorded). Within each day, the frequency of animals involved in each activity was calculated for each individual observation of sheep or goat behaviour. The calculation of frequencies involved all the activities sampled, namely grazing, browsing, resting and walking.

The corrected frequencies (preference indexes) approach was used for the data analysis. The frequency of sheep and goats in each activity was computed, in addition to each land use type and part of the day. Also, the seasonal variations were computed of animal frequencies in each land use in each time of the day (table 1).

Table 1: Details of different frequencies considered

Animals observed in each activity	* Land use type
	*Period of the year (cool days, warm days, summer, winter)
Animals observed in each land use type	*Part of day (morning, middle-day, afternoon) in different periods of year (cool days, warm days, winter, summer)

The day was classified into morning, middle-day and afternoon, by dividing the daylight period. The year was classified into four periods; the summer corresponds to the months of June, July, August and September; cool days to the November, January, February, March; warm days to the April. May, October and winter December and January.

Animal-environmental interactions were analysed by comparing the expected and observed frequencies (observed / expected). This approach shows the main patterns of association between animal activities and environmental variables. In addition, the relationship between physical variables and land use types permits the analysis of the landscape organisation and the animals 'perception of the environment'.

Numerical output allows us to identify the level of the relationship between variables: the association is positive or preferred when the quotient is higher than to 1.24; indifferent, when there is a value between 0.75 and 1.24, and negative or not preferred, when the corrected frequency value is lower than 0.75).

3. Result

The animals' perception of the environment are focused on habitat types or land uses types. Table 2 shows the preference index values for the four principal activities and five principal land uses types (annual crops, perennial crops, meadows, scrublands and forestlands). Stables and paths were also considered.

Table 2: Preference index values of activities in different land uses and stable and path

Activities	Annual crops	Perennial crops	Meadows	Shrubs	Forest	Stable	Path
Sheep							
grazing	1.63	1.03	1.94	0.12	0.10	0.07	0.00
resting	0.22	0.45	0.20	1.97	2.54	2.82	0.08
walking	0.63	1.46	0.25	0.14	0.07	0.05	7.24
browsing	1.35	2.61	0.13	3.66	0.82	0.00	0.37
Goats							
grazing	3.21	0.62	2.36	0.73	0.13	0.00	0.16
resting	0.37	1.23	0.62	0.26	1.69	4.11	0.21
walking	0.48	0.49	0.40	0.88	0.34	0.22	4.05
browsing	0.78	1.25	0.99	1.57	1.24	0.00	0.34

The relationship between animal activities and land use types permits the investigation of the animal habitat preferences and activity patterns.

Grazing activities are positively related to annual crop land use (1.63; 3.21) and meadows (1.94; 2.36) in both kinds of flocks.

Browsing activities are positively related to annual and perennial crop areas and scrublands in the case of sheep, whereas goat flocks concentrate browsing activities on scrublands (3.66).

Resting activities are positively related to patches of forestlands (2.54), scrublands (1.97) and stables (2.82) in sheep flocks. Goat flocks rest in stables or forestlands (1.69).

Sheep and goat flocks use mainly the path to walk; nevertheless perennial crop lands are used by sheep to move into other land use types.

Annual crop land uses are used by sheep for grazing and browsing; activities of resting and walking are not frequent in this land use type. Goats use preferentially annual crops for grazing. These results suggest that some ancient areas of annual crops were converted into long-term fallow or have been abandoned. For that reason, sheep flocks use this land use type for grazing and browsing.

Perennial crop lands are used by sheep, mainly for moving up from some land use types to others (1.46) and browsing (2.61). Goats use them to browse (1.25). There isn't an association between perennial crop areas and resting activity (0.45 and 1.23 for sheep and goats, respectively). It relates to the organisation and specific function of each land use type, for example, the flocks rest in forest lands and not in chestnut orchards, despite their availability and good shade.

Forestlands are used by goats (1.24) for browsing and resting (1.69), whereas sheep use this land use for resting (2.54). Scrublands are used to feed sheep (3.66) and goats (1.57); they are also places for resting by sheep (1.97). Meadows are used only to feed in both species.

Table 3 shows the preference index values from the five principal land use types (also stable and paths) in different periods of the year (cool days, warm days, winter, summer) of sheep and goats flocks.

Table 3: Preference index values of land uses (also stable and path) in different periods of the year.

Land uses	Sheep				Goats			
	cool	warm	winter	summer	cool	warm	winter	summer
annual	1.56	1.46	0.62	0.63	1.63	0.88	0.95	0.77
perennial	1.50	1.44	2.04	0.40	0.23	1.48	3.39	0.36
meadows	1.24	0.83	2.03	0.84	1.08	0.47	1.54	1.20
shrubs	1.00	0.26	0.00	1.63	1.50	1.35	1.11	0.45
forest	0.07	0.20	0.11	1.92	0.13	1.00	0.47	1.60
path	0.97	1.04	1.87	0.83	0.98	0.64	1.49	1.14
stable	0.04	0.96	0.00	1.50	0.04	0.91	0.00	1.85

In the case of sheep flocks, cool days are positively related to annual (1.56) and perennial crops (1.50) and negatively related to forestlands. Goat flocks on cool days prefer to use annual crops (1.63) and scrublands (1.50). On warm days, sheep show the same pattern (annual and perennial crops) and goats replace annual with perennial crops (1.48). In the winter period goats and sheep show the same pattern, using for the most part perennial crop lands and meadows. In summer, itinerant sheep are strongly connected with forest (1.92) and shrub (1.63) land use types. Itinerant goats are positively connected with forest lands (1.60) and negatively related to shrub (0.45) and perennial (0.36) land use types.

The relationship between animal activities and time of day, as well as period of year, permits the investigation of how the animals understand their environmental constraints and opportunities.

There is a general widespread pattern for both species (table 4). In the morning, animals preferentially walk and browse. The mid-day period is used for resting. The afternoon period is used for grazing.

Resting in both species is connected with the higher temperatures of mid day, in all periods of the year. The resting activity in goats in winter is unreliable. Sheep flocks show a stronger reluctance for morning grazing on cool days and in winter. In the case of goats, only in summer periods they are reluctant to graze in the mornings. In summer, all activities excluding repose are negatively connected with mid-day time.

4. Discussion

The relationship between activity preference and time of the day, land use type, and their seasonal variation suggest a complex pattern of use of landscape by the flocks.

During their daily itineraries, the flocks use different land use types for different purposes; they can be used for browsing, grazing, resting, or walking. Also, these uses can change throughout the year and day. The results confirm those found by (Castro 2004) with different methodologies; in particular, using the time spent in each land use type.

The data indicate that flocks move over the landscape with a special perception of benefits and requirements. The displacement is guided by a complex interpretation of land uses type profits (fodder, shade or transit between habitats), environmental constraints like temperature of mid-day, moisture of pasture in the morning, and land use types occurring near villages.

Table 4: Seasonal variation of preference index activity values in different periods of day

	Sheep			Goats		
	morning	mid-day	afternoon	morning	mid-day	afternoon
warm days						
Activities	morning	mid-day	afternoon	morning	mid-day	afternoon
grazing	1.06	0.76	1.32	0.51	0.78	1.52
resting	0.07	1.80	0.43	0.44	1.61	0.46
walking	1.42	0.82	0.99	1.29	0.75	1.20
browsing	3.20	0.57	0.21	1.23	0.92	1.00
summer						
grazing	1.17	0.00	1.76	0.90	0.53	1.62
resting	0.63	1.92	0.52	0.09	2.29	0.35
walking	1.91	0.00	0.99	1.20	0.21	1.24
browsing	1.99	0.00	0.91	1.35	0.12	1.02
cool days						
grazing	0.59	0.73	1.25	0.34	0.91	1.55
resting	0.64	2.09	0.33	0.00	1.90	0.60
walking	1.72	0.86	0.97	1.35	0.60	1.24
browsing	3.36	1.68	0.14	1.48	1.00	0.67
winter						
grazing	0.33	1.02	1.17	0.37	1.03	1.33
resting	0.00	1.87	0.66	0.81*	0.75*	1.44*
walking	1.81	0.70	0.99	1.34	0.54	1.39
browsing	2.13	0.99	0.70	1.41	1.36	0.30

*not reliable, because only six animals were observed in this activity

The seasonal variation of frequencies in different land use types for sheep and goats suggest that the itineraries vary during the year, regarding different needs of animals and dissimilar opportunities for exploitation of resources. Shepherds recognize these different habits and use them accordingly to manage their production systems (Meuret 1996; Baumont et al. 2000).

The occurrence of resting was markedly associated with the places in which shelter was provided and the period of the year where the temperature increased. Various authors (De Miguel et al. 1997) described the same pattern.

The feed activities (grazing and browsing) are related in the case of sheep to annual and perennial crops, meadows and shrubs. Frequently, the meadows are enclosed by hedgerows or splashed by scattered riparian trees. In the case of goats, they related to annual crops, meadows and scrublands. An interesting aspect is the different value of browsing activity in meadows for sheep and goats. In the first case, they are negatively related. In the case of goats, the value (0.99) shows that browsing activity can take place in meadows (presence of isolated trees or hedges); also interesting is the value of browsing activity on scrublands for sheep (3.66) and goats (1.57), showing goats browsing a bit everywhere while sheep browse specially on scrublands. These results agree with those reported by authors that pointed out the different foraging styles between sheep and goats.

The complex pattern of landscape use by flocks described in this paper, show the importance of each land use type for a particular animal activity. The natural complexity of Mediterranean landscapes has been increased by traditional pastoral activity. Several structures of the

landscape, such us hedgerows, scattered trees on the arable fields, forage trees, have been preserved over time by their functional value. However, part of these structures is threatened by the abandonment of agriculture and rural areas. Also, this specific pastoral system is strongly threatened. As a result, specific measures for its conservation should be taken as soon as possible, in accordance with European Landscape Convention assumptions.

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Does forest certification contribute to boreal biodiversity conservation? Swedish and Russian experiences

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Abstract

Forest Stewardship Council (FSC) is one of the leading forest certification schemes, which encourages sustainable forest management. While many studies have been done concerning the political and social outcomes of FSC, little is known about the contribution of certification for biodiversity conservation on the ground. We analysed the FSC standard content for biodiversity conservation at different spatial scales, and outcomes of FSC implementation for boreal biodiversity conservation on-the-ground using concrete forests management units in Russia and Sweden. Focusing on state forest management units in both countries we evaluated the connectivity of set-aside forests by applying morphological spatial pattern analyses. The Russian standard included spatial scales from tree and stand to landscape and ecoregion, while the Swedish standard focused on finer scales. Areas set-aside for FSC were similar in both countries, but formal protection in the Russian study area was three times higher than in Sweden. Swedish set-aside core areas were two orders of magnitude smaller, had much lower connectivity and were located in a fragmented forestland holding. To conclude, the potential of FSC for biodiversity conservation depends on the amount of formal protection, the spatial configuration of forest management units, and the functionality of habitat networks. Thus the areas certified according has limited information contents.

Keywords: structural and functional connectivity, Sveaskog Co, Komi Republic, formally and informally protected areas

1. Introduction

At the beginning of the 1990s different forest certification schemes appeared in order to promote implementation of sustainable forest management (SFM) policies in both developed and developing countries (e.g., Gulbrandsen 2005). The Forest Stewardship Council (FSC) and the Program for the Endorsement of Forest Certification schemes (PEFC) are the two leading forest certification schemes, and both aim to encourage SFM implementation at different levels from local to global (Cashore et al. 2003, 2005; Auld et al. 2008; Gullison 2003).

In this paper we focus on the certified forests in the boreal biome on the European continent. The FSC scheme is the only international certification system with wide geographical coverage in boreal forests in Europe, and the vast majority of the FSC certified forests in Europe are located in the boreal ecoregion. Sweden and the Russian Federation have the largest areas of FSC-certified forest in Europe, and both use wood to create forest products sold on international markets where certification matters to customers.

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Many studies have been made concerning the political and social outcomes of FSC (e.g., Cashore et al. 2003, 2005; Gulbrandsen 2005). In spite of ecological issues being the main concern at the initiation of the FSC system, little is known about the contribution of certification for biodiversity conservation on-the-ground (Brawn et. al. 2001; Gulisson 2003; Gulbrandsen 2005; Rametsteiner and Simula 2003). The aim of this paper is to analyse the potential of FSC certification in terms of standard content and outcomes for boreal biodiversity conservation on-the-ground using large concrete forest management units in Sweden and the Russian Federation as study areas. We first analyse and compare the biodiversity conservation requirements at different spatial scales in national FSC standards in Sweden and Russia. Secondly, focusing on two large state forest management units we evaluate the structural connectivity of forests set aside for biodiversity conservation by applying morphological spatial pattern analyses (Vogt et al. 2007 a,b). Finally, we discuss the potential of FSC certification for biodiversity conservation with different levels of ambition in managed boreal forests in Russia and Sweden.

2. Methodological framework

2.1. Study areas

Our study areas were the Bergslagen management unit (hereafter Bergslagen) of Sveaskog Co in south-central Sweden and the Priluzje forest management unit (hereafter Priluzje) in the Komi Republic in the Russian Federation. Bergslagen (59º N, 16º E) encompasses a total area of 563,629 ha of forest land ownership, including water and mires. The forested area consists of many forest polygons distributed in an area exceeding 4,000,000 ha within 9 counties in south-central Sweden. The main forest tree species are Norway spruce (*Picea abies*) and Scots pine (*Pinus silvestris*). Forests with domination of birches and aspen in younger succession stages occupy less then 8% of the total forested land. Priluzje (60ºN; 49º E) occupies 810,252 ha, and it forms one contiguous block of forested land. The main tree species are Norway spruce (*Picea abies*) and Scots pine (*Pinus silvestris*). Forests with domination of birches (*Betula spp.*) and aspen (*Populus tremula*) occupy almost 40% of the total forested land as a consequence of previous large-scale disturbances by fire and logging. Priluzje still hosts pristine forests with natural dynamics, and consequently near-natural composition, structure and functions.

2.2. Analyses of the FSC standard content on biodiversity considerations

There are, at least, four levels of ambitions for biodiversity conservation (Angelstam et al. 2004), viz.: (1) species may be present, but not in viable populations; (2) viable populations may be present, but only those that are not specialised on natural forest structures or having large area requirements; (3) communities of all naturally occurring species of the representative ecosystems of an eco-region are present, but large scale disturbances and global change can threaten their ecological integrity, and (4) ecosystems and governance systems have adaptive capacity and form resilient social-ecological systems (=landscapes).

The level of ambition for biodiversity conservation is correlated with the spatial scale of forest management. There are, as a minimum, four relevant spatial scales: (1) Trees in a stand cover individual trees and groups of trees within a forest stand (Eriksson and Hammer 2006). On this spatial scale species with very small habitat requirement could be maintained for a limited time, thus satisfying relatively low ambitions in biodiversity conservation (the first level of ambition above). (2) Stands in a landscape correspond to the scale of a delimited area of similar tree composition, age structure, diameter and height (Eriksson and Hammer 2006). This spatial scale matches the maintenance of species with small area requirements such as vascular plants, but not viable populations of fungi and lichens in the long term (i.e., the first and second levels of ambitions). (3) Landscapes in an eco-region large enough to accommodate the needs of species with relatively large area requirements and habitat patch dynamics for species that track certain

successional stages (i.e., the third level of ambition). (4) Finally, eco-regions on the global level encompass the spatial scale which allows maintenance of ecosystem composition, structures, and functions linked to natural processes (Angelstam et al., 2004; Cabarle et al. 2005) (the highest level of ambition).

The Russian and Swedish FSC standards (Russian National FSC 2008, Swedish National FSC 2010) contain criteria and indicators (C&I), concerning ecological, economic and social-cultural dimensions of SFM. We assessed the extent to which current criteria and indicators capture the four spatial scales of biodiversity conservation in both standards.

2.3. Area proportion of set-aside forests

The study areas contained formally (according to the national legislation) and informally (voluntary within the FSC and company policy frameworks) protected forests, which were set aside for biodiversity conservation. To estimate the area and area proportion of formally and informally protected areas for biodiversity conservation we selected all forests which are protected from relevant digital spatially explicit data bases used by the forest companies in Priluzje and Bergslagen. Spatial analyses were made for stand types with different age and tree species. In Priluzje the latest forest inventory was done in 1992 and was updated in 2002. In Bergslagen the last forest inventory was done in 1990, and it was then updated yearly taking into account the forest management activities undertaken.

2.4. Assessment of structural connectivity of forest habitats

The spatial configuration of forests set aside for biodiversity conservation is important to satisfy the requirements of species with different levels of ambitions for biodiversity conservation. According to Taylor et al. (1993, 2006), there are two kinds of landscape connectivity: structural and functional. Structural connectivity describes only physical relations among habitat patches and does not provide functional connectivity if corridors are not used by target species. Functional connectivity is species-oriented and increases when some change in the landscape structure increases the degree of movement or flows of organisms through the landscape.

To assess structural connectivity created by the forests set aside for biodiversity conservation in our two case studies we used Morphological Spatial Pattern Analyses (MSPA) (Vogt et al. 2007a, 2007b; Ostapowicz et al. 2008). Following (Vogt et al. 2007a, 2007b), we considered seven classes of forest pattern: core, islet, edge, perforation, loop, bridge and branch. The informally and formally protected forests were merged to create the focal forest polygons for assessment of structural connectivity of forest habitats. All focal forest polygons were classified according to their age class and tree species composition. The vector forests maps derived from GIS were converted into raster maps with 25-m pixels. According to Ostapowicz et al. (2008), the MSPA classes on output maps depend on the size parameter used in the morphological model. From a biological perspective several studies show that the edges affect the environment in forest patches. We used the results of studies presented in (Aune et. al. 2005) that indicates that in the boreal forests edge effects vary among species groups, but that they generally extend at least 25 m into the forest and greater than 50 m for some groups. Therefore, in MSPA processing we quantify connectivity in our study areas twice with edge width of 25 and 50 m.

3. Results

3.1. FSC requirements for biodiversity conservation in Russian and Swedish standards

In the Russian FSC standard biodiversity considerations were included into 14 criteria with 48 indicators, and in the Swedish FSC standard to 12 criteria with 55 indicators. Multiple indicators considered different aspects of biodiversity conservation. The C&I in both standards

were thus relevant for biodiversity conservation at different spatial scales. Some indicators referred to only one spatial scale of biodiversity considerations, while other corresponded to several spatial scales. Our analyses showed that in the Russian standard four spatial scales were reflected, and the majority of C&I corresponded to the scales of stands in a landscape and landscapes in an ecoregion. In the Swedish standard three spatial scales were considered, and the majority of C&I were relevant to the scales of trees in a stand and stands in a landscape.

3.2. Area proportion of set-aside forests

In Bergslagen the formally protected forests included Natura 2000 sites with high conservation interest at the EU level, nature reserves created for the purpose of conserving biological diversity, protecting and preserving valuable natural environments or satisfying the need of areas for outdoor recreation; and nature of national interest with high natural or cultural value which must be protected from actions that may significantly damage the natural environment. The formally protected forests occupied around 4% of total forested area in Bergslagen. There were also several types of informally protected forests such as: (a) forests belonging to the management objective class NO which are left untouched in order to protect its high natural values; (b) forests of the NS class to be managed in a way to maintain a high nature values, and (c) forests of the PF class where the aim is to combine wood production with set-aside of trees and small patches of some nature/culture value. The informally protected forests in Bergslagen covered almost 9% of the total forested area.

In Priluzje formally protected forests fell into the following categories: (a) forests with water protective functions along rivers and streams; (b) forests along roads; (c) forests along fish spawning places; and (d) special protected areas. The formally protected forests amounted to almost 12% of the total forest area in Priluzje. The informally protected forests included pristine forests, and forests with high social and cultural values for local people, which are excluded from commercial use. Together these forests occupied approximately 10% of total forested area.

3.3. Structural connectivity

In Bergslagen pine, coniferous and spruce forests together occupied 84% of the total forested area set aside for biodiversity conservation. The majority of the forest pattern classes (core, edge, bridge and branch) were associated with these forest types, and the mostly with pine forests. Mixed and deciduous forests were underrepresented, and the main pattern classes created by these forests were edges and branches. By contrast, in Priluzje deciduous and mixed forests were the dominant forest types set aside for biodiversity conservation, and occupied 61% of the total area of formally and informally protected forests. More than half of the core areas were represented by deciduous and mixed forests. Edges were the second pattern class by the size of occupied area, and were represented mainly by deciduous and mixed forests.

In Bergslagen core and edge were the two dominant classes in the forest pattern when the edge width was defined as 25 m. Taken together these two classes occupied 69% of forested area set aside for biodiversity conservation. When the edge width was increased to 50 m the forest pattern became very different. The area of core decreases almost three times (from 35 to 12%), and islet increased almost four times and became the single dominant pattern class. In Priluzje the forest pattern was very different. With an edge width of 25 m, core was the only dominant class, occupying 70% of the total area of forest set aside for biodiversity. The total area of two classes in Priluzje (core and edge) was equal to the sum of areas of four classes (core, edge, branch and islet) in Bergslagen. This could indicate that in Bergslagen the forests set aside for biodiversity were more fragmented than in Priluzje. With an edge width of 50 m the forest pattern changed. The core areas decreases to 47%, and the area of branch and edge increased. However, these changes in proportion of forest classes were much less pronounced than in Bergslagen.

The total number of cores in the forest pattern of Bergslagen was 11,172 (with edge of 25 m) and 3,662 (with edge of 50 m). The size of cores ranged from 0.06 to 941 ha. The majority of cores (almost 70% of the total number) were less than 1 ha large. Core areas from 10 to 100 ha constituted only 6% of the total number core areas, but included more than 40% of the total core area. The total number of core areas in Priluzje was much smaller than in Bergslagen, and amounted to 227 with 25-m edge and 207 with 50-m edge. The minimum size of a core was 0.06 ha and the maximum was 37,397 ha. The majority of cores ranged from 0.1 to 10 ha. However, more than 90% of the total core area were more than 1,000 ha large.

Based on analyses of the habitat selection of red-listed species (e.g., Berg et al. 1994) and the focal species approach (e.g., Lambeck 1997) applied to boreal focal species, we selected the most valuable cores of different forest types for focal species depending on old and old-growth forests. We selected cores of spruce, pine, coniferous, mixed and deciduous forests in the age of more than 110 years, which belong to the groups of old and old-growth forests in Bergslagen and Priluzje.

There were 3,668 valuable cores in Priluzje and 4,940 cores in Bergslagen with an edge width of 25 m. Almost 80% of old and old-growth forests' cores in Priluzje were a part of larger cores of forest area which were set aside for biodiversity conservation. The total number of valuable cores in Bergslagen decreases to 1,207 if the edge width equals to 50 m, and in Priluzje the same changes occur but not so extreme – down to 3,233 valuable cores. The total area of valuable cores in Priluzje was almost 6 times larger then in Bergslagen (39,413 ha in Priluzje and 6,299 ha in Sweden with the edge of 25 m). These differences increase with edge width of 50 m. The area of valuable cores decreases in both study areas but more in Bergslagen (down to 24,617 ha in Priluzje and to 2,289 ha in Bergslagen). These changes indicate that the edge size affects the number and area of valuable habitats in Bergslagen much stronger than in Priluzje. The sizes of valuable cores for biodiversity varied considerable in our study areas. For example, in Priluzje total number of cores was bigger in the size interval from 1 to 10 ha.However, the largest area of old and old-growth forests' cores lay in the size interval from 10 to 100 ha. In Bergslagen the core distribution was different. The majority of cores were between 0.1 to 1 ha, and the most of the old and old-growth forest core areas were from 1 to 10 ha.

4. Discussion

Analysis of the content of the Russian and Swedish FSC standards showed that the Russian standard contained higher biodiversity conservation ambitions, thus including maintenance of communities of all naturally occurring species of the representative ecosystems of an eco-region. By contrast the C&I of the Swedish FSC standard were more focused on the maintenance of species, which are not specialised on natural forest structures or have large area requirements.

The total area of formally and informally protected areas as a proportion of the total forested area of the forest management units in Priluzje was almost 70% larger than in Bergslagen, and approximately half of these forests in Priluzje were set aside according to the national legislation. In Bergslagen the area of voluntary protected forests was almost twice as large as the area of formally protected forests. The large difference in the spatial configuration of the forest holdings in the Bergslagen case study (a dispersed archipelago of forest holdings) and the Priluzje case study (one contiguous patch) should be noted.

A review of the patch size requirements of individuals of different groups of species indicate that the core patch size distribution was satisfactory in the Swedish case study mainly for plants, fungi and lichens, but not for birds and mammals. By contrast, the majority of core areas in the

Russian case study had the potential to host viable populations also of the most area-demanding focal species.

To conclude, biologically relevant analyses are needed to assess functionality of set-asides for biodiversity conservation. We conclude that the potential of FSC for biodiversity conservation is dependent both on the amount of formal protection, the spatial configuration of forest management units, and the functionality and renewal of habitat networks.

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Impact of tree species replacement on carbon stocks in forest floor and mineral soil

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Abstract

This study aims at evaluating the influence of replacing areas of *Quercus pyrenaica*, which represents native vegetation of Serra da Nogueira, NE of Portugal, by *Pseudotsuga menziesii* on carbon stocks in forest floor and mineral soil. Three sampling areas were selected in adjacent locations with similar soil and climate conditions. The first area, covered by *Quercus pyrenaica* (*QP*), represents the original soil. The second area is in a 40 years old stand of *Pseudotsuga menziesii* (*PM40*), and the third one, also under *Pseudotsuga menziesii*, is 15 years old (PM15). In each sampling area, at 10 randomly selected points, samples were collected in the forest floor (0.49 m^2 quadrat) and in the soil (at 0-5, 5-10 and 10-20 cm depth). The forest floor stores 17, 13 and 6% of total carbon for *PM40*, *PM15* and *QP*, respectively. Four decades after species replacement, a soil organic carbon loss is observed, although no significant differences were found when comparing soil under introduced (*PM*) with original species (*QP*). A carbon loss of around 30%, in *PM15*, and gains of about 10%, in *PM40*, are computed when considering mineral soil and forest floor together.

Keywords: Quercus pyrenaica; Pseudotsuga menziesii; forest floor; soil organic carbon.

1. Introduction

The increase in atmospheric carbon content, as expected considering actual trends, draws attention to the highly valuable role of forest ecosystems in the global carbon cycle (Eswaran et al., 1993). The majority of the native vegetation in Iberian peninsula (Portugal and Spain) have been replaced by other forest species, particularly fast-growing conifers plantations. Although this replacement may have beneficial economic consequences, it is essential to understand environmental effects such as in carbon sequestration for mitigation of greenhouse gases. The knowledge of the differences among species in what regards C sequestration should be a decision support tool when introducing new forest species and can be used strategically to reach environmental goals (Oostra et al., 2006; Schulp et al., 2008; Vallet et al., 2009).

Species replacement implies changes in carbon stocks in forest floor and soil organic matter (Peltoniemi et al., 2004) because tree species litter quantity, quality and distribution in soil horizons have high influence in carbon storage (Oostra et al., 2006). Decomposition rate of plant residues can be slower or faster, depending on their nature. In general, it is accepted that organic residues from coniferous species decompose more slowly than broadleve species, for example, due to the presence of non-hydrolyzable polyphenolic compounds in litter (Faulds and Williamson, 1999). On the other hand, fast-growing species would accumulate carbon more rapidly than slow-growing species, but several studies shown that substitution leads to a carbon

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loss (Schroth et al., 2002; Wang and Wang, 2007; Vallet et al., 2009). Carbon stored in forest ecosystems depends fundamentally on forest age and management pratices (Post and Kwon, 2000; Paul et al., 2002; Pregitzer and Euskirchen, 2004). Species choice is actually a management option to increase carbon storage (Vallet et al., 2009).

The main objective of the present study was to quantify the impact of replacing a native hardwood species (*Quercus pyrenaica*) by a fast-growing conifer plantation (*Pseudotsuga menziesii*) on carbon stocks in forest floor and mineral soil, and its persistence through time.

2. Methodology

The study area was located in Serra da Nogueira, northeast of Portugal (41° 45'N and 6° 52'W), in the range between 1000 and 1100 m altitude. The annual average temperature is 12º C and annual average precipitation is 1100 mm, concentrated from October to March (INMG, 1991). The native vegetation is *Quercus pyrenaica* (*QP*), which occupies about 6,000 ha and represents the area of *QP* most extensive in Portugal. Over the last decades, some of the *QP* area have been replaced by fast-growing species, mainly *Pseudotsuga menziesii*, process where the fires have had an important role. Soils are classified as Orthi-Dystric Leptosols derived of schists (Agroconsultores and Coba, 1991).

To assess the impact of species replacement on carbon stocks in forest floor and mineral soil three sampling areas were selected in adjacent locations with similar soil and climate conditions. Selected study species were 15 year old (*PM15*) and 40 year old (*PM40*) stands of *Pseudotsuga menziesii* and stands of *QP*, the latter representing the original soil. The stands characterization is presented in Table 1.

Table 1: Mean stand characteristics for *Pseudotsuga menziesii* and *Quercus pyrenaica*.

Stands	Number of stems (trees ha^{-1})	Age (years)	Dominant height (m)	Mean diameter (cm)	Basal area (m^2 ha^{-1})
P. menziesii (*PM40*)	3800	40	20.1	27.7	229.3
P. menziesii (*PM15*)	6700	15	13,9	16.6	144.3
Q. pyrenaica (*QP*)	19300	-	8.5	7.3	81.6

In each one of the three stands (*PM15*, *PM40*, *QP*) 10 areas of 70 x 70 cm (0,49 m^2) were randomly established. In each one of these, the forest floor, defined as organic material deposited over mineral soil, was collected. Forest floor samples were dried at 65 ºC for 72 h to determine dry mass.

Total soil organic C down to 20 cm depth (sampled in the same points where forest floor had been removed) was calculated from C concentrations determined in samples collected in the 0-5, 5-10 and 10-20 cm soil layers. Bulk density (BD) was estimated at the same depths using the equation:

$$BD = 100 / (\%OM / BD_{OM}) + ((100 - \%OM) / BD_{min\ soil}) \qquad (1)$$

where OM is soil organic matter, BD_{OM} the bulk density of organic matter (assumed to be 0.244), $BD_{min\ soil}$ the mineral soil bulk density (assumed to be 1.64) (Post and Kwon, 2000; Paul et al., 2002).

Samples for soil C were air dried and sieved to determine the coarse fraction (> 2 mm). All samples of forest floor and mineral soil were analyzed for total C by dry combustion (ISO, 1994). Soil samples were tested with an acid-drop but no carbonates were detected, thus the total soil C was assumed to be comparable to soil organic C. Forest floor mass values were converted to carbon (t C ha^{-1}) multiplying these values by the C concentration in dry matter.

Soil organic carbon (SOC, t C ha^{-1}) was calculated multiplying C concentration by bulk density and thickness of the mineral soil layer with a correction for coarse elements content.

3. Results and discussion

Carbon concentration is significantly higher in forest floor under native species (*QP*), but the amount of organic residues accumulated on the soil surface is higher under the introduced species (*PM40* and *PM15*). The carbon stocks under *PM40* is about three times higher than the original soil, following the pattern *PM40 > PM15 > QP* (Figure 1). These results seem to be related to the decomposition rate, since under coniferous it is evident, on the surface, the presence of a large amount of slightly decomposed organic debris, unlike under the deciduous there is less amount of organic material, which suggests a more rapid decomposition and subsequent connection to the mineral fraction. Similar results were obtained by Rapp (1984) and Fonseca (1999). Among the conifers, differences also appear to be due to the age of the stands and the increase in density of canopy cover observed from *PM15* to *PM40*. In temperate forests, forest floor remain relatively constant or increase with age, reaching a peak after about 70 years of stand development (Pregitzer and Euskirchen, 2004).
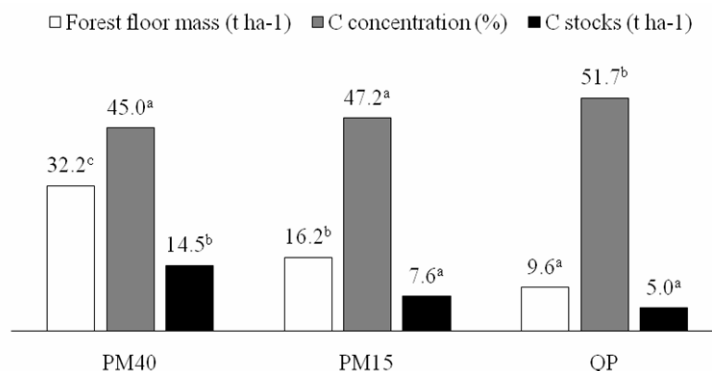
Figure 1: Forest floor mass (t ha^{-1}), C concentration (%) and C stocks (t ha^{-1}) in forest floor. For each variable, averages with the same letter are not significantly different (*P<0.05*).

The soil organic carbon concentration showed a vertical gradient for *QP*, with the highest values in the 0-5 cm layer and the lowest in the 10-20 cm layer. In introduced species (*PM15* and *PM40*) this gradient is not visible (Table 2), which may be related to disturbance caused by site preparation (Alcázar et al., 2002), and subsequent cleaning of stands.

Table 2: Changes in soil organic carbon concentrations (%) and soil organic carbon stocks (t C ha^{-1}) with soil depth for species observed, expressed as mean and standard deviation.

Depth (cm)	Stands		
	PM15	*PM40*	*QP*
	SOC concentration (%)		
0-5	3.0 (0.9)[a]	4.7 (1.0)[b]	5.8 (1.0)[b]
5-10	2.9 (1.0)[a]	4.7 (0.8)[b]	4.9 (0.3)[b]
10-20	3.0 (1.1)[a]	4.6 (0.8)[b]	4.5 (0.3)[b]
	SOC stocks (t ha^{-1})		
0-5	15.2 (4.0)[a]	21.7 (3.6)[b]	25.0 (3.1)[b]
5-10	13.6 (4.3)[a]	19.8 (2.8)[b]	21.5 (1.1)[b]
10-20	27.1 (9.2)[a]	40.6 (6.0)[b]	39.8 (2.1)[b]

For each layer and variable, averages with the same letter are not significantly different (*P<0.05*).

The 0-20 cm soil profile contained an average of 55.9, 82.1 and 86.3 t C ha^{-1} in the *PM15*, *PM40* and *QP*, respectively (Figure 2). The proportion of soil organic carbon storage in relation to total (forest floor plus mineral soil 0-20 cm) was 87.5% for *PM15*, 84.5% for *PM40* and 94.6% for *QP*. All soil layers show significantly lower carbon storage values under *PM15*, than under *PM40* or *QP*. Despite the statistically non-significant differences found between *PM40* and *QP* in soil layers, after 40 years of species replacement there are still carbon losses in *PM40*, when compared to native vegetation (Figure 3). The differences observed in soils under *PM15* are mainly due to the shorter recovery time since disturbance caused during stand installation (Dick et al., 1998).
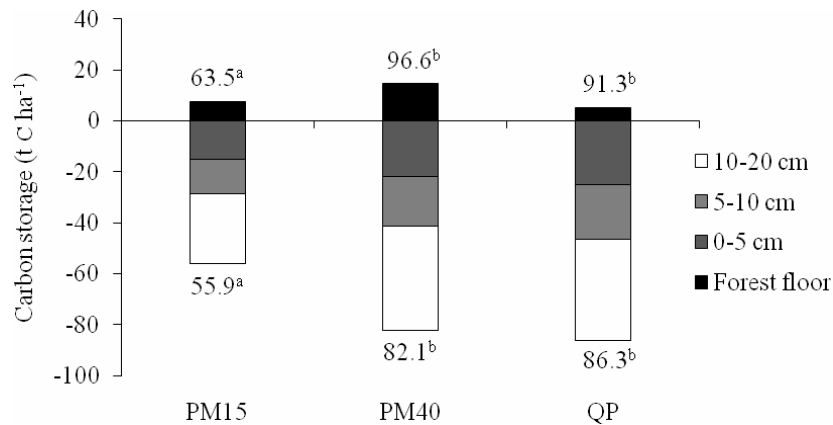
Figure 2: Total forest floor and soil organic carbon storage (numbers above bars in t C ha^{-1}) according to species. Numbers below bars indicate total soil organic carbon storage in t C ha^{-1}. For each layer, averages with the same letter are not significantly different (*P<0.05*).

In *PM*, forest floor was a carbon sinks (2.6 and 9.5 t C ha^{-1} for *PM15* and *PM40*, respectively) whilst mineral soil was a carbon source (30.4 and 4.2 t C ha^{-1} for *PM15* and *PM40*, respectively), as compared with the native vegetation (*QP*) (Figure 3). Pregitzer and Euskirchen (2004) reported increases in C content of soil with age for the temperate forests, and this was also an overall trend found in our study for soil C pool (Figure 3).
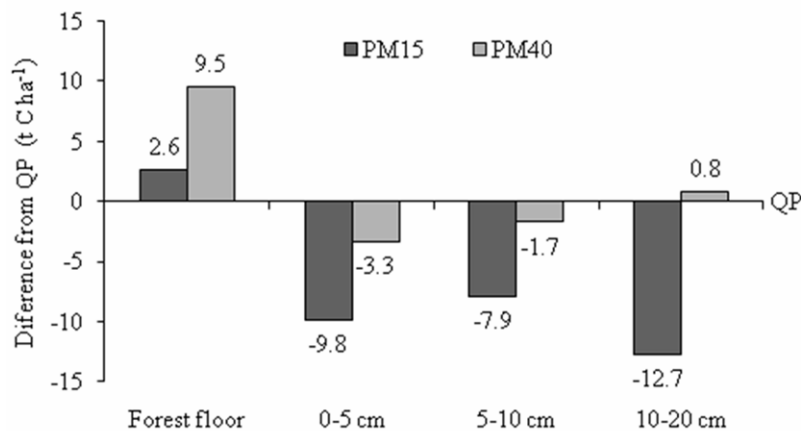
Figure 3: Gains (positive values) and losses (negative values) of carbon over time (t C ha^{-1}), due to the replacement of the species *QP* by *PM*.

The replacement of native vegetation (*QP*) by a fast-growing specie (*PM*) has effects on C stocks that depend on the time scale considered. The additional C storage of the *PM40* stands compared to *QP* is 5.3 t C ha^{-1}. After 15 years (*PM15*) the C loss reaches 27.8 t C ha^{-1}. There are many factors and processes that determine the distribution and rate of change in soil organic carbon storage when the type of vegetation and soil management practices are changed, among which stands age may assume great importance, as shown in this study.

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Disentangling recent changes in forest bird ranges in Mediterranean forests (NE Spain): Assessing global change impacts and guiding landscape management

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Abstract

In Mediterranean Europe, after the widespread afforestation and forest maturation following a large-scale decline in traditional uses, many forest bird species have expanded their ranges in the last decades of the 20th century. In order to disentangle the processes mediating recent range changes of forest birds in the Mediterranean region of Catalonia (NE Spain) and to provide forest management guidelines, we studied the relationships between variations in forest bird species richness at 10x10 km and forest landscape dynamics associated with land abandonment (afforestation and maturation), fires and management. The widespread afforestation and forest maturation appeared to counteract the potentially negative effects of fires on species richness, being the impact of forest management on birds much smaller than the impact of the former. Nevertheless, forest practices of moderate intensity and an adequate management of landscape connectivity pattern may be beneficial, allowing species to better face range changes associated with global change.

Keywords: afforestation, fires, forest maturation, species richness variation, sylvicultural treatments

1. Introduction

Ecosystems of Mediterranean Europe appear to be especially susceptible to the impacts of global change (Metzger et al. 2008) since many large-scale factors such as climate and land-use changes or modifications in the perturbation regime are expected to simultaneously impact these regions, with largely unknown overall effects on current biodiversity patterns (Sala et al. 2000). However, forest management could help to buffer the expected negative impacts of global change in the years to come. For instance, forest management could mitigate climate change by modifying wildfire behaviour (De Dios et al. 2007). Therefore, providing guidelines for a proactive management is of fundamental in ecological research.

As opposed to the current biodiversity crisis due to global change, many forest birds in Catalonia (NE Spain) have expanded or maintained their ranges in the last years of the 20th century (Estrada et al. 2004). Particularly, in this Mediterranean European region, land abandonment has boosted afforestation (Poyatos et al. 2003) and forests have also significantly

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aged (Spanish National Forest Inventory; Ministerio de Medio Ambiente 1997-2007), although fires burnt approximately 240,000 ha between 1975 and 1998 (Díaz-Delgado et al. 2004).

In order to provide effective forest management guidelines to better face global change impacts in Mediterranean Europe, this study aimed at determining the influence of forest landscape dynamics at 10x10 km associated with land abandonment (afforestation and maturation), fires and management on the variation of forest bird species richness in Catalonia in the two last decades of the 20th century. For this purpose, we considered data from bird atlases, forest inventories, fire perimeters' and land-use maps.

2. Methodology

2.1 Forest bird changes

Data on changes in the ranges of forest birds were gathered from the Catalan Breeding Bird Atlases (CBBA; Estrada et al. 2004). The CBBA data are derived from a series of large-scale surveys covering the whole extent of Catalonia in two different periods: 1975–1983 (Atlas1) and 1999–2002 (Atlas2). A total of 385 10x10 km UTM squares were surveyed in each of the different time periods. The field work was conducted by volunteers from March to July, recording evidence of breeding either by sound or sight.

We considered the variation of species richness between atlases from the species occurrence data for each Atlas period. The analyzed species did not include: (1) the most common species (>90% of total squares in Atlas 2) or very scarce (<10% of total squares in Atlas 2), (2) species with specific problems of detectability or (3) those species which tend to be irruptive or opportunistic (see Estrada et al. 2004; Gil-Tena et al. 2009). The total number of forest species complying with these criteria was 30, being most of them expanding (n=17), while the rest remained stable but showing some local changes in distribution (n=7) or significantly contracted their range (n=6) (Table 1; Estrada et al. 2004).

To control for changes in sampling effort between atlases, we applied regressions between the species richness for each atlas and the variability in sampling effort available for 309 UTM squares (log transformed; Estrada et al. 2004). We used the residuals of the former regressions to compute the variation of richness of forest bird species between atlases, which was the final dependent variable (Figure 1).

2.2 Forest dynamics

To assess forest structure changes we used data from 7712 permanent plots measured in the Second and Third Spanish National Forest Inventory (NFI2 and NFI3, respectively; Ministerio de Medio Ambiente 1997-2007). In Catalonia, the field work was carried out from 1989 to 1991 for the NFI2 and from 2000 to 2001 for the NFI3. The sampling density was about one NFI plot every 1 km^2. To assess forest maturation we considered the absolute variation of basal area (ΔG) obtained from the permanent plots measured in the NFI2 and NFI3. As indicator of the intensity of forest management at the plot level we computed the removed basal area between forest inventories (Removed G), estimated as the amount of basal area of those tally trees (diameter at breast height >7.5 cm) that had been inventoried in the NFI2 but that were not present in the same permanent plots in the NFI3. We considered only the silvicultural treatments that can affect stand basal area, differentiating between regeneration (clearcutting, shelterwood and selective cutting) and stand improvement treatments (precommercial thinning and thinning). Plots affected by fires (612 plots) were excluded from the analysis to avoid confounding effects between silvicultural treatments and fires in those plots.

To quantify afforestation, we calculated the absolute variation of forest area (ΔForest) obtained from the Land-use Map of Catalonia for 1987 and 1997 (see methods in Viñas and Baulies 1995), subtracting the amount of burnt forest area gathered from the government data of fire

perimeters. Fires were assessed by means of the accumulated amount of burnt forest area (Burnt) during the first and second edition of the CBBA. Furthermore, to determine whether the initial conditions of forest influence bird range changes, we also computed the initial state of both basal and forest area (G and Forest, respectively).

2.3 Analysis

We performed Pearson's correlations between the variation of forest bird species richness and the initial forest conditions (Forest and G), the variation of basal area (ΔG) and forest area (ΔForest), burnt forest (Burnt) and the removed basal area in improvement and regeneration treatments (IMP and REG Removed G, respectively). Excluding the case of variation of forest area that in Catalonia is mainly associated with afforestation in formerly cultivated areas, we computed partial correlations controlling for the effect of initial forest conditions since changes in forest structure due to forest maturation, fires and forest management may be strongly influenced by them. In the case of partial correlations of the initial forest conditions, for forest area we considered the influence that may have the initial basal area and vice versa. We also calculated a multivariate general linear model for assessing forest bird species richness variation as a function of the former independent variables. We used a hierarchical modeling approach (two steps; see also Gil-Tena et al. (2009, 2010)) to progressively consider initial forest conditions (Step 1) and forest dynamics (Step 2). Significant variables at Step 1 were introduced in Step 2 and their contribution to the model evaluated by means of standardized partial regression coefficients (β). In each step, we used a forward stepwise selection process (p-to-enter=0.05).

3. Result

The variation of forest bird species richness during the period between Atlases was positive for much of the study area covered by forests (59% of UTMs covered by forests increased species richness) whereas the negative values mainly corresponded with poorly forested areas (Figure 1). Agreeing with this, initial forest conditions were significantly related to the variation of forest bird species richness (Table 2). In the case of initial forest area (Forest), Pearson's correlation was significantly different from partial correlation controlling by the effect of initial basal area (G; p=0.005). This agrees with the positive correlations between variation of species richness and initial basal area (Table 2) and with the fact that the difference between Pearson's and partial correlations was lower than for initial forest (p=0.026), indicating that the variation of species richness was mainly associated with forests with a certain structural development (in terms of G).

Variation of species richness was also associated with forest dynamics, particularly with variation of basal area (ΔG). According to the difference between Pearson's and partial correlations when controlling for the effect of initial basal area (p=0.007), the maturation in previous forest areas with a developed structure strongly influenced species richness variation. Afforestation, in terms of increment of forest area, was also positively related with species richness variation but to a lesser extent than maturation (Table 2). Burnt forest area showed a non-significant positive correlation with species richness variation that only turned significant when considering initial forest conditions (Table 2). Regarding forest management influence on bird species variation, sylvicultural treatments seem not to preclude species richness variation, which is particularly true for regeneration treatments (Table 2). These results were quite independent of the initial forest conditions (in all the cases, p>0.05 when comparing Pearson's and partial correlations).

The results obtained in the multivariate model (R^2= 0.24; Table 3) confirmed the importance, for species richness variation, of the maturation produced in forests with a developed structure (in terms of G). Afforestation also seems to be favoring species richness variation but changes in

forest structure due to management did not appear to have any influence. The weak positive influence of burnt forest area may indicate that species richness varied despite fires.

4. Discussion

Although the unexplained variation of the models may evidence that other factors not considered here affected forest bird range changes at the study scale or others, our results demonstrated that the general positive variation of forest bird species richness (Figure 1) was significant in forested areas with a developed structure that matured during the 20 last years of the 20th century. Afforestation was also shown as potentially influence species variation. These results agree with previous studies at the same scale and area (Gil-Tena et al. 2009, 2010) which showed that forest maturation and afforestation, mainly due to land abandonment, have favored ranges of many forest birds and overridden the potentially negative effects of fires. Nevertheless, we cannot discount different levels of impact of forest fires on forest birds at smaller scales (<10x10 km) and/or depending on their degree of sensitivity (Ukmar et al. 2007). This would be particularly true if we consider the large impacts that climate change and fire increase are expected to have on Mediterranean forest landscapes (Colombaroli et al. 2007).

Excluding scale issues, the apparent lack of influence of forest management on bird ranges when simultaneously considering the rest of forest dynamics could be explained by the fact that forest management in the region is of moderate intensity and may not prevent the development of forest structure (Gil-Tena et al. 2010). Nevertheless, and as previously stated, forest management has been pointed out for its potential role in buffering global change impacts (De Dios et al. 2007). Particularly, forest management should focus on fire prevention in order to create forest landscapes less prone to burn that simultaneously allow harbouring forest bird diversity (Gil-Tena et al. 2007). Furthermore, an adequate management of the forest landscape connectivity pattern, which has probably improved due to forest maturation and afforestation occurred in the last decades, may allow species to better face range changes associated with climate change (Opdam and Wascher 2004). New improved methods and tools that may be particularly suitable for these purposes are available, such as Conefor Sensinode software (Saura and Torné 2009).

Acknowledgements

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Table 1: Considered forest bird species. According to the CBBA, the trend considering sampling effort is also reported in brackets. +, - and =: expanding, contracting and maintenance trend.

Forest bird species (trend)
Accipiter gentilis (-), *Aegithalos caudatus* (=), *Anthus trivialis* (=), *Caprimulgus europaeus* (+), *Circaetus gallicus* (+), *Corvus corax* (=), *Corvus corone* (=), *Dendrocopos major* (+), *Dendrocopos minor* (+), *Dryocopus martius* (+), *Erithacus rubecula* (+), *Falco subbuteo* (+), *Fringilla coelebs* (=), *Hieraaetus pennatus* (+), *Lullula arborea* (+), *Otus scops* (-), *Parus ater* (+), *Parus caeruleus* (-), *Parus cristatus*(+), *Parus palustris* (=), *Phylloscopus collybita* (+), *Picus viridis* (-), *Regulus ignicapilla* (+), *Sitta europaea* (+), *Strix aluco* (=), *Sylvia atricapilla* (+), *Sylvia cantillans* (+), *Troglodytes troglodytes* (-), *Turdus philomelos* (+), *Turdus viscivorus* (-)

Table 2: Pearson's and partial correlations, when controlling by the effect of the initial forest area (r_{forest}) and basal area (G; r_G), between the change in forest bird species richness and forest dynamics, fires and management. Δ: Change; IMP and REG: improvement and regeneration treatments, respectively; *, ** and ***: $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$, respectively.

Variable	Correlation
Forest	$r=0.37^{***}$, $r_G=0.16^{**}$
G	$r=0.41^{***}$, $r_{\text{forest}}=0.25^{***}$
ΔForest	$r=0.22^{***}$
ΔG	$r=0.44^{***}$, $r_{\text{forest}}=0.31^{***}$, $r_G=0.25^{***}$
Burnt	$r=0.06$, $r_{\text{forest}}=0.11^{*}$, $r_G=0.12^{*}$
IMP Removed G	$r=0.17^{**}$, $r_{\text{forest}}=0.08$, $r_G=0.06$
REG Removed G	$r=0.27^{***}$, $r_{\text{forest}}=0.13^{*}$, $r_G=0.12^{*}$

Table 3: Analysis of the factors behind changes in forest bird species richness between the two atlas periods. The general linear model was conducted in two steps according to a hierarchical process. The information in the table concerns to that of each variable in their corresponding step of assessment.

		β	p
STEP 1: Initial conditions	G	0.297	<0.001
	Forest	0.187	0.004
STEP 2: Forest dynamics	ΔG	0.237	0.001
	ΔForest	0.130	0.011
	Burnt	0.105	0.036
Adjusted R^2=0.24			
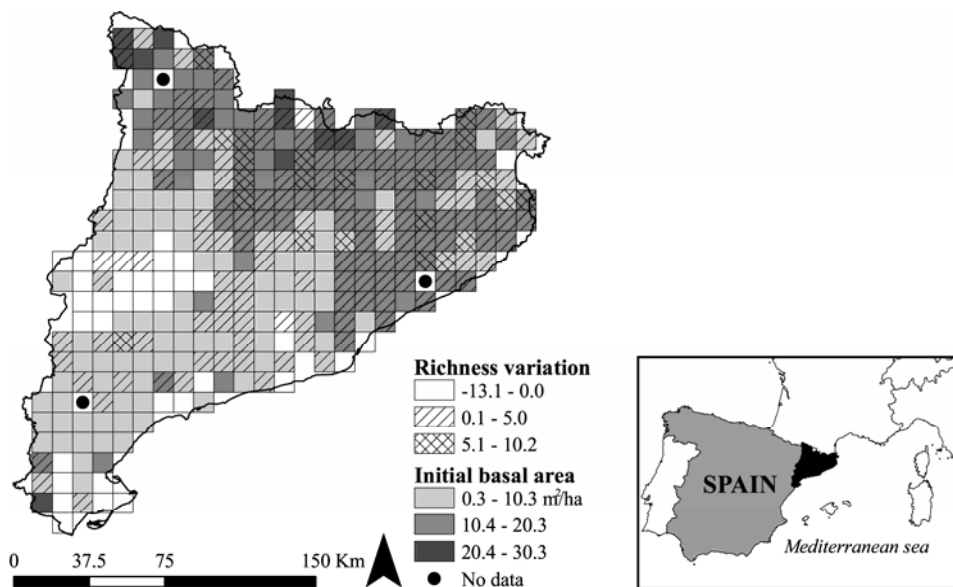
Figure 1: Geographic situation of Catalonia (NE Spain), shown in black color in the lower right chart. Representation of the initial basal area and the variation of forest bird species richness between Atlases after considering sampling effort.

Assessment of human and physical factors influencing spatial distribution of vegetation degradation - Environmental Protection Area Cachoeira das Andorinhas, Brazil

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Abstract

This study examined human and physical factors influencing the spatial distribution of vegetation degradation in a protection area. A map data set was used for the human and physical factors investigation. Those factors comprised: roads network, rural settlements/village/city, tourist sites, mining sites, agricultural areas, drainage, slope and geology. The vegetation degradation diagnosis was made with utilization of five ecological indicators: cover of invasive species, understory, canopy, bare soil and dead shrub percentage. Regression and correlation analyses were used to investigate the relationship between vegetation degradation and factors. The factor slope presented significantly negatively correlated to vegetation degradation in forest areas. Distance to tourist sites showed significant negative correlation in the savannah and rocky shrublands. Those factors can enhance humans and livestock accessibility to natural vegetation areas, which may increase intensity of damaging activities. The information can contribute to conservation strategies improvements in the protection area.

Keywords: vegetation degradation, change, spatially explicit factors, ecological indicators, conservation

1. Introduction

Vegetation degradation, unlike deforestation, is not a very obvious phenomenon. The changes are revealed gradually, sometimes not in terms of decrease of area, but represented by qualitative losses, for example, through the reduction of species diversity, increase of invasive species, decrease of the shrub layer, reduction of woody species and biomass decline (Hargyono 1993).

The investigations of spatially explicit factors (such as slope, roads) influencing vegetation degradation processes rely on the fact that those factors can represent an expression to some underlying structural driving forces, such as demographic and political forces (Mather 1990).

Most of the investigation of factors influencing vegetation degradation in the spatial context has been directed at arid landscapes associated with land degradation, desertification and soil erosion processes (Guerrero-Campo and Montserrat-Marti 2000, Kembron 2001). The situation has generated studies that combine vegetation degradation with other processes, such as, soil erosion. In general, however, they lack considerations of the quality and quantity of vegetation (Eswaran 2001).

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The present study examined the vegetation degradation phenomenon in a protected area, characterized by subtropical moderately humid climate, where degradation affects not only forest, but also other vegetation types. The main objectives of this study were:

1. assess the variations of vegetation degradation;
2. investigate the association between spatial distribution of vegetation degradation and human (roads network, rural settlements/village/city, tourist sites, mining sites, agricultural areas) and physical factors (slope, geology, drainage).

2. Methodology

2.1 Study area and map data set

The Environmental Protection Area (EPA) Cachoeira das Andorinhas comprises an area of 18.700 ha. It is located in the north of the Ouro Preto Mountain Range, Minas Gerais state, in the west extreme of the Brazilian Atlantic Forest dominion, setting bounds with the Savannah dominion (Rizzini 1979). The climate is subtropical moderately humid. The mean annual temperature varies from 19.5ºC to 21.8ºC.

The data sources utilized for the map data set composition comprehended: Landsat TM image 30m resolution; topographic map (for roads, rural settlements, villages, and city); contour map; geology map; and drainage map. Data collection in the field was carried out for the ground truth and localization of tourist and mining sites. The DEM (Digital Elevation Model) was obtained from a digitized contour map aiming the creation of the slope map. The classification of the Landsat TM image into land cover classes was carried out through a cluster of steps of supervised classification. The overall classification accuracy obtained was 82%.

2.2. Data collection and analysis

Data collection in the field was carried out in a total of 47 sample plots (25 x 25m) using stratified random sampling. For the establishment of vegetation degradation levels in the area 5 ecological indicators (*I*) were selected according to the literature (De Pietri 1992; De Pietri 1995; Hargyono 1993). The classes of vegetation degradation defined comprehended: not degraded (0), low degraded (1), moderately degraded (2), highly degraded (3) and extremely degraded (4). The direction of the influence of each indicator in the vegetation degradation process was defined through the use of multivariate analysis (Principal Component Analysis). Higher proportion of invasive species cover (%), lower estimation of canopy cover (%) and lower proportion of understory cover (%) meant higher level of degradation in the forest areas. The higher degradation condition in the savannah and rocky shrublands was determined according to the higher proportion of invasive species cover (%), higher proportion of bare soil (%) and higher percentage of dead shrubs. The invasive species considered were: *Arundinaria effusa*, *Eupatorium* sp., *Gleichenia* sp., *Lantana lilacina*, *Melinis minutiflora*, *Panicum* sp., *Pteridium aquilinuum*, *Rhynchospora exaltata*, *Solanum* sp., *Vernonia scorpiodes*; Poaceae 1; Poaceae 2.

Principal Component Analysis (PCA) was implemented for the definition of scores that represented the vegetation degradation variations and for checking redundancy in the data. For the forest areas the human factors distance to agricultural areas and distance to tourist sites presented clustered to village/city/ rural settlements, and were removed from the analysis. For the savannah and rocky shrublands the variable distance to village/city/ rural settlements was clustered to mining sites and removed from the analysis.

The presence and absence of damaging activities was verified through the marks and signs of fire, cutting, free grazing, fences, tracks and garbage. In order to investigate the relationship among the variations in vegetation degradation (scores) and human and physical factors, regression and correlation analysis were performed using SPSS software. The significant factors comprised those that presented p values significant at $\alpha = 0.05$, for a one-tailed test.

3. Result

The results of the categorization of the 28 sample plots of the forest areas into vegetation degradation conditions are presented in the Table 1. From the total of areas sampled, 28% were classified as extremely degraded (4), 36% as highly degraded (3), and 36% were found moderately degraded (2). The forest intermediate stage (FIS) presented 60% of the sample plots classified as highly degraded and 40% as moderately degraded. The forest advanced stage (FAS), otherwise, comprehended 40% of sample units classified as highly degraded and 60% as moderately degraded. The scrub areas (S) were all (100%) classified as extremely degraded.

For the savannah (SA) and rocky shrublands formations (RS), in the totality of 19 sample plots, 10 % were found extremely degraded (4), 6% presented highly degraded (3), 37% were classified as moderately degraded (2), 37% low degraded (1) and 10% not degraded (0) (Table 2). The savannah had 9% of the sample plots classified as highly degraded, 46% as moderately degraded, 36% as low degraded and 9% as not degraded. The rocky shrublands comprehended 25% classified as extremely

The results of the correlation analysis, obtained from linear regression, for investigation of the relationship among vegetation degradation scores and human and physical factors, in the forest areas, are shown in the Table 3. The physical factor slope presented a significant negative correlation coefficient ($R^2 = - 0.223$; $p = 0.011$) to vegetation degradation in the forest areas. The correlation analysis results for the savannah and rocky shrublands formations (Table 4) showed that the human factor distance to tourist sites was the one that presented a significant correlation ($R^2 = - 0.250$; $p = 0.029$) to vegetation degradation.

Activities of cutting and grazing were found in higher proportion in the FIS (60% and 50% respectively) and FAS (40% and 70%), while the presence of fire was evidenced only in the FIS (10%). Signs of fire occurred in higher proportion in the scrub (100%), savannah (100%) and rocky shrublands (100%). Grazing activities were also testified as important in those areas, occurring in 88% of the scrub, 90% of the savannah and 75% of the rocky shrublands areas. Indicators of mining activities, on the other hand, were restricted to the rocky shrublands areas (25%), due to the presence of the rock substrate, especially quartzite, target of exploitation. Besides that, garbage signs (cans, plastics, etc) resulted from tourist activities were observed only in the rocky shrublands (25%). From the 47 sampled areas 87% showed the presence of tracks, and 81% the absence of fences.

Table 1: Categorization of sample plots of the forest areas according to vegetation degradation indicators (Ia – Invasive Species Cover; Ib - Understory Cover; Ic – Canopy Cover)

Sample Plots	Type	Ia	Ib	Ic	Vegetation Degradation Scores	Vegetation Degradation Classes
1	FIS	2	3	2	-6.816	3
2	FIS	2	2	2	-10.504	2
3	FIS	3	3	2	20.553	3
4	FIS	3	3	2	27.488	3
5	FIS	2	3	3	6.914	3
6	FIS	1	3	2	-21.307	2
7	FIS	3	3	2	29.753	3

8	FIS	2	1	2	-19.634	2
9	FIS	1	3	2	-19.053	2
10	FIS	2	3	2	0.049	3
11	FAS	3	3	2	20.553	3
12	FAS	3	3	2	32.007	3
13	FAS	1	2	1	-47.215	2
14	FAS	1	1	2	-37.944	2
15	FAS	1	3	1	-30.508	2
16	FAS	1	3	2	-15.294	2
17	FAS	2	3	2	8.456	3
18	FAS	1	3	2	-7.658	2
19	FAS	2	3	2	3.085	3
20	FAS	1	3	2	-3.057	2
21	S	4	0	3	51.892	4
22	S	4	0	3	58.792	4
23	S	4	0	3	58.792	4
24	S	3	0	4	37.400	4
25	S	3	0	4	41.219	4
26	S	4	0	4	64.910	4
27	S	4	0	4	61.092	4
28	S	4	0	4	61.092	4

Table 2: Categorization of sample plots of the savannah and rocky shrublands according to vegetation degradation indicators (Ia – Invasive Species Cover; Id – Bare Soil Cover; Ie – Dead Shrubs Percentage)

Sample Plots	Type	Ia	Id	Ie	Vegetation Degradation Scores	Vegetation Degradation Classes
1	SA	3	2	2	70.965	3
2	SA	3	1	1	62.608	2
3	SA	0	0	3	1.425	1
4	SA	3	0	1	48.332	2
5	SA	2	1	0	30.965	1
6	SA	1	1	2	20.719	2
7	SA	0	2	2	22.127	2
8	SA	2	1	1	34.830	2
9	SA	1	1	1	0.570	1
10	SA	0	1	0	3.640	1
11	SA	0	0	0	0.000	0
12	RS	1	0	1	3.815	1
13	RS	0	0	2	1.083	1
14	RS	0	0	3	1.824	1
15	RS	0	0	0	0.000	0
16	RS	1	2	2	29.471	2
17	RS	1	2	2	36.360	2
18	RS	2	4	2	100.823	4
19	RS	2	4	4	93.542	4

Table 3: Correlation coefficients among human and physical factors and vegetation degradation scores in forest areas (bold entry indicate result significant at $\infty = 0.05$)

Independent Variables					
Human Factors			Physical Factors		
Distance to village/city/ settlement	Distance to the roads	Distance to mining sites	Slope %	Geology Classes	Distances to drainage
-0.086	-0.001	-0.021	**-0.223**	0.072	0.100

Table 4: Correlation coefficients among human and physical factors and vegetation degradation scores in savannah and rocky shrublands (bold entry indicate result significant at $\infty = 0.05$)

| Independent Variables | | | | | | |
| Human Factors | | | | Physical Factors | | |
Distance to agricultural areas	Distance to the roads	Distance to mining sites	Distance to tourist sites	Slope %	Geology Classes	Distances to drainage
-0.069	-0.137	-0.056	**-0.250**	-0.181	-0.061	-0.001

4. Discussion

The results of categorization of vegetation in degradation classes showed that the majority of sampled sites were found degraded. The findings have certainly relation with the large amount of damaging activities signs found in the sampled areas. Different authors refer to the contribution of activities such as grazing, cutting and fire to processes of vegetation degradation (Kakembo 2001; Hofstad 1997; De Pietri 1995; Kumar and Bhandari 1992; De Pietri 1992; Talbot 1986). Regarding the fencing system Kumar & Bhandari (1992) found inside a protection site, higher degradation due to free grazing in unfenced areas in relation to the fenced ones.

The forest areas presented higher levels of degradation while undisturbed and low degraded situations were found only in the savannah and rocky shrublands. The large availability of resources, especially wood for fuelwood and building materials in the forest areas (Michael Arnold & Dewees 1997), can be a source of major attraction for damaging activities in those areas.

In the savannah areas of the EPA the trees are short and occur in low proportion, sparsely distributed through the grass layer, and consequently they do not have the potential for cutting and charcoal production activities, characterized as the highest important disturbance pressure in most of the savannah areas in Brazil (Mistry 2000). Disturbances caused by fire, although can occur in savannah areas in cases of accidental or criminal intensive burning, are not a major problem when that factor is kept in periodical lower frequencies (Coutinho 1990). Since fire is an old component of savannah ecosystems the vegetation has developed resistance and dependency on this factor (Mistry 2000; Coutinho 1990; Rizzini 1979). Perhaps grazing can contribute more to degradation processes in the savannah of the EPA, and the highest level of degradation was found in one plot with presence of grazing marks and livestock.

The rocky shrublands are attractive especially for mining activities, but the impacts, although large, are restricted to the mining location. Similarly, the impacts of tourist activity on the rocky shrublands are limited to those areas close to waterfalls and cities. Grazing activities, although evidenced might be limited by the presence of large rock blocks, escarpments and deep holes (Verweij 1995).

The results of correlation analysis for the forest areas showed that slope is a significant physical factor influencing the vegetation degradation distribution in the EPA Cachoeira das Andorinhas. The negative association of this factor with forest degradation agrees with Mather (1990). This author argues that slope is a proximate factor that can increase accessibility of humans to forest areas. Verweij (1995) argued that cattle also tend to choose relatively easy walking routes to meet their goals. In the study area, activities of cutting and grazing might be hindered by the slope steepness, with presence of higher degradation levels in the areas with lower slopes.

In the savannah and rocky shrublands formations the human factor distance to tourist sites presented a significant negative correlation with vegetation degradation. The tourist visitation is higher in the southern part of the EPA, where Ouro Preto county and the Andorinhas waterfall are located. In protected areas in Costa Rica and Belize, Farrell and Marion (2001) also found that intense tourist visitation can degrade natural resources and contribute to vegetation damage and loss. The authors argued that successful ecotourism and protected area management needs effective management of natural areas for visitor enjoyment and resource protection.

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Role of planted forests and trees outside forests in sustainable forest management in Iran

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Abstract

From a forestry point of view, Iran is divided into five vegetation regions and during the period 1960-1999, afforestation amounted to 2,221,000 ha total area planted. The annual rate forest plantations establishment is 63,000 ha, the majority being implemented under government investment. The state grants substantial support to promote private investment in fast growing tree species plantations, which amount to 150,000 ha of which, 35% are young stands. The present evaluation of Trees outside forests in Iran is incomplete for lack of comprehensive data and information. Collaborative efforts between government, municipalities, NGOs and citizens' groups have led to the establishment of a quite dense network of urban and peri-urban forests in Iran, estimated in 1996 to be 530,288 ha. Result show that the current situation of Iran's natural resources is a reflection of its past and present social, ecological, technological, economic, political and administrative measures. Technical or engineering solutions are not enough; they need to take into account the needs, priorities and aspirations of the rural poor.

Keywords: Plantation, Forest, Tree, Urban, Establishment

1. Introduction

Iran covers an area of 1.65 million km2, enclosed within 8,731 km of frontiers, of which 2,700 of coastline boundaries, and 6,031 of land borders. Almost 60% of the country is mountainous, while deserts of the High Central Plateau cover one third of the territory. Environmental characteristics are Owing to its highly contrasted topography, Iran displays a variety of climates ranging from hyper arid (centre and east regions) to Mediterranean semi-arid and sub-humid (mountain regions) and humid (Caspian coastal area, west Azerbaijan and southwest Zagros mountain range). With its mean annual rainfall of 253 mm, Iran is drought-prone; precipitations being erratic and highly variable.

Being endowed with a rich diversity of ecosystems, plant and animal species, Iran is one of the world's most important gene pools; it counts 8,200 plant species (1,900 endemic), over 500 bird species and 160 species of mammals. Five plant species, 20 mammals, 14 birds, 8 reptiles, 2 amphibians, 7 fish and 3 invertebrates are considered either endangered, or threatened and vulnerable. Historical evidence indicates that the vast, arid areas of central Iran were once covered with valuable range and forest vegetation. Human activities are believed to have strongly contributed to desertification. The main land use categories of Iran are the following: Forests [12.4 million ha - 7.4% of territory]; Rangelands [90 million ha - 55% of the country]; Deserts [34 million ha - 21% of the country]; Cultivated lands [23.6 million ha – 14.4 % of territory]) exceed by far the forest land area; Urban and rural settlements, infrastructures and

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water bodies (4 million ha - 2.2% of the national territory). The total potential arable land amounts to 37 million ha (17 million ha under irrigation – 20 million ha rain fed).

From view point of surface water and groundwater resources it's divided into 37 basins and 174 watersheds, the country is drained by 3,450 permanent and seasonal rivers. The Persian Gulf and the Caspian Sea receive the highest flows. In 1996-97 precipitation generated 330 billion cubic metres (BCM) of surface water, 130 BCM renewable water and 126 BCM harvestable water resources, of which 87.5 BCM were harvested (94 % used by agriculture). About 70 BCM groundwater, were discharged in 1996 by 275,300 semi-deep wells, 100,700 deep wells, 46,700 springs and 32,000 qanats.

2. Methodology

2.1 Forests and rangelands global estate

As a result of losing ownership and usufruct rights, the ex-owners and the traditional forest dwellers/users lost interest and sense of responsibility towards sustaining and protecting forests and rangelands, used since without restraint to face growing demands that came with population growth. Forests occupy 12.4 million ha (7.4 % of country) and include 1.9 million ha of productive commercial forests. The rest amounts to 5.5 million ha (West and Zagros), 2.5 million ha (South and desert), and 2.5 million ha in other regions. Rangelands include lands covered by natural grassland, shrub-land and a combination of both. Iran's rangelands occupy 90 million ha (54.8% of country area); the condition of 16% of the rangelands is excellent, whereas 66% are in favorable to fair condition and 18% are in poor and degraded form.

2.2 Deforestation

The overall deforestation figure for the period 1958–1994 is widely accepted as being equal to about 5.6 million ha. The presentation that follows gives the rates of deforestation according to the widely accepted classification of forests in Iran: Caspian broadleaf deciduous forest (1.5 million ha); Arasbaran broadleaf deciduous forest (100,000 ha); Zagros natural forests (1.7 million ha); Irano-Touranian Central Forests (2 million ha); and Semi-savannah subtropical forests (300,000 ha).

2.3 Change in vegetation cover

No assessment has been made with regard to the forest annual cover change. However, considering that the present deforestation is limited, the average annual plantation rate of 63,000 ha should result in a slight positive change in national vegetation cover.

2.3.1 Natural forests

From a forestry point of view, Iran is divided into five vegetation regions as follows: Hyrcanian broadleaved forests [1.905,000 ha] along the Caspian coast; Arasbaran forests [150,000 ha] of North Western Iran; Irano-Touranian arid forests [2,895,000 ha] in the Central Plateau Region; Zagrosian forests [5,050,000 ha]; and Persian Gulf and Sea of Oman tropical arid forests [2,400,000 ha].

2.3.2 Planted forests

During the period 1960-1999, afforestation amounted to 2,221,000 ha total area planted (all categories inclusive). The annual rate forest plantations establishment is 63,000 ha, the majority being implemented under government investment. Tree species planted are generally limited to

indigenous or acclimatized exotic species. To ensure maximum success, most plantations are irrigated during 2-3 seasons. Water shortages are a major constraint to planting, particularly in arid zones. Site preparation costs are high, and establishment of irrigation facilities very expensive. The State grants substantial support to promote private investment in fast growing tree species plantations (poplar), which amount to 150,000 ha of which, 35% are young stands.

2.3.3 Trees outside forests

The present evaluation of trees outside forests in Iran is incomplete for lack of comprehensive data and information. In 2000 it was estimated that orchards accounted for 1,704,000 ha, about 14 % of the total forest area of Iran. Collaborative efforts between government, municipalities, NGOs and citizens' groups have led to the establishment of a quite dense network of urban and peri-urban forests in Iran, estimated in 1996 to be 530,288 ha (mean annual area treated 3,760 ha). Urban and peri-urban forestry is gaining momentum in the country and many provinces have developed their own urban forestry establishment program.

2.4 Forest, range and environmental protection strategies

Forests and range: The government is pursuing a strategy of multiple forest utilization and is launching a vigorous national reforestation and afforestation program to reclaim degraded forests and rangelands, protect watersheds and manage industrial forests on a sustained-yield basis. It also aims to involve private enterprises to obtain long-term concessions for large forest areas, with the objective of industrial utilization and sustained yield management. In the tree plantation program, the objective is to move towards more people participation and involvement as several programs are carried out on sub-contract basis with private enterprises.
Environmental protection: The national environmental protection strategy's goal is to put 10% of the national land area under protection. At present, 8.2 million ha are being protected by the Department of Environment, which manages the following categories of protected areas:
National parks (11 sites – 1.3 million ha); Wildlife refuges (25 sites – 1.9 million ha); Protected areas (47 sites – 5.3 million ha); National nature monuments (5 sites); and Biosphere reserves (9 sites – 1.9 million ha).

3. Result

1.1 Causes and effects of deforestation and degradation

Some of the salient indirect causes to deforestation and degradation are:
Land and water tenure and users' rights and incentives: These include: Incentives granted to enhance agricultural production, which have constituted an encouragement to extend the areas cultivated by converting, with the State's consent significant forest and rangelands to agriculture land; Indirect incentives granted for forest and rangeland exploitation, through omitting to tax products and incomes derived from such operations; Promoting excessive water mobilization as an encouragement to the extension of productive irrigated agriculture, mostly implemented through forest and rangeland clearing; and Land nationalization, which is held responsible for the breakdown of traditional systems of forest and range management, resulting in the disintegration of the forest and range resources.
Poverty triggering factors: These include: Unchecked population growth which inevitably results in extreme pressure being exerted on the limited natural resource base available to the country; Poverty, which concerns 40 % of the rural population that attempt to maintain basic living standards by increasing livestock numbers on the already overcrowded rangelands; and Lack of investments and on off-farm job and revenue opportunities that compel more people to

depend increasingly on marginal lands, at the expense of former forest and rangelands for their crop production.

Response capacity to forest and range misuse issues: The response capacity is weak because: Inability to react on a timely basis to misuse and calamity impacts, for lack of timely and reliable data and information; Top-down approach adopted to trigger community involvement in the process of natural resources rehabilitation has not set in motion the required sense of ownership of, and responsibility for, the resource that may lead to sustainable success; and Some gaps in knowledge related to natural resources, participatory procedures.

Legal/regulatory tools did not incorporate the human dimension and consequently failed to promote the protection and sustainable management of the land resources; The form of conservatism that prevails within the forestry and range sector makes it impossible to delegate fully the responsibility to its traditional users to administer, manage and sustain the resource; and Despite commendable efforts, the government's commitment to sustainable natural resources management remains insufficient.

The main direct causes to deforestation and range degradation are: climatic conditions, which limit vegetation's establishment and resilience and constitute hostile conditions for rehabilitation; accentuated topography, which triggers acute erosion processes; properties of soil which often hamper the emergence and survival of natural regeneration; natural destructive calamities, such as floods, wind, temperature and drought extremes; and pests and diseases.

Allocation of forest, woodland and rangeland for the purpose of agricultural and urban development; Misuse of forest resources through excessive fuel wood, construction, wood gathering, grazing and browsing; Misuse of rangeland resources resulting from increased livestock numbers, well beyond carrying capacity; Inadequate agricultural practices, particularly abusive utilization of unsuitable farm machinery for subsistence shifting cultivation combined with "free grazing" on marginal steep sloped lands; Agricultural land abandonment; Infrastructure construction; and Man-made catastrophes such as fires, wars, refugee influxes.

Deforestation and degradation result in loss of land productivity, which is translated by decline in biomass, in species diversity and in genetic resource; decline in habitat caused by loss of vegetative cover, erosion, salinization, water logging, lowering of water tables ; and soil erosion increase.

Natural resources degradation results in poverty expansion. Besides the traditional "underclass" often identified among forest and rangeland dwellers, the new population groups affected by poverty are the rural-to-urban migrants, the landless and near landless, the disabled, and the rural female group. The collapse of various production systems, which are not economically viable anymore, forces more rural population to migrate to cities. Regarding the extent of deforestation, clearing forest for agriculture, forage production and firewood and charcoal has reduced forests by 30 % over the last 40 years.

4. Discussion

4.1 Development choices

Iranian foresters have gained much valuable experience in such fields as sand dune fixation, mangrove regeneration, poplar and other fast-growing species plantation, management of non-wood forest products, development of extensive urban and peri-urban forests, development of intermediary forms of participation to forest and range sustainable management ; Despite imposing resource rehabilitation programs, government has not significantly and sustainable contributed to poverty alleviation among forest and rangeland dwellers; Following nationalization of all lands, rapid population growth as well as unsustainable human activities and other natural causes, Iranian forests and rangelands have lost very substantial areas in the last decades.

Planning and decision-making are highly centralized, leaving little space for provincial and local initiatives to program and project formulation, planning and decision-making;
Need to re-assess the country's training needs for participatory forest and range protection, rehabilitation, management and development;

4.2 Natural resources use and management

Socio-economic value of forests and rangelands is very significant as more than 5 million people live in forests or in their vicinity, while 450,000 persons live permanently on the rangelands; and Planted forests are established without any preconceived idea of their future sustainable management. Trees outside forests are not yet well perceived in terms of their actual or potential contribution to the national economy and to the well being of people.
The current situation of Iran's natural resources is a reflection of its past and present social, ecological, technological, economic, political and administrative measures. Technical or engineering solutions are not enough; they need to take into account the needs, priorities and aspirations of the rural poor.
So, it's recommended that: Adopt participatory planning and resource management approaches to sustainable forest resources management, with due regard for biodiversity conservation; Assessing and monitoring ecosystems; Participatory planning and management become a standard approach to understand the needs and aspirations of communities and individual families to contribute in those matters that directly impact upon their sustainable livelihoods; Poverty alleviation and support to local communities: Enhance and promote long-term employment and revenue opportunities among forest and rangeland dwellers by strengthening stakeholders' interest and investments in sustainable resources management; and Development and widespread distribution of alternative domestic energy: Provide alternative domestic energy sources to cover the entire rural countryside.
Promote more environmentally and people friendly approaches to agricultural development and expansion, by adopting efficient and non-destructive production systems, particularly in mountain areas, and rehabilitating lands that have been exhausted of their productive potential, to their initial land-use choice; and Improve land productivity and soil fertility in rehabilitation of degraded lands, including incorporating trees and planted forests in the landscape.

4.3 Enhancing the role of planted forests

Integrated planted forests in a broader land-use context in an attempt to respond to the priority needs and aspirations of people; Maintain or increase the present rate of afforestation/reforestation; and government prepare arid, semi-arid and tropical silvicultural and management models as well as guidelines for the rehabilitation, silvicultural treatment, management and development of mangroves, fodder tree plantations, and Haloxylon persicum stands developed through plantations and seeding.
Grant more support to farmers to maintain and expand poplar and fast growing species' plantings for shade, shelter and other uses; Promote trees outside forests in private holdings, particularly in agroforestry where trees support agriculture and livelihoods; Develop an adapted silviculture for the specific needs of urban/peri-urban forests and publish silvicultural guidelines for various species in different ecological contexts; Consider the productive capacity of the urban and peri-urban forests and prepare management plans accordingly; Promote the planting of trees outside forests, mainly fodder trees in sylvo-pastoral systems; and Arrange a short training course on the silvicultural treatments of fodder tree and shrub species and on sylvo-pastoral management of recently rehabilitated wooded rangelands.

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Values of mangroves and its interaction with marine ecosystem

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Abstract

Mangrove forests have been traditionally utilized by the local people for a variety of purposes in Nayband national park. Values of mangroves are recognized as various benefits: Lumber or similar construction wood; Poles, fuel wood, fishing gear; Raw materials for the wood-based industry of various nature and including board mills, rayon mills, match factories and charcoal products; Non-timber products including tannin to supply raw materials for leather tanning industries, fishing net processing units, thatching material for roofing and raw materials for indigenous medicine; Edible products including honey and wax, game animals, meat and fish, fruits, drinks and sugar, natural spawning ground for fish and crustaceans, especially for shrimps and prawns; Contribution to mud flat formation and control of erosion; Capability to check inland salinity intrusion; Enhanced capability to combat the impact of cyclone and tidal surge; Enhanced capability to function as a shelter belt during storms and cyclones. So in view point of these various use and benefits for human and marine ecosystem, conservation of mangrove forests would be a main strategy in the area.

Keywords: Marine ecosystem, Benefits, Restoration, Yield, Strategy, Impact

1. Introduction

Mangroves are woody trees or shrubs that grow in Intertidal region along tropical and subtropical coasts. With favorable geomorphic conditions, mangroves commonly form extensive tidal forests in moist, humid equatorial climates. Under these conditions, individual trees may attain heights of 40-45 meters and have stem diameters of more than 1 meter. Tidal mangrove forests under the favorable conditions of humid production climates and low to moderate soil salinity commonly have high rates of primary production and growth that are equivalent to those of the best terrestrial forests. On the other hand, under less favorable conditions, such as high soil salinity or arid climates, rates of primary production and growth are generally somewhat less. There are approximately 60 species of mangroves World-wide. About 45 of these occur in the South-east Asian/Western Pacific region, commonly referred to as the New World. The Old World region of Central and South America has 45-species, while there are about 10-12 species of Africa and Arabia. Asia and the Western Pacific are thus rich in terms of mangrove flora.

In addition to differences in species richness between major continental regions, their is also a marked reduction in the number of species with increasing latitude. Thus, while there are about 35 species on the North-eastern tip of Cape York Peninsula, only 4-5 species of mangrove occur near Brisbane, reducing to a solitary species, Avicennia marina, at the Southernmost limit of distribution of mangroves at Corner Inlet on the Southern coastline of mainland Australia. There

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is a similar reduction in the number of species with increasing latitude in the Northern hemisphere.

Mangrove forests are important for a number of reasons:

1. Mangrove forests and estuaries are the primary nursery area for a number of commercially important shrimp, crab and fish species. They are also important nursery areas for other species which are they not used commercially, but which for, part of the food chain for commercial species offshore.

2. Mangrove vegetation stabilizes shorelines and the banks of rivers and estuaries, providing them with some protection from tidal bores, ocean currents and storm surges.

3. In many countries of South-east Asia and the Pacific, mangroves are used commercially for the production of timber for building, firewood and charcoal. Experience has shown that when these activities are managed appropriately it is possible to derive timber products from mangrove forests without significant environmental degradation, and while maintaining their value as a nursery and source of food for commercial capture fisheries.

2. Methodology

2.1 Mangrove ecosystem

Due to the projected sea level rise, changes are being caused in the mangrove swamps of Sunder bans. In some areas, mangroves have died out while in other areas mangrove swamps have become more saline and the composition of species of both fauna and flora is changing. It is therefore proposed to study the ecology of mangroves of various salinity levels-low, medium and high. In these areas it is proposed to study the physicochemical conditions, productivity of benthos, phyto and zooplankton, availability of juveniles of prawns and fish and use them for growing. In addition, it is also proposed to study the role of different kinds of ecosystems, for the kind of species they will support for breeding and reproduction, as nursery grounds and as habitat for growing adult fish.

2.2 Function and uses of mangroves

Mangrove forest ecosystems fulfill a number of important functions and provide a wide range of services at the local and national levels (Box). Fishermen, farmers and other rural populations depend on them as a source of wood (e.g. timber, poles, posts, fuel wood, charcoal) and non-wood forest products (food, thatch – especially from nipa palm – fodder, alcohol, sugar, medicine and honey). Mangroves were also often used for the production of tannin suitable for leather work and for the curing and dyeing of fishing nets. However, this production has declined in recent years, mainly because of the introduction of nylon fishing nets and the use of chrome as the predominant agent for curing leather (FAO, 1994).

Mangroves support the conservation of biological diversity by providing habitats, spawning grounds, nurseries and nutrients for a number of animals. These include several endangered species and range from reptiles (e.g. crocodiles, iguanas and snakes) and amphibians to mammals (tigers – including the famous Panthera tigris tigris, the Royal Bengal tiger – deer, otters, manatees and dolphins) and birds (herons, egrets, pelicans and eagles, to cite just a few). A wide range of commercial and non-commercial fish and shellfish also depends on these coastal forests. The role of mangroves in the marine food chain is crucial. According to Kapetsky (1985), the average yield of fish and shellfish in mangrove areas is about 90 kg per hectare, with maximum yield of up to 225 kg per hectare (FAO, 1994). When mangrove forests are destroyed, declines in local fish catches often result. Assessments of the links between

mangrove forests and the fishery sector suggested that for every hectare of forest cleared; nearby coastal fisheries lose some 480 kg of fish per year (MacKinnon and MacKinnon, 1986). Mangrove ecosystems are also used for aquaculture, both as open-water estuarine mariculture (e.g. oysters and mussels) and as pond culture (mainly for shrimps).

Because of its high economic return, shrimp farming has been promoted to boost the national economy and alleviate poverty in several countries. This activity is often an answer to the financial constraints on many farmers and local communities and represents a source of employment. However, if unsustainably planned and managed, it can lead to uncontrolled deforestation and to pollution of coastal waters, damaged or totally destroyed coastal ecosystems and the loss of the services and benefits provided by mangroves. A series of international principles for responsible shrimp farming have been prepared (FAO/Network of Aquaculture Centers in Asia-Pacific/UNEP/ World Bank/Worldwide Fund for Nature, 2006; FAO, 1995a), with the main aim of offering guidance on reducing the sector's environmental impact while boosting its contribution to poverty alleviation. The principles were welcomed by many countries (FAO, 2006b)) and will hopefully provide support to the development of more ecofriendly shrimp production.

The increasing popularity of ecotourism activities also represents a potentially valuable and sustainable source of income for many local populations, especially where the forests are easy accessible.

Mangroves also help protect coral reefs, sea-grass beds and shipping lanes by entrapping upland runoff sediments. This is a key function in preventing and reducing coastal erosion and provides nearby communities with protection against the effects of wind, waves and water currents. In the aftermath of the 2004 Indian Ocean tsunami, the protective role of mangroves and other coastal forests and trees received considerable attention, both in the press and in academic circles. After more than two years, there are still contrasting views on this issue: eyewitnesses reported that coastal forests had saved villages from the destruction and lives, while some analyses asserted that elevation and distance from the coast were more significant determinants of protection than the forest cover itself.

Even though additional studies are needed to define specific details and limits of this protective function, the numerous studies and workshops undertaken on this topic over the past couple of years have brought to light a number of interesting factors. Experts and scientists agree that thick and dense coastal forest belts, if well designed and managed, have the potential to act as bioshields for the protection of people and other assets against some tsunamis and other coastal hazards (i.e. coastal erosion, cyclones, wind and salt spray). However, generalizations – and the creation of a false sense of protection provided by these bioshields – should be avoided, because mangroves and other coastal forests are not able to provide effective protection against all levels of hazards and may not be effective as shields against tsunamis as severe as the one that occurred in 2004. A full description of the factors to be taken into account with regard to enhancing the protective functions of mangroves and other coastal forests goes beyond the scope of this report. Interested readers are referred to FAO (2007) for further information.

2.3 Undervalued resources

Despite the many services and benefits provided by mangroves, these coastal forests have often been undervalued and viewed as wastelands and unhealthy environments. The high population pressures frequently present in coastal zones has in some places led to the conversion of mangrove areas for urban development. In order to increase food security, boost national economies and improve living standards, many governments encouraged the development of shrimp and fish farming, agriculture, and salt and rice production in mangrove areas.

Mangroves have also been fragmented and degraded through overexploitation for wood forest products and pollution. Indirectly, habitats have been lost because of dam construction on rivers, which often diverts water and modifies the input of sediments, nutrients and freshwater. Even though dense mangrove forests can be important in coastal protection, natural disasters should

also be listed among the possible causes of degradation: several tropical countries are frequently hit by cyclones, typhoons and strong winds, and the trees in the front lines may be damaged and/or uprooted during these catastrophes.

Over the last few years, however, awareness of the importance and value of mangrove ecosystems has been growing, leading to the preparation and implementation of new legislation and to better protection and management of mangrove resources. In some countries, restoration or re-expansion of mangrove areas through natural regeneration or active planting has also been observed. In addition, many governments are increasingly recognizing the importance of mangroves to fisheries, forestry, coastal protection and wildlife. Despite these positive signs, much still needs to be done to effectively conserve these vital ecosystems.

3. Result

The mangrove lands that, used to be considered as waste land in the past, have recently been treated as a valuable ecosystem, especially for their unique features. Mangrove forests have been traditionally utilized by the local people for a variety of purposes. Values of mangroves are recognized as various benefits. Study developed in the south west of Iran in Boushehr province and recognized that the forest of the mangrove ecosystem is capable to yield the following direct benefits:

Lumber or similar construction wood; Poles, fuel wood, fishing gear; Raw materials for the wood-based industry of various nature and including board mills, rayon mills, match factories and charcoal products; Non-timber products including tannin (mostly from bark) to supply raw materials for leather tanning industries, fishing net processing units, thatching material for roofing and raw materials for indigenous medicine; Edible products including honey and wax, game animals, meat and fish, fruits, drinks and sugar.

The mangrove ecosystem can yield the following indirect benefits:

Natural spawning ground for fish and crustaceans, especially for shrimps and prawns; Contribution to mud flat formation and control of erosion; Capability to check inland salinity intrusion; Enhanced capability to combat the impact of cyclone and tidal surge; Enhanced capability to function as a shelter belt during storms and cyclones.

4. Discussion

Sustainable management of mangrove

The mangrove ecosystem is a complex one. It is composed of various inter-related elements in the land sea interface zone which is linked with other natural systems of the coastal region such as corals, sea grass, coastal fisheries and beach vegetation. The mangrove ecosystem consists of water, muddy soil, trees, shrubs and their associated flora, fauna and microbes. It is a very productive ecosystem sustaining various forms of life. Its waters are nursery grounds for fish, crustacean and mollusk and also provide habitat for a wide range of aquatic life, while the land supports a rich and diverse flora and fauna. It also influences the micro climate, prevents coastal erosion, enhances accretion and combats natural calamities such as cyclones and tidal bores.

The concept of mangrove management has considerably evolved, as these formations have become better understood. Instead of simple management of the first stand, it is now realized that the whole ecosystem must be considered. It was also realized that, due to the diversity of mangrove formations, specific regulations are essential.

For most of the mangrove areas of the world, "fishery" and "forestry" are the two conflicting demands on mangrove lands. Apportioning of the mangrove land resource to these two major uses under the concept of sustainable management of the ecosystem needs further research

though a ratio of 20:80 is suggested for ponds to mangroves, on 25 ha allocations as "woodlot silvo-fishery" (Choudhury 1996). It is suggested that the mangrove area that may be sacrificed for fish ponds, can be calculated by using the following formula (Llaurado and Lindquist 1982).

The Max. Area that can be brought under Aquaculture = (S-F) / 2S

where:
S= Value of fish yield per hectare
F= Value of forestry per hectare, which must include the linkage values such contribution to open fishing, near-shore fishing, erosion control, biodiversity value, eco-tourism, shelterbelt value, etc.

This formula seems to be too simple and is based completely on monetary aspects.
Ecological restoration of mangrove habitat is feasible, has been done on a large scale in various parts of the world, and can be done cost-effectively. The simple application of the five steps to successful mangrove restoration described here would at least ensure an analytical thought process and less use of "gardening" of mangroves as the solution to all mangrove restoration problems. At appropriate sites with normal or near-normal tidal hydrology and with establishment of mangroves through natural recruitment or planting, restored mangrove systems can become indistinguishable from nearby natural mangrove systems within a short time. So in view point of these various use and benefits for human and marine ecosystem, conservation of mangrove forests would be a main strategy in the area.

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The importance of Environmental Education to restore and preserve natural and cultural heritage: the case of Pirai da Serra – South of Brazil

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Abstract

Pirai da Serra is located in the south of Brazil and it represents an impressive natural and cultural heritage. The area of Pirai da Serra is characterized by canyons, escarpments, grassland vegetation, araucaria forests, fauna and flora diversity, archaeological material (rock art) and cultural traditions. In the last decades, despite some efforts to avoid degradation, it is possible to observe a permanent transformation in the landscape in terms of environmental collapse. Some examples of local natural dilapidation are a wide use of land to increase agriculture, development of exotic species of forest, forest burning and scarcity of water, among other environmental impacts. Considering these circumstances, it is urgent the development of Environmental Education practices which promote the involvement of the local community in order to prevent a complete devastation. The local community participation (teachers, students, parents, people from cultural groups, social movements and government, among others) is essential to promote an environmental practice. This kind of practice must be able to deconstruct non-environmental actions and increase the consciousness of people in relation to restoration and preservation of natural and cultural heritage of the area.

Keywords: environmental collapse, cultural heritage, environmental education,

1. Introduction

This essay discusses environmental awareness related to the protection of natural and cultural heritage. It argues that environmental education must be understood as a future-orientated approach to people's life in relation to preservation of the planet and humankind. Environmental education represents an important tool for the defence of natural and ecological reserves such as Pirai da Serra, located in the South of Brazil. This essay is organized into three parts. The first part shows some aspects concerning the methodology of the research and discusses about the importance of environmental awareness and environmental education. The second part presents some considerations with regard to the importance of environmental education to preserve and restore natural and cultural heritage. Finally, the last part brings about some reflections concerning the idea of critical environmental education and the defence of natural and cultural heritage.

2. Typifying the methodology of the study and introducing some essential concepts about Environmental Education

Research practice in education, and particularly in environmental education, has adopted a variety of approaches through different theories and methodologies. Distinct perspectives have been used to conceptualise and analyse the development of environmental education practice.

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This essay is framed on bibliographical research. In synthesis, bibliographical research can be understood as a scientific mode to gather data from different theoretical backgrounds. This kind of research is essential since it permits the identification of the status of knowledge. Indeed, it provides opportunities for new contributions about the subject.

In addition, the observation methodology was used as a process which operated from an open system of information. This allowed a significant degree of flexibility in the gathering of general and particular impressions from the fieldwork.

In fact, the use of a flexible design represented an important component of the process. Instead of formal observation, in which the researcher's intention is merely to observe the situation without interfering in the event, this study decided to use participant observation. In the case of this study, participant observation formed a part of a cognitive process in which the researcher could realise and recognise the main aspects of the context.

2.1 Environemtal education to restore and preserve natural and cultural heritage

"If education is the solution, what is the problem?" This enigmatic question, posed by David Orr 2001, raises a challenge to education in contemporary society. There is no doubt that the environment and the associated harmful consequences of human actions represent one of these challenges for education. As a result, the reality of the environmental world has emerged as a complex subject which has to be discussed and interpreted in the educational arena. Nevertheless, the environment and education are not simple concepts; rather, both incorporate distinct notions of the world and involve complex political and social dimensions. Particularly these concepts are more intricate when connected to the idea of environmental preservation.

Environmental problems are the result of the collapse of economic rationality in contemporary society and that an environmental crisis has arisen from a crisis of civilisation (Leff 2001). This implies the recognition that there are some limits to capitalist growth and a need for the construction of a new paradigm of sustainable development.

In fact, despite certain international efforts to reduce environmental problems as well as inequalities and the setting out of guidelines for social and ecological welfare, many people around the world are still living in precarious conditions. Contemporary history has shown that the promise of a different world (greener world) seems to have been overwhelmed by the dominant structures of modern economies. Instead of offering alternatives to people and nature, such as the implementation of strategies to avoid consumption, modern society has been encouraging the exploitation of natural resources and is endorsing distinctly imperial positions in a capitalist society. As an example of this is the growing of cultivated areas of exotic forests (for wood extraction) in opposition to the safeguarding of native forests.

The contradictions this leads to are evident in this study. No doubt, the world has never before witnessed such a range of technological advances within 'the global society'. Rapidly and distinctly these courses of action interfere in the structure of biodiversity as well as in the natural organization of ecosystems and forest landscapes. In addition, many countries have been suffering the consequences of centralised politics of exclusion from 'the global world' in which large sectors of the population have not been allowed access to basic environmental resources in society such as drinkable water.

It is within the complex area that lies between rhetoric and the real dimensions of environmental issues that education has played a role in responding to problematic situations from ecological and social crises. In these circumstances, some specialists have used education as a new discourse to bring about changes of attitudes and behaviour in relation to the natural world. In

this scenario, environmental education is undertaking an important task with regard to ecological sustainability. For instance, Agenda 21 (UNCED 1992) is particularly clear in this regard when it supports the notion that education is an essential prerequisite before one can begin to contribute to these changes to be brought about.

The orientations of education towards the idea of sustainability of the planet and raising consciousness of this matter have become prominent issues for educational principles in the area of environmental education. These principles, which are based on statements from the Tbilisi Conference (UNESCO 1977), envisage environmental education as an important component for the creation of a sustainable environment and a fairer society. In global terms, environmental education which is associated with ideas of sustainability plays a crucial role in dealing with environmental problems and it has been backed up by international educational, political and social discourses from governments and society.

The main goal of the next topic is to endorse the position that promotion of new strategies for fair and consistent education with an emphasis on a critical perspective is particularly important in realising the potential of people to promote environmental actions toward natural and cultural heritage.

3. Environmental Education and the protection of natural and cultural heritage: the case of Piraí da Serra – South of Brazil

Pirai da Serra (*Pirai means Fish River in indigenous name and Serra means Peak in Portuguese*) is located in Parana State, South of Brazil. The area of Pirai da Serra represents an impressive natural and cultural heritage. The place is characterized by canyons, escarpments, grassland vegetation, araucaria forests, fauna and flora diversity, archaeological material (rock art) and vast culture. The cultural tradition of the region come from the beginning of Brazilian colonization and it has a wide range of customs which are expressed in people's habits (e.g. specific dishes, religious events, among others)

In the last decades, despite some efforts to avoid degradation, it is possible to observe a permanent transformation in the landscape in terms of environmental collapse. Some examples of local natural dilapidation are a wide use of land to increase agriculture, development of exotic species of forest (e.g. *pinus* plantation) and forest burning, among other environmental impacts. From the middle of last century it is possible to observe a rapid expansion of industrialization processes nearby the region which, no doubt, affects the local environment. Rapidly, people from community have been experienced these changes in their lives. Particularly, it is possible to points out the scarcity of water and a progressive deterioration of the native landscape.

Considering these circumstances, it is urgent the development of environmental education practices which promote the involvement of the local community in order to prevent full devastation of the place. The local community participation (teachers, students, parents, people from cultural groups, social movements and government, among others) is essential to promote an environmental practice. This kind of practice must be able to deconstruct non-environmental actions and increase the consciousness of people in relation to restoration and preservation of natural and cultural heritage of the area and present sustainable alternative practices.

Sustainability should be understood through a critical approach in intellectual and practical terms, as a counter-hegemonic discourse. This means that sustainability must be seen as a process where people are able to participate in the social and political construction of their environment. In this way, environmental education plays a fundamental role and must go

beyond idealised forms of imposing behaviour and attitudes on others; rather it should incorporate a critical social understanding of nature and environmental problems.

This is what some authors such as Fien 1993 and Huckle 1998 regard as 'education *for* the environment' and what Khan 2004 defines as 'ecopedagogy'. In addition, this is what this essay endorses as being 'critical environmental education' (Schimanski 2005)

It is important to points out that critical environmental education is an essential strategy. In other words, it may provide the basis for changing behaviour to create new strategies to improve environmental conditions, leading to a better quality of life and to equity. Following this, a critical interpretation of social and ecological concerns is indispensable. This implies breaking down traditional attitudes, such as the pretence that superiority can be imposed by a dominant discourse which does not take into account social and cultural differences.

In other words, it is necessary to consider the community as a space for praxis. People should engage with this and consequently it is necessary to create new conditions for social participation at community. To this extent a "new culture of argument" (Myerson & Rydin 1996) linked with critical thinking can be used to usher in a new democratic culture. The establishment of an emancipatory or critical interest (Habermas 1983) can provide people with a new understanding of how to make environmental interpretations of local and global changes. This can be the base on which to create a new "identity and ecological democracy" (Huckle 2001). In other words, environmental education is a form of citizenship education, which may be able to reinforce the ability of people to reflect on and act in society. In this sense, some points are important to reflect about it as follow:

> 1. It is necessary to formulate new initiatives for support, which encourage critical thinking in relation to the natural environment and cultural heritage;
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> 2. It is necessary to encourage a kind of critical thinking, which can lead to a new culture of argument and a new democratic culture in society concerning environmental good practices;
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> 3. It is imperative support the growth of creative and interdisciplinary critical approaches for the protection and enhancement of natural and cultural heritage areas;
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> 4. It is of fundamental importance to clarify that there should be a link between environmental education and citizenship in a political perspective to maximize the human and social potential required in environmental strategies to the defense of nature;
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> 5. Above all, it is essential that community appreciate that there is a connection between environmental education and social justice. This relationship is underpinned by moral and ethical values, can lead to a new way of improving the quality of life for people.

4. Conclusion

Environmental education needs to provide people with the knowledge, understanding and capacity to promote awareness and positive attitudes towards environment. In this sense, one of the main goals of environmental education is focused on the idea of increasing knowledge to understand ecological processes as well as to stimulate people to get involved in actions which can help to overcome environmental challenges.

In relation to the defense of natural and cultural heritage, environmental education can be an important strategy to "give voice to people" from community (Armstrong, Moore, Russell and Schimanski 2009) This means that environmental education can improve what some authors call "the sense of place" (see for instance Lesley P. Curthoys & Brent Cuthbertson 2002) in the community. That is, education plays a fundamental role regarding environmental issues helping people to improve their sense of being part of the environment.

In the case of Pirai da Serra, the development of environmental education practice should be able to create new public and social spheres in which people feel themselves as subjects and not merely objects in its relation to the nature. In practical terms, this means that environmental education is the process of becoming enlightened about environmental issues that can give rise to a more equitable and sustainable society by carrying out concrete actions able to produce good practices in relation to nature.

As a conclusion it is important to asserts that this study regards environmental education as a process of enlightenment of knowledge through a practice engaged with problem-solving and based on participatory actions. In fact, environmental education should go beyond the development of skills and behaviour in issues regarding environmental protection. Protecting nature is an essential matter but it cannot be undertaken in isolation from an environmental ethic concerning political, educational and social change.

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The certification of forest management and its contribution to the rights of workers

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Abstract

The certification of forest management must assure that the wood used in products that are extracted from acceptable environmental standards of forest organization. In addition, forest certification must have compliance with related national and international law. The FSC (Forest Stewardship Council) institutes some criteria to guideline conscientious and responsible forest management. These criteria are grounded by environmental, social, cultural and economical aspects which are essentials to promote a sustainable society. In this sense, this study is framed on some reflections concerning the certification of forest management in Brazil. Particularly it addresses the need of assuring the rights of workers, and compliance with occupational health and safety measures. The main idea is to present some discussions concerning the respect in relation to rights of workers in connection with community participation in the management process to control and prevent labor injuries.

Keywords: Forest Management; labor legislation and certification

1. Introduction

According to the Brazilian Association of Planted Forests (2007), Brazil is one of the sectors that contribute the most to the country's development in the macroeconomic and microeconomic area. However, keeps in its recent history, the daily experience of child workers, workers in poor working conditions, health and semi-slavery, that are disrespectful to the decent work. According to Silva (2000) is the dramatic situation of workers in this sector, extensive working hours, low salaries, the non-compliance with laws, the ignorance from the workers about the risks they are submitted to, and absolute lack of control when it comes to working conditions. Until recently, accidents and occupational diseases from these workes in Brazil were only partially understood by the public opinion, by institutions that have responsibility in the area and by social workers in general. It is in this context that this paper proposes a reflection about the socio-cultural aspects observed in the process of certification of forest management in Brazil, related to the current labor legislation (health and safety standards at work), since under those rules, are the first steps to the garantee of decent working conditions by male and female workers in the forestry sector or outsourced workers, and the relationship with neighboring communities or close to areas of management. The research has its base on literature and documents.

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2. In search of decent work in the Brazilian Forest Sector

The concept of forest management has emerged as a form of control of productive forestry practices, through the recovery in the market for products tha came from responsible forests management. To the FSC, the certification Principles and Criteria to a given Forest Management unit, St (P & C FSC) is applicable to all types of forests (tropical, boreal and temperate) and management types (native or plantation). In this paper, good management means, as Viana (2002, p.20) which refers to "the best management practices applicable to a particular forest management unit, considering its characteristics and sociocultural constraints, environmental and economic and the technical and scientific knowledge existing. "

According to the International Labour Organisation, decent work involves the opportunity to realize a productive work with equitable remuneration, safety at the workplace and social protection for families, better prospects for personal development and social integration, organization and participation in decisions affecting their lives. Considering that in the nineties, Brazil experienced a productive framework for restructuring, with the reduced presence of workers in society and the state with a consequent decrease of social rights.

This problem accompanied by the employment disruption, and the precarious working conditions, such factors contributed to increase the worker´s health injuries. And that was only in 1988 that Brazil was known as a Democratic State of Law according to its Constitution, and that in its Chapter II, about the Social Rights, that rural workers began having the same rights that the urban workers had.

Considering that the understanding of society in recent years, is much more improved about environmental issues, sustainability and current resources for environmental monitoring based on high technologies, have allowed a closer society accompaniment on forest management and their environmental impacts.

According to Busch (2008) it is a challenge for entrepreneurs to show the consumers how these issues have been object of concern. In this sense, the certification process in the forest management appears as an excellent response to the consumer as well, contributing to garantee decent working conditions for workers in this sector.

To certify the management, the FSC uses criteria and principles which support the responsible management in compliance with environmental, socio-cultural and economic aspects. The principles to be observed are ten, however, is the principle number 4 (four) entitled: Community relations and workers' rights. Stipulates that forest management should maintain or enhance long-term social welfare and economic development of forest workers and local communities. As the principles are more evident if there is respect for decent work.

The criteria to be observed and / or evidenced in this principle:

> 1.Job opportunities, training and other services should be given to the inserted or communities or the ones that are adjacent to areas of forest management.

> 2 Forest management should achieve or exceed all applicable laws and / or regulations related to health and safety of their workers and their families.

> 3. Must be guaranteed the rights of workers to organize and voluntarily negotiate with their employers, as outlined in Conventions 87 and 98 of the International Labour Organisation (ILO).

4. The planning and implementation of forest management activities should incorporate the results of social impact assessments. The consultation process with the population and the groups that are directly affected by the manegement must be maintained.

5. The appropriate mechanisms to resolve complaints and provide fair compensation in case of loss or damage that affects the legal and customary rights, the property, the natural resources or livelihoods of local people should be adopted. The necessary actions to avoid such losses or damages must be done.

6. The responsible for the forest management must consider initiatives in the social area field to be included in planning and operations of forest management activities. Must be maintained and confirmed the existence of information and clear opportunity to participate from the local community(ies) that is (are) directly affected for forest management operations, and consider their perspectives on the issues that directly affect their quality of life.

7. There should be mechanisms for dialogue and the resolution of complaints between the worker and the responsible for the forest management unit, including the representation, which is formally recognized by the workers.

8. Workers must pay the minimum consistent with the market average in the region, according to the productive activity that is performed.

9. Should not be used child labor, in violation of the Law, in the forest management unit. The work of the young people, that are in the age of apprentices, is only allowed in non-strenuous activities considered by the authorities and with the guarantee of access to education.

10. The female labor during pregnancy and breastfeeding should be accompanied by preventive measures of risks and dangers that are inherent to the productive activity that is performed.

11. In the hypothesis of substantial changes in the employment framework of forest management unit, the preventive actions to minimize the impacts of layoffs on workers and on the local communities must be taken.

12. The adoption of programs or strategies to flexible the work should not result in harm to the rights lawfully acquired by forestry workers. The person responsible for forest management unit must undertake sustained efforts to minimize the differences between workers and the contractors themselves and avoid the precarious working conditions.

13. The community's access to management and non-predatory collection of forest products derived from wood or not, is allowed and regulated in the places where such access has existed for legal or historical reasons, by formal permission granted by the responsible from the forest management unit, in compliance with the property rights.

These thirteen criteria, based on indicators, provide an analysis of the reality of the company being certified. This way, we observe that in Brazil, the companies that are certificated appropriate themselves to the principles demands. Particularly in relation to the employees; they guarantee the proper registration, with wages in accordance with labor agreements; adapt their structures to provide safe working conditions with a team consisting of doctors and labor engineers, and in case of accidents remains the logistic structure suitable for the service.

Regarding the hiring workforce, companies rely on public programs that intermediate the workforce, prioritizing the local recruitment. In small companies without certification, it is common the variation of the workforce, given to the low qualification and education, that is a commodious situation for the employers from small businesses related to the recruitment process, therefore, with the structural surplus of the workforce, many are those who expect a job oppening, what reflects in the decrease of salaries. In times of unemployment prevailing in the country in the nineties many workers were subjected to work in any conditions and for any salary.

When necessary the larger companies invest their own resources in training, and other smaller, have resources of public policy work. As Silva (2000) in research conducted in the south region of the country shows that the limited supply of skilled workforce is one of the intrinsic factors to this sector, and the average in years of schooling from the workers are five years.

A worker in the forestry sector is mostly male, so women in this sector are more in the planting of seedlings in nurseries
Tem seus direitos a maternidade e a infância assegurada pelas políticas públicas de saúde. They have their rights to maternity and childhood assured by public health policies. As for the presence of the children´s and adolescent´s work in this sector, Brazil since the late eighties, put on his political force to eradicate child labor and confrontation, and one of the first activities to be tackled was the work of children in the coal production in which htere were a high number of working children.

Dealing with situations of child labor has been a subject of discussion between civil society and state, with the definition of several enforcement actions by the government, improving education policy and income transfer programs that are articulated with social protection of the poor families.

3.Conclusion

According to FSC the certification produces benefits, that are: better prices, increasing of the productivity, the improving of the image; the guarantee of origin, the market recognition, social responsibility, contribution to the cause.And, for workers there is an improvement in security conditions at work, in working conditions. Since the indicators used to have certification have as a reference the international conventions.

O Fórum Mundial subordinado ao tema 'Trabalho Digno para uma Globalização Justa, iniciativa conjunta da OIT e da Presidência Portuguesa da União Europeia. Realizado em 2007, propõe uma meta simples: criar as condições para que mulheres e homens de todo o mundo para ter acesso a um trabalho digno e produtivo, em condições de liberdade, equidade, segurança e dignidade. Como imperativo ético e de cidadania, e também como base para um desenvolvimento sustentável.

To ensure the management sets its principles and criteria for certficação on a tripod that supports the responsible care in compliance with environmental, socio-cultural and economic aspects. Therefore, this tripod is paved in sustainability and without decent work there is no economic or environmental sustainability

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Role of non-wood forest products for sustainable development of rural communities in countries with a transition: Ukraine as a case study

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Abstract

Sustainable use of non-wood forest products (NWFPs) is a component of sustainable forest management. NWFPs provide important use and non-use values to stakeholders in rural landscapes. The aim of this study was to analyse the policies with relevance for NWFP in order to define the potential contribution of these forest resources to rural development in countries in transition from socialistic planned to market economy, like Ukraine. We analysed national and international policy documents, national and regional management regulations concerning the use of NWFPs and reviewed relevant literature. We concluded that there were a need to investigate the role of NWFP in countries with different economic and social-cultural conditions and systems of governance of natural resources.

Keywords: non-wood forest products, sustainable forest management, countries in transition, Ukraine

1. Introduction

Globally forests provide wood resources and a large variety of non-wood goods as a resource base for livelihoods and development. Non-wood forest products (NWFPs) are defined as goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests (Chandrasekharan 1995). Use of NWFPs has a long history as an important component of the livelihoods of people living in and in the vicinity of forest and woodland landscapes. NWFPs were, in fact, one of the first sources of food, medicine, fibre, and other substances that have sustained local communities since the first human settlements (Ryabchuk 1996, Bradley and Bennett 2002). Estimates indicate that 80% of the population in developing countries in the world use NWFPs to meet some of their nutritional needs (Janse and Ottitsch 2005). In addition to food forests also provide herbal medicine which is vital to poor people that are not a part of a national healthcare system (Chandrasekharan 1995, Bradley and Bennett 2002; Ryabchuk 1996; Malyk 2006).

NWFPs have attracted considerable interest as an important component of sustainable forest management (SFM) policies (Elbakidze et al 2007, Elbakidze and Angelstam 2007, MCPFE 1993, Siry et al 2005), and in different implementation initiatives and projects towards sustainable management of forest landscapes in many countries (Varma et al 2000). There have been many efforts to complement industrial timber production with an aim to increase the multiple values of forests for users, owners and local communities that depend on them.

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However, the role of NWFP in the livelihoods of local communities in different contexts has not been studied in detail. In particular there is a lack of comparative studies which show the contribution of NWFPs in rural development in countries with different economic and social-cultural conditions as well as systems of nature resource governance. Such knowledge is needed for policy-makers and organisations involved in rural and economic development, which put their efforts to promote new modes of forest use replacing or disrupting existing traditional livelihood strategies (Hyde and Köhlin 2000).

Following the break-up of the Soviet Union, Ukraine re-appeared as an independent new state in 1991. To promote sustainability on national as well as regional and local levels Ukraine has joined the process of developing sustainable forest management principles. In Ukraine these are oriented towards sustainable yield forestry, maintenance of forest biodiversity and socio-cultural values (Forest Code of Ukraine 2006). The strategic objectives of the national forest policy are related to those enumerated in international agreements of sustainable development (UNCED 1992), sustainable use and protection of forests in Europe (MCPFE 1995, MCPFE 2003, MCPFE 2007). Ukraine has signed the 17 resolutions of the Ministerial Conference on Protection of Forests in Europe.

The end of Soviet central planning caused a decline of jobs in industry including forestry and agriculture (Nordberg, 2007). In many forest and woodland regions of Ukraine local people therefore have had to go back to traditional land use practises due to difficult economic conditions (Elbakidze and Angelstam, 2007). Different NWFPs have thus become a part of the social fabric and livelihood (Bihun, 2005) in many rural areas. There is now often conflict between increase of harvested timber and the emerging sustained yield forestry and vital interests of local people in the sustainable production of NWFP.

The aim of this study was to analyse the policies with relevance for NWFP in order to define the potential contribution of these forest resources to rural development in countries with different economic and social-cultural conditions and systems of governance and government of natural resources. We analysed national and international policy documents concerning sustainable forest management, national and regional management regulations related to the use of NWFPs and reviewed relevant literature.

As the next steps we will interview local forest stakeholders in villages located in our case study areas in Ukraine, study the reasons, places and methods of NWFPs collection, amount of harvested NWFPs by different groups of forest stakeholders, existing practices of NWFP utilization, including traditional one.

2. Methodology

First we analysed national forest policy documents, management regulations concerning use of forest resources in Ukraine. A comprehensive literature review was done about NWFPs, management of forest resources and rural development.

3. Result

Sustainable use of non-wood forest products as a component of sustainable forest management policies
Policies at global, international, EU and national levels clearly pronounce the importance of NWFP. Indeed, NWFP as a relevant attribute to rural development and natural resource conservation have increased globally (Janse and Ottitsch, 2005, Chandrasekharan 1995, Ticktin

2004, Elbakidze and Angelstam 2009). At the United Nations Conference on Environment and Development (UNCED) in 1992 in Rio de Janeiro it was declared that the promotion of and use of non-wood forest products is an important part of sustainable development (UNCED, 1992). SFM is supported by different processes and organizations, taking into account the specific forest conditions (The Montréal Process 2007, McDonalda and Lane 2004, Rametsteiner and Mayer 2004) The Montreal Process (MP) developed SFM principles for the temperate and boreal forests of non-European countries (The Montréal Process 2007).

Sustainable forest management (SFM), an important part of sustainable development as a societal process at the Pan-European level, is described as "the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems" in the Helsinki Resolution which is the European level process to develop the SFM concept (MCPFE 1993).

Criteria and indicators for SFM in European counties were developed by the Ministerial Conferences on Protection of Forest in Europe (MCPFE 1993, MCPFE 1998a, MCPFE 1998b, McDonalda and Lane 2004). The European criteria and indicators provide guidelines for SFM at the national and sub-national levels, and is an attempt to operationalise and complement the existing definition of SFM (Lazdinis, 2000).

Management of NWFPs is a component of SFM according to international policy documents, such as, for example, MCPFE resolutions. It is declared in the Helsinki resolution (MCPFE 1993) that the interest of and demand for non-wood forest products has been increasing and encouraged as a part of sustainable management of forests (MCPFE 1993). It also promotes the cooperation of the forestry sector in developed countries with countries with economic in transition (MCPFE 1993).

According to the Resolution L2 (MCPFE 1998a), criteria 3 is to maintain and encourage productive functions of forests, which include both wood and non-wood products. The descriptive indicators of the criteria 3 require the development of management plans for NWFP (MCPFE 1998a). At the 4th Ministerial conference in Vienna the criteria and indicators were improved with the aim to increase benefits of rural livelihoods from forests (MCPFE 2003, Rametsteiner and Mayer 2004, Wang 2004) and included values and quantity of non-wood goods from forests and other wooded lands (Rametsteiner and Mayer 2004). Vienna Resolution 2 highlighted the importance of the promoting the use of wood and NWFPs (MCPFE 2003).

Analysis of national forest policy documents and management regulations
Ukraine has recently joined the process of developing national SFM principles, which have been adopted into the national legislation and forest programs (Forestry code of Ukraine 2006, Lisy Ukrainy, 2009). The main trend of the forest legislation development has been to provide a balance between the conservation of forest ecosystems, and sustainable multi-purpose use of forests (Angelstam et al. 2009). The outcomes of forest sector reformation, which began in 1991, were new Forest Code adaptation in 2006 and elaboration of the State Program "Forests of Ukraine during 2010-2015" in 2009. In Ukraine forest management is conducted according to the Forest Code and within the framework defined by the State Programme "Forest of Ukraine in 2010-2015".

The Forestry Code of Ukraine (2006) consists of 110 articles, of which four include information about NWFPs and their management, these are called secondary forest products. There is, however, neither an explanation of what kinds of non-wood products that are included into this category, nor how they should be managed (Forestry Code of Ukraine 2006). The direct use of

NWFP includes harvesting of hay, grazing, picking fruits, nuts, mushrooms, berries and medical herb. The collection of NWFP for private needs in state and community forests is free to everyone. Private forests are owned by private persons or companies, and may occupy up to 5 ha. In private forest local people have to secure a permit for harvesting of NWFPs from the owner (Forestry Code of Ukraine, 2006). Collection of NWFPs with the aim to sell them is called "special use of NWFPs". Commercial collection of NWFPs by a private person or a company requires a special permit and the collector has to pay a fee to the state or the forest owner.

The State program "Forests of Ukraine during 2010-2015" is based on the MCPFE criteria and indicators, and defines the guidelines for forest management towards SFM. Collection of secondary forest products (NWFPs) in managed forests should be done without harming forest ecosystems (Cabinet Ministriv of Ukraine 1996). Medical herbs and mushrooms which are listed in the Red Data Book of Ukraine (Cabinet Ministriv of Ukraine 1996, Red Data Book of Ukraine, 1996) are not allowed to harvest, not even parts of the plants or mushrooms. There is a list of species that are endangered and should be collected under strict control, this include a special ticket or permit that all collectors has to buy. Harvesting of wild berries is allowed if the ground covers of berries plant are more than 10%, the cover of medical herbs are more than 5% of the ground cover in the forest (Cabinet Ministriv of Ukraine, 1996). The requirements concerning harvesting of medical herbs also include regulations about the parts of the herbs which could be collected, for example, roots should be harvested less than 10%. For leaves and stands of the herb less than 40% of the biological productivity in the forest could be harvested. The forestry enterprises are obliged to protect forest wood and non-wood resources from illegal or harmful consumption by people.

In protected forests there are many restrictions regarding harvesting of NWFPs. There are certain limitations on harvesting of NWFPs in other types of protected areas. For example, in a national nature park the use of NWFPs is prohibited in the management zone of strict nature protection, however, it is allowed in the management zones where tourist faculties are located and where local people conduct their land use activities. Collection is always prohibited in strict protected reserves (Law of Ukraine on Nature Protected Areas in Ukraine, 1992).

4. Discussion

The economic importance of the forest and forestry wood and non-wood products is significant, especially in rural areas in the north and west of Ukraine (Nordberg, 2007). Commercialisation of NWFPs has a potential to contribute to the livelihoods of rural people in Ukraine. Value-added processing of NWFPs could in addition contribute to household income.

Thus, sustainable management of NWFP is potentially important to support rural development (MCPFE, 1998). NWFP and their value-added processing have attracted considerable interest as a component of different development projects in recent years due to their potential to support rural livelihoods (Angelstam et al. 2009, Angelstam and Elbakidze 2009). At the same time, in some European regions, NWFPs and services provide more revenue than wood sales (MCPFE 2007, Arnold and Pe´rez 2001). However, there are many challenges to balance production of wood as is economically the most important product of forests and the increasing demand for NWFPs from European forests (MCPFE, 2007).

To conclude, there is a need to investigate the role of NWFP in countries with different economic and social-cultural conditions and systems of governance of natural resources. The next step in our studies of NWFP will be to interview local forest stakeholders in villages located in case studies in Ukraine and Sweden. Key topics that will be studied include the

reasons, places/habitats and methods of NWFPs collection, amount of harvested NWFPs by different groups of forest stakeholders, existing practices of NWFP utilization, including traditional one.

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The regional analysis of forest management risks
(by the example of Russian northern areas)

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Abstract

The northern taiga areas of Russia are rich of coniferous and softwood forests, but a number of adverse natural-climatic and economic factors makes proper forest management difficult. Additional efforts and measures are required to mitigate the impact of the harsh climatic conditions on the forestry activities. The analysis of natural hazards and risks in forest management, which would also take into account related social and economic consequences, is a prerequisite condition for sustainable usage and preservation of forest potential in the northern territories of Russia. In order to assess and estimate the risks in forest management, there was conducted an integrated analysis based on weighted summation of such quantitative indices as the amount of forest resources, ecological potential of woods, the degree of natural-climatic hazards and other factors. Based on the calculation of the forest resource balance, the quantitative estimation of valuable woods loss was made.

Keywords: forest management risks, natural-climatic hazards, economic consequences.

1. Introduction

The efficiency analysis of forest management practices usually includes the assessment of risks caused by environmental and climatic conditions of the territory. The risk level also largely depends on economic and geographical situation in the region: natural resource potential, remoteness from woodworking centers, development of roads and transportation network, availability of qualified manpower. Environmental conditions are a major factor determining how fast or slow the territories are settled and cultivated, while social and economic situation mainly influences the scale, forms and methods of using natural resources and economic opportunities based on them.

The risks in *forest management* can be defined as the probability of full or partial destruction of the region's forest resource base resulting in considerable economic damage and caused both by the action of natural processes and the influence of anthropogenic factors. Research in this sphere is especially topical for those regions where full-scale economic activity and sustainable forest exploitation are restrained by adverse environmental and climatic conditions, despite of the considerable natural resource potential.

In this respect, the Tomsk region (Tomsk oblast, as an administrative unit) presents a classic example of a northern Russian territory – with intensive usage of forest resources and a high forest resource potential. The region possesses considerable forest resources – the forest fund lands occupy 90.5% of the territory; of them the forest covered lands make up 67.3%. Total amount of timber reserves of the territory is 2820.88 mln. m^3. Over 70% of the forest fund is formed by commercial forest, about 30% – by protected forest, of which approximately 6% belong to specially protected natural territories. Approximately a half of the commercial forest consists of coniferous woods, most valuable tree species here being pine-tree, fur-tree, silver fir and cedar (Forest Plan 2008).

Despite such a considerable forest vegetation potential, the share of forestry products in the total regional product structure accounts only for 6%. In many respects this is due to economic reasons – general recession in the development of forest industry, distant location of logging sites, deterioration of the major forest fund and other reasons (State of environment 2009).

In addition to economic reasons, severe environmental and climatic conditions play there own restraining role: low winter temperatures, great weather variability, large and sudden changes of daily and annual temperatures, severe hydrological situation. All these factors aggravate the risks of forest exploitation activities in the Tomsk region territory; creation of forestry-based infrastructure requires involving additional resources in order to minimize the consequences of adverse weather conditions and better adapt to them. Thus, the analysis of natural hazards and risks influencing the forest exploitation practices, which would take into account social and economic consequences connected with them, is an important and essential prerequisite condition for sustainable usage and preservation of the forest resources of the territory.

2. Methodology

This paper presents the analysis of risks in the sphere of forest management, considering both environmental and economic parameters and based on the complex analysis of environmental and climatic hazards, as well as resource and ecological potential. For the analysis of the study area the comparative-geographical method was employed. To determine the risks connected with adverse environmental conditions, we used the methods of qualitative factor analysis and ecologo-economic balance of the territory. Also, a considerable amount of reference statistical and cartographic material was used in the research.

Climatic and hydrological conditions bearing risks for the forest exploitation in the Tomsk region can be divided into two classes: the risks connected with plantations loss and the risks connected with forestry works management. The second group of risks associated with geographical location and natural properties of the territory can be divided into hydrological and climatic – these risks are mostly indirect, but their socio-economic consequences are no less important.

To the date, the first group of risks, those leading to the plantations loss, has been studied to more detail. The greatest risk in the forest exploitation is connected with forest fires, which are primarily of anthropogenic origin. Also, forest diseases and injurious insects have a large impact. The area of plantings lost for these reasons varies considerably by years and different forestry sites. The loss amount mostly depends on weather conditions of the current year and, in case of harmful insects, also of previous years. Besides, 15% of total risks are connected with hurricane winds and 13% – with forest fires caused by thunderstorms. At this, the main damage falls onto economic forests of natural origin, where the impact of all adverse factors is revealed most vividly (Nevidimova and Melnik and Volkova 2009).

For the analysis of ecological and forest resource potential different types of plantings were chosen, based on the statistical data for the period of 1991-2006 and the data received from 21 weather forecast stations located in different climatic areas of the territory.

The assessment of ecological potential included such stratum parameters of dominant species as productivity class, average volume density and average annual growth rate. The tree species types and plantations proportion in the forested area have also been taken into account in the calculation. Ecological potential can be defined as a set of useful properties of planting communities, needed to perform their basic environmental, landscape-protecting, landscape-stabilizing and economico-ecological functions.

To practically assess the impact of each of these factors on the ecological potential, their heterogeneous quantitative parameters were converted into scores. Ecological potential (EP) was calculated by the formula:

$$EP = 2/3 \sum_{i=1}^{n} S_i (B_i + P_i + Z_i) + 1/3 \sum_{j=1}^{k} S_j (B_j + P_j + Z_j) \tag{1},$$

where B - average productivity class; P - average volume density, scores; Z - current growth rate, scores; S - percentage of each species in the forested area. The first component characterizes the ecological potential of coniferous species, the second one – that of softwood species. The ratio of deciduous to coniferous woods is one to three, showing a characteristic share of each species in the Tomsk region. The territorial distribution of the estimated ecological potential for the Tomsk region is shown in the figure below.

The forest resource potential is understood as a set of useful properties of forest communities allowing them to provide natural raw materials, food and feed resources, to perform industrial and energy supply functions for the economy. When assessing the forest resource potential, the following indices were considered: average productivity class, average growing stock, average age and species composition of the forest stand.

By analogy with the assessment of ecological potential, the forest resource potential (RP) was calculated based on the growth rate tables and using the following formula:

$$RP = 2/3 \sum_{i=1}^{n} S_i (B_i + M_i + A_i) + 1/3 \sum_{j=1}^{k} S_j (B_j + M_j + A_j) \tag{2},$$

where B - average productivity class, scores; M - indicator of growing stock, scores; A - average age, scores; S - percentage of each tree species in the forested area. The first component characterizes the forest resource potential of coniferous species, and the second one – that of softwood species.

3. Result

Ecological potential and resource potential of forests were assessed for all major tree species present in the Tomsk region. The table 1 shows the assessment of ecological potential and forest resource potential for different forestry sites, based on the example of a pine tree, as one of the most common tree species in the Tomsk region. Based on the tables of growth rates and other quantitative characteristics, all average stratum parameters used in the analysis were assigned a score of 1 to 5 (see Table 2).

Integrated risk analysis in forest management largely depends on the resource and ecological potential of forests and the impact of climatic factors most dangerous to forests – forest fires, winds and thunderstorms, injurious insects, forest diseases.

The risks of forest fires, winds and thunderstorms, pests and forest diseases were assessed as a functional dependence between the level of each type of risks and the level of resource and ecological potentials of the forests.

Based on the conducted research and approbation of the described approach, there was performed territorial differentiation and quantification of the Tomsk region by the risk degree in forest management (see Fig. 1).

4. Discussion

The research has shown that both the nature and the degree of risks in forest management are determined by climatic and forest growing conditions in the Tomsk region. Negative environmental factors have a large impact, directly affecting the development of forest industry in the region. However, geographical distribution of forest exploitation activities within the Tomsk region itself does not largely depend on the climatic conditions, being mainly determined by the resource potential of forests and transport accessibility of the area. Thus, the main logging activities in the territory of Tomsk region are conducted in the areas with the highest degree of risks and adverse factors in forest exploitation, being drawn by a high timber resource potential in these areas.

In addition to the general strategy for sustainable usage of the region's natural resources based on the analysis of environmental risks, we have proposed a system of limitations and regulations for forest management practices. To increase the adaptive capacity of forest resources, the impact of natural risks should be mitigated by taking certain measures. For northern territories, the following key measures for better adaptation to the major risk factors are recommended: reduction of deforestation, restoration of cultivated peatlands, tree species improvement with the purpose to increase the biomass productivity and ecological functions of forests, creation of mineralized strips, periodic tree cuttings for better forest quality and thinning, preventive controlled fires, cleaning the forest from rubbish, creation of prophylactic barriers against the fire, building roads for fire fighting purposes, extermination of stem pests, etc.

The described above approach can be used in other regions as well, taking into account specific local environmental conditions.

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Table 1: The assessment of ecological potential and forest resource potential of a pine tree for different forestry sites

The forestry sites	Age	Age, score	Productivity class	Productivity class, score	An average volume density	An average volume density, score	Growing stock	Growing stock, score	Current growth rate	Current growth rate, score	Percentage of a pine tree in the forested	The assessment of ecological potential	The assessment resource potential of forests
Aleksandrovskoe	138	4	4	2	0,53	3	221	4	1,2	2	0,39	2,76	3,95
Asinovskoe	85	3	3,8	3	0,68	5	146	2	2,1	3	0,21	2,36	1,72
Bakcharskoe	112	5	5,7	1	0,55	3	95	1	0,9	1	0,26	1,29	1,81
Verhneketskoe	126	4	4,3	2	0,61	5	133	2	1,4	2	0,45	4,05	3,60
Kargasokskoe	122	4	4,9	2	0,56	3	126	2	1,2	2	0,37	2,62	3,00
Vasuganskoe	133	4	5,4	1	0,55	3	114	2	0,9	1	0,26	1,28	1,79
Kolpashevskoe	112	5	5,1	1	0,56	3	103	2	1,1	2	0,32	1,94	2,58
Kriivosheinskoe	107	5	4,9	2	0,61	5	120	2	1,4	2	0,23	2,11	2,11
Molchanovskoe	110	5	4,7	2	0,58	3	116	2	1,5	2	0,35	2,43	3,12
Kedrovskoe	118	5	5,4	1	0,54	3	105	2	0,9	1	0,21	1,06	1,70
Parabelskoe	110	5	4,7	2	0,55	3	117	2	1,2	2	0,35	2,44	3,14
Pervomaiskoe	84	3	3,3	3	0,66	5	169	3	2,6	3	0,09	0,96	0,79
Teguldetskoe	120	5	4,7	2	0,6	5	126	2	1,3	2	0,07	0,65	0,65
Chainskoe	123	4	5,8	1	0,49	3	86	1	0,7	1	0,13	0,66	0,79
Shegarskoe	105	5	4,6	2	0,58	3	112	2	1,5	2	0,14	0,96	1,23
Zuryanskoe	80	2	1,8	5	0,72	5	231	4	3,5	5	0,04	0,58	0,43
Timiryazevskoe	84	3	2,4	4	0,74	5	219	4	2,9	4	0,34	4,44	3,76
Tomskoe	77	2	1,4	5	0,73	5	248	4	3,7	5	0,04	0,54	0,39

Table 2: The scale of average stratum parameters in a scores based on progress of growth of a pine tree

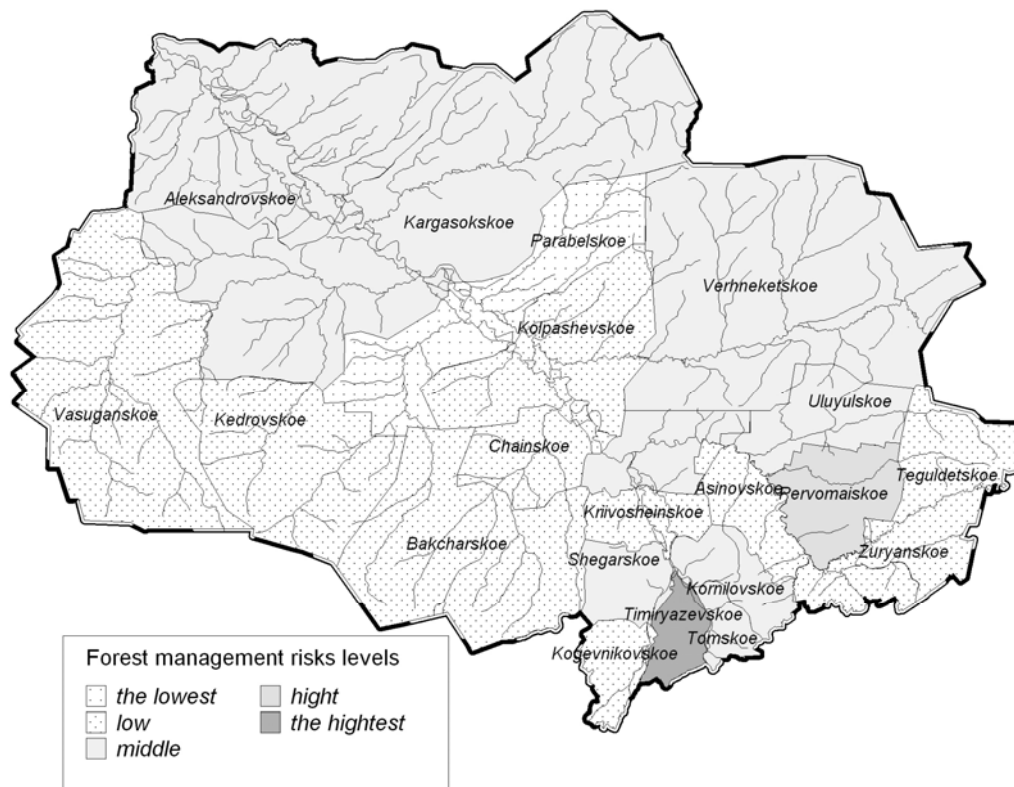| Productivity class	Score	Age	Score	An average volume density	Score	Indicator of growing stock	Score	Current growth rate	Score
1-2	5	101-121	5	0,6-0,79	5	more 250	5	more 3,3	5
2-3	4	121-141	4	0,8-1	4	200-249	4	2,5 -3,2	4
3-4	3	81-101	3	0,4-0,59	3	150-199	3	2-2,4	3
4-5	2	61-81	2	0,2-0,39	2	100-149	2	1-1,9	2
more 5	1	41-61	1	0,1-0,19	1	less 100	1	less 1	1

Figure 1: The risks in forest management in the Tomsk region

Section 8
Urban forestry in changing regions

Biodiversity and recreational values in urban participatory forest planning in Finland

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Abstract

In Finland most of the urban green areas are forests with indigenous understorey vegetation. Urban forests are often located near residential areas, and they are actively used for outdoor recreation. Municipalities own most of these forests in Finland. The aim of this study was to gain overall picture and to discover the main development needs of planning and managing municipality owned urban forest.

Most of the municipalities have inventoried the biodiversity of their forests, and used lighter management methods than for commercial forests. Participatory planning has been commonly used for taking forest users' opinions into account and for integrating multiple values. Multi-functional forest planning, multi-criteria decision analysis and advanced decision-support tools are still rather new approaches in the field of urban forestry. However, these modern methods could be useful for integrating multiple values into planning process and thus to improve the quality of urban forest planning.

Keywords: municipally owned urban forest, participatory planning, biodiversity, recreation

1. Introduction

In Finland about 80 % of urban green areas are forests. According to Finnish law, citizens are allowed to use forests for recreation freely, and therefore outdoor recreation is common particularly in forests that are located near residential areas. In this article we define urban forests as forests with indigenous understorey vegetation. Thus, they do not include gardens, parks and street trees.

Urban forestry has been defined on an European level as "planning, design, establishment and management of trees and forest stands with amenity values, situated in or near urban areas" (Forrest et al. 1999). In fact, urban forests provide multiple values for inhabitants. Therefore recreation, aesthetics and biodiversity have to be taken seriously into consideration when planning and managing these forests.

Municipalities own most of the urban forests in Finland. Participatory planning has been used for urban forest planning in municipalities since 1990's (Löfström 1990, 1996, 2001). The purpose of the participatory planning is to gather information, wishes and preferences from local inhabitants and other users of urban forests to different planning processes that concern the future use of these forests. In its best, this kind of approach gives people an actual opportunity to influence the way the urban forests are managed in their surroundings. Participatory planning

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can also be used to solve local problems and even conflicts (Löfström 2006, Löfström etc 2007, 2008a, 2000b, Mikkola etc 2008).

The aim of the study was to gain an overall picture of the planning and management of municipally owned urban forests and to discover together with the urban practitioners the main development needs of planning processes. We studied especially if multiple values, e.g. recreation and biodiversity and forest users' opinions were taken into account. Another aim was to study the applicability of multi-criteria decision analysis and advanced decision-support tools to urban forest planning.

The aim of our case study in Puijo, located in the city of Kuopio, was to develop optimal participatory planning process and to investigate environmental values, views and opinions of citizens concerning forest management in Puijo.

2. Methodology

The research methods used were mail surveys and interviews of urban forest planners, working groups and seminars involving forest planners and other stakeholders as well as analysis and follow-up of ongoing municipal forest management planning processes. This article consists of results of several studies which have been carried out during 2005-2009.

In the recent Puijo planning process, the opinions of local people were collected with different methods. The data were collected in 2009 in the surrounding housing areas of Puijo forest through both mail survey and Internet survey during the participatory forest planning project. The mail survey was sent to 2000 inhabitants and about 25 % of them responded to the inquiry.

3. Result

The majority of the municipalities used lighter and a wider range of forest management methods for recreational forests than are generally in use in commercial forests. In recreational forests nature-oriented forest management methods were preferred. According to municipalities' view old forest stands, broad-leaved trees, and natural regeneration increase biodiversity, aesthetic and recreational values. However, municipalities have received also negative feedback from forest users when they have left decaying trees valuable for biodiversity into urban forests.

Conflicts arising from enhancing both the biodiversity and the recreational use of forests may partly be due to the lack of knowledge. For example decaying wood has been collected for fire wood. Many forest users preferred forests where walking and running is easy, which indicates that decaying trees should be removed. In addition, safety of recreational forests is important for municipalities, and that has been one reason for removing standing dying trees. A solution might be to leave decaying trees into clusters that are not located near pathways.

Municipalities are interested in improving forest biodiversity in the recreational forests they own. In their forests, many municipalities have actively inventoried the occurrence of ecologically valuable habitats and features important for, e.g. threatened and endangered species. However, municipalities expect more instructions and training on how to protect biodiversity in practice in their forests. They consider that financial incentives are also important for promoting biodiversity Compensation should be based on diminished returns and raised costs for forest management due to e.g. habitat restoration.

Today, more than half of the municipalities use participatory planning for their forests. There are various approaches for participatory planning. Municipalities arrange meetings for the general public, invite inhabitants and stakeholders to take part in planning groups, or inquire the expectations and wishes of inhabitants by using questionnaires. The use of the Internet as a means of interaction has also increased. Some municipalities were not very satisfied with the achievements gained with public participation. One of the practical problems was the integration of various qualitative feedback truly into forest planning -the question is how to combine the different wishes of users and owners in the actual planning process. In addition clear objectives for public participation were often lacking.

In Puijo's case the opinions of the users of Puijo and citizens living near the area were studied in the beginning of forest planning process and opinions were well taken into account e.g. in the creation of the plan alternatives. Citizens had different views concerning management methods that could be applicable to Puijo forest. Some citizens wanted more intensive management in future and accepted even clear cuttings in Puijo, although quite many of the citizens perceived most of all biodiversity and untouched Puijo forest in future. The study showed that many citizens had emotional relationship to Puijo and this makes the attitudes and opinions towards forest management stronger.

The study results also indicate that most municipalities do not have clear objectives for planning and managing urban forests. Most of the municipalities had a management plan for their forests. In some municipalities, these plans covered only commercial forests. However, there was considerable variation in the planning standards and practices. In most cases, alternative forest plans and management schedules were missing. Roughly one fifth of the municipalities have drawn up a strategic urban forest plan for their forests, setting down principles for planning and management for the next ten years.

4. Discussion

Nature-oriented forest management was preferred more in municipally owned recreational forests than in commercial forests. In fact, since the 1980's, there has been significant shift in urban forest management practice towards the consideration of forest aesthetics, recreation and biodiversity (Löfström 1990). The similar trend has occurred also in the management of urban forests in the other Nordic countries (Gundersen et al. 2005).

Nature-oriented forest management was regarded as a way to increase both ecological and aesthetic values. However, there were some contradictions between the enhancement of recreational use and the biodiversity of the forests. Participatory planning is a rather new tool for integrating aesthetic and ecological values for the management of urban forests. The use of this method for urban forest planning in municipalities has increased clearly: in the year 2006 it was three times more common than in 2000 (Löfström 2001, 2006). Thus, the participatory planning of municipally owned urban forests has become almost a rule in recent years in Finland. Also a clear strategic viewpoint for owning forests is becoming more widespread. In the year 2000, only 6 % of municipalities had already completed a strategic urban forest plan for their forests, whereas the percentage in 2006 was about 20.

Municipalities had actively inventoried biodiversity values of urban forests and involved local inhabitants and stakeholders into forest planning processes. However, the practical problems were e.g. the integration of various qualitative data into forest planning process and the lack of objectives for planning and management of forests and participation. These problems were partly due to insufficient resources and a lack of forest practitioners in municipalities.

Participatory planning of Puijo forest was a challenging process when trying to integrate a range of different values into the management and to cope with the strong emotions, opinions and expectations of the citizens. Multiple values, for example recreation, aesthetics and biodiversity have to be taken into consideration when managing Puijo forest in future.

Multi-functional forest planning, multi-criteria decision analysis and advanced decision-support tools are rather new approaches in the field of urban forestry. However, this study showed that these modern methods could be useful tools for integrating multiple values – such as recreational, ecologic, cultural, aesthetic values- into planning process and thus to improve the quality of urban forest planning.

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Urban tree inventory and socio-economic aspects of three villages of Ponta Grossa, PR

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Abstract

This study aimed at an analysis of urban tree road in villages Esmeralda, Jardim Carvalho and Vilela, Bairro Jardim Carvalho in Ponta Grossa, identifying the percentage of native and exotic species and also relate to afforestation with the socio-economic aspects of the local population. It also seeks to provide subsidies to the municipal government for the development of an afforestation plan. Measurements were taken of the sidewalks, as well as analysis of possible conflicts with the space that is. About individual trees, 27% are native species and 73% exotic, and the species *Lagerstroemia indica* L. (extremosa) the species that stood out with 18%. This result demonstrates the trend in urban areas the prevalence of exotic species and the weak participation of the green element in the urban landscape. Were identified conflicts with urban facilities highlighting and the need for a correct and efficient management.

Key-words: Urban Afforestation, Exotic, Native

1. Introduction

The addition of trees to the ecosystem elements anthropogenically modified, typical of the environment of cities (Kulchetsck, 2006), brings countless benefits. Mascaró and Mascaró (2002) propose, therefore, trees in cities, highlighting the important role that vegetation is as soothing urban pollution, in addition to environmental, energy and landscape. Soon, vegetation, justified also by chemical factors, physical, ecological and psychological, should be considered in the order of the priorities of urban planning. Search is thus a return to lost balance and a significant improvement in quality of life.

Factors that should be considered in urban trees are many and can be highlighted: the urban environment, characterized in terms of climate, soils, topography, the physical space available in relation to the width of streets and sidewalks, land clearance, the height the buildings and the presence of electrical cords air, water pipe, sewer, storm sewers, telephone network, the characteristics of the species to be used, in regard to climatic adaptability, resistance to pests and diseases, tolerance to pollution, lack of principles toxic or allergenic, and phenological characteristics (shape, size, root, flowering, fruiting, etc.) and morphological characteristics. Examined the issue of ecological adaptation (acclimatization, naturalization, housing) should be alert to the readiness of the city for the trees, not introducing the species to be random. (Urban Tree, 2004; Sampaio, 2006; Serafim, 2007).

This work is part of a larger project that aims to inventory all city trees, providing support to the government to implement public policies related to this topic.

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This research aims to analyze the current context of the afforestation of public roads from villages Esmeralda, Jardim Carvalho and Vilela in Ponta Grossa, identifying native and exotic species present, and also examine the afforestation as a reflection of the socio- economic aspects of population.

2. Characterization of study area

Ponta Grossa, located under the average elevation of 975 meters, is included in the Second Paraná Plateau in the east-central region of Parana State, being an important road and rail junction of the state. (IBGE, 2008).

The Jardim Carvalho is located in the northeast of the city and houses within its limits thirteen villages. Were chosen as the spatial area of the district three villages, namely: Esmeralda, Jardim Carvalho and Vilela. We opted for these three towns they are demographically more concentrated and have vast socio-economic disparities, and were the closest to the downtown area.

The three villages comprising 11 census tracts, which total, according to IBGE (2000), 6971 inhabitants, with 2007 inhabitants in the village Jardim Carvalho, 602 in the village Esmeralda and 4362 in Vilela.

As one of the objectives of the research was to investigate the relationship of urban environmental quality (through the indicator of urban forestry) with socioeconomic indices, data from the 2000 census were prevalent for the analysis. We selected some variables that characterize the people responsible for permanent private homes - such as education and income - and to those which have stressed the social inequality between the villages Esmeralda / Jardim Carvalho and Vilela.

Looking at Figure 1 it is noted that the rate of people with lower educational level is higher in Vilela, and 2% of the illiterate population, while in villages Esmeralda and Jardim Carvalho that number drops to 0.3 and 0.2, respectively . The variable 'Course highest attended - College' was the one that showed the difference between the two groups this census: Jardim Carvalho and Esmeralda has more than twice as many people with this level of education compared with Vilela. It should be noted that this village has 1,700 people more than the other two villages, thus demonstrating how low is that index.

Thus, from the variables 'Course highest attended – College' and '15 years of study' is possible to conclude that the villages Esmeralda and Jardim Carvalho have better rates of schooling than Vilela.
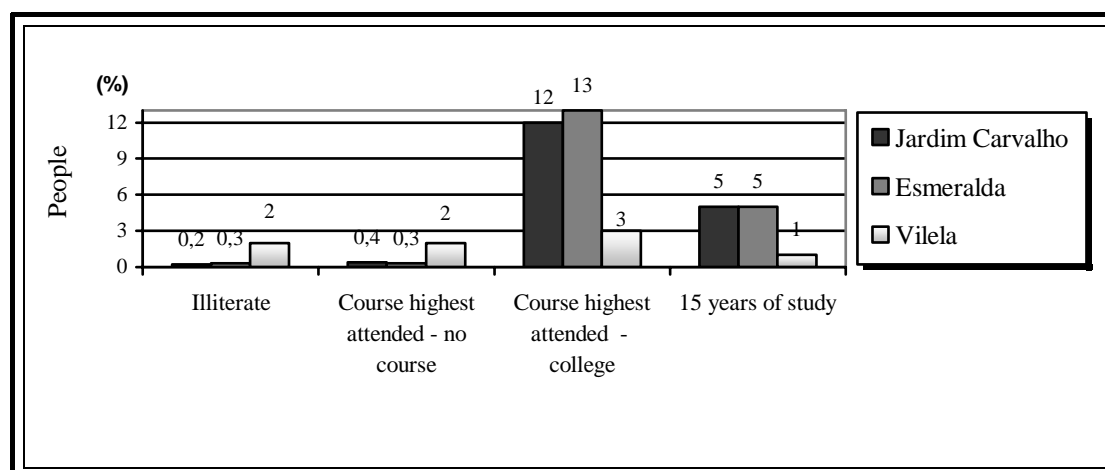

Figure 1 - Schooling of heads of permanent private households in villages Esmeralda, Jardim Carvalho and Vilela. Source: IBGE (2000).

In relation to local income, which can be said, reflects the level of education of the population is concentrated in villages Esmeralda and Jardim Carvalho. One sees this phenomenon in Figure 2, which illustrates, also in proportion to the population, these data. The greater the number of monthly income of heads of households, increased economic inequality, because these two villages are increasing numbers with increasing income, unlike Vilela, which the numbers decrease with the increase of it. This village puts forward in the two graphs were examined, the worse indices of education and monthly income, thus setting a framework for social and economic disparities between villages so close.
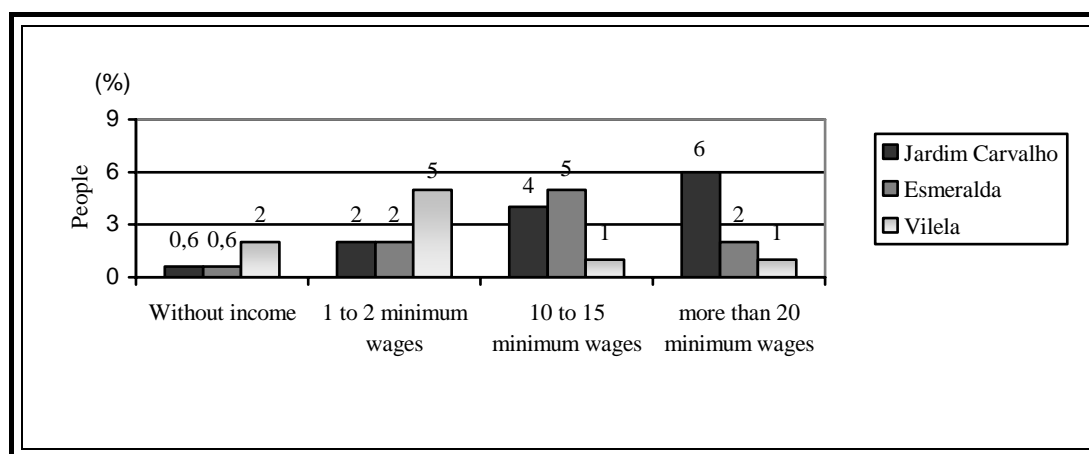

Figure 2– Nominal monthly income of heads of permanent private households in villages Esmeralda, Jardim Carvalho and Vilela. Source: IBGE (2000).

From the data presented was based on the hypothesis that these socioeconomic indices may reflect quantitative and qualitative urban forestry in this area, a phenomenon that will be addressed before the data obtained from field work.

3. Methodology

We first performed a literature on the subject trees, especially of roads, thereby having contact with the methodologies already applied. Were also selected data from Census 2000 to assess the environmental quality while reflecting socio-economic development.

For delimitation of the study area, as well as research planning, cartograms were produced to map the paths to be scheduled through the software *Arc View* 3.2 GIS Laboratory, Department of Geosciences, State University of Ponta Grossa. Were used as the digital cartographic base of the municipality of Ponta Grossa.

The following worksheets were produced for species identification, linking individual trees in each side of the road (right / left) and the distances in which they were in the building and the curb, apart from possible conflicts with the structures the city (like breaking sidewalks and conflict with the electric grid).

Such information has been verified through research on site, which it based individuals with PBH (perimeter at breast height), less than 20 cm, and they were clearly located on sidewalks and public walkways. When the impossibility of identification in the field, samples were collected for identification in Herbarium of State University of Ponta Grossa with the aid of works Lorenzi and Souza (1999), Lorenzi (2002) and Lorenzi et al (2003).

In the research field were also made photographic records of the species most frequent conflicts and ways identified with potential for afforestation. Finally, with the data already collected, comparisons were made with other sites of Ponta Grossa already inventoried, to have a diagnosis of urban forestry roads in the area.

4. Result and Discussion

We covered 59 routes, which had 479 individual trees to the total. Of these, 29 were identified at family level, 19 at genus level and 411 species, of which 27% are natives and 73% exotic. Due to the absence of flowers and / or fruit (elements necessary for correct identification) and the radical pruning, 20 tree specimens were not identified.

The species most often was the *Lagerstroemia indica* L., commonly known as the Extremosa, the family Lythraceae, constituting 18% of total species (74 individuals).

The second species was the most present *Ligustrum lucidum*, Oleaceae family, with 15.32% followed by the species of Ficus benjamina Moraceae with 10.94%. It is noteworthy that the species *Ligustrum Lucidum* had many conflicts with sidewalks, like *Ficus benjamina*, which, because of its shallow root is not recommended for narrow forest roads. It is therefore important to know the characteristics of the species for its correct use. It is also recommended to research the species native to the area thereby avoiding the excessive use of exotic species.

For Santamur Junior (2002, apud Quadros, 2005) does not exceed more than 10% of the same species, 20% of the same genus and 30% from the same botanical family. According to this author, the species *Lagerstroemia indica* and *Ligustrum lucidum* exceeded the limit of tree species recommended for health (18% and 15.32%, respectively). In relation to any botanical families exceeded this parameter, the most frequent: Bignoniaceae with 16%, 15% Lythraceae, Fabaceae with 14% and 13% to Oleaceae.

As surveyed, there are only 39 species in the arborization of the villages Esmeralda, Jardim Carvalho and Vilela, predominantly exotic on the native. The three most common species together represent 44.26% of the total cataloged.

The average distance from the curb found for the sampled population was 0.52 m. Value lower than that found in other locations as those raised by Milano (1984, 1988 apud Loboda et al 2005) and Ng (1995 apud Loboda et al 2005), from 1.56 to Curitiba / PR, and 1.20 m Maringá / PR , and 2.1 m for Cascavel / PR, respectively. The average distance from buildings (1.20 m) was also a low rate when compared with the values found by Nunes (1995 apud Loboda et al 2005) in Apucarana and Cascavel, respectively, 2.41 I 3.3 m, and Maringá, 1.47 m (ibid.). Data concerning the average distance of trees to the curb and the buildings show an average width of 1.72 m for the tours of the area sampled. Therefore, tours of small, should include trees, shrubs and small trees, since the limited space hinders the development of afforestation.

The lack of planning of afforestation culminates in conflicts with urban facilities such as the presence of spinning air, which is one of the most important factors when planning the arborization. It was observed conflicts with the electric grid in 68 cases (28.57%), often having to be done pruning, changing the natural shape of the tree also produces an anti-aesthetic.

The lack of free area and the choice for species with shallow root system eventually undermine, among other urban facilities, the sidewalks, which end up and breaking. Therefore one should choose a tree with deep roots, and leave at least 1m² of space pavement that allow the infiltration of water and nutrients (Santos and Teixeira, 2001), avoiding situations like breaking sidewalks, which represent 148 cases (62.18%) found in the study area.

Another practice is deeply rooted in Brazil's painting trunks, and found 22 cases in the sampled area. For Santos and Teixeira (2001) this practice provides dubious aesthetic effect and can cause damage to health, as the bark of trees has its own defenses.

Among the 479 tree specimens found, 389 are located in the Jardim Carvalho and Esmeralda Village, in other words, 81%, leaving only 90 for Vilela, or 19%. Therefore, making a correlation, one realizes that the urban environmental quality also reflects income inequality, as stated Berto (2008). With the socio-economic data from the IBGE this paper, the social disparity between the villages Esmeralda / Jardim Carvalho and Vilela was evident, with the indices of trees obtained confirmed the importance that the income has in the establishment of environmental quality. Contributed to this analysis the fact the town Vilela have the lowest levels of education, income and only 19% of trees cataloged in the search.

We agree with Seraphim (2007, p. 4) when it concludes that "aspects of environmental quality may be clear in some localities in urban areas depending on the distribution of vegetation and indicate the quality of life of residents."

In the field research were also identified five pathways (Adjaniro Cardon, Graciliano Ramos, Rocha Pombo, Monte Alverne and Henrique Thielen) who all have potential to be wooded. In these, the hunt is wider than 3m, the streets are wide, the houses are setback and spinning air is absent.

Conclusion

It was evident that the urban environmental quality also reflects the income inequality since the villages with better socio-economic - and therefore more assisted by basic infrastructure - they also presented a greater number of trees and a greater awareness about environmental issues. So we can conclude that education is strongly related to a condition where the theme Environmental urban areas.

Through the survey and analysis of arborization, we could perceive that there is an unequal distribution of individual trees, focusing on villages Esmeralda and Jardim Carvalho with 81% of the tree, against only 19% for the village Vilela.

Encouragement of the arborization should be taken, considering that seven streets were not found any tree, and there are roads with trees and very few individuals with the potential to make plantations without risk of conflict with the sidewalk or spinning air.

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Lisbon's public gardens, host place for world's trees

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Abstract

This study aims to contribute to the characterization and evaluation of Lisbon's Gardens. Within the framework of the 2009 project "Methods of Characterization and Classification of Lisbon's Public Gardens with heritage interest", 31 of Lisbon's Public Gardens were studied and a new methodology was developed to measure their landscape, historical, social and cultural value

Garden's Landscape value was evaluated according to several parameters, one of which was the botanical quality indicator. It determines trees' richness and uniqueness, assessed by botanical diversity and singularity evaluation methods (e.g., surveys, Shannon index, Equitability), and trees' heritage interest, based on their rarity, age, size and health.

3751 trees in 31gardens were studied. The following results were obtained: 46 families, 83 genus and 139 species. 48% are exotic, 35% naturalized, 13% indigenous and 4% exotic invaders.

Lisbon's Mediterranean climate allows the coexistence of different tree species, from Northern Europe to subtropical climates. In addition to its aesthetical value, this botanical diversity plays a central role in increasing biodiversity and promoting urban ecological sustainability.

Keywords: Public Gardens, Heritage Interest, garden's trees, Botanical Diversity, Lisbon

1. Introduction

Lisbon's climate allows for the coexistence of various indigenous and exotic tree species, from Northern Europe to subtropical climes. In addition to its great aesthetical value, this botanical diversity provides a habitat for the fauna and plays a key role in increasing biodiversity and in the urban ecology thus contributing to a sustainable city.

This botanical richness is mostly due to the Portuguese Discoveries and contact with other cultures which meant that plant species from around the world were brought to Portugal, in particularly to Lisbon. These "new" plants, from all over the world, were a challenge for botanists, gardeners and horticulturists, for whom the public and private botanical gardens and gardens were the "stage" for their experiments.

Many of these species were well suited to our climate, and today in Lisbon's streets, parks and gardens we can find specimens such as: *Tipuana tipu, Phytollaca dioica, Chorisia speciosa and Jacaranda mimosifolia* from South America; palm trees from the Canaries; *Casuarina cunninghamiana, Grevillea robusta* and *Lagunaria patersonii* from Australia, *Taxodium distichum* from the USA, *Metrosideros excelsa* from New Zealand, alongside Portuguese flora. Some of these trees, which stand out because of their size, structure, age, rarity or for historic and cultural reasons, have been classified by the National Forestry Authority, and add to

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Lisbon's ecological, landscape, cultural and historic heritage. At the present time Lisbon's tree collection is made up of 18 clusters, 54 single trees belonging to Lisbon Municipal Council and 6 privately owned single trees classified as trees and/or clusters of Public Interest.

Under the Project "Methods of Characterization and Classification of Lisbon's Public Gardens of Heritage Interest" (2009) a study was carried out to apply a new methodology to the measurement of the gardens' Landscape, Historical and Socio-cultural value.

The aim of this study is to contribute to the effective characterization and evaluation of Lisbon's gardens. The overall value attributed to each garden was directly related to its heritage importance, use as public space and other factors.

2. Methodology

Under the Project "Methods of Characterization and Classification of Lisbon's Public Gardens of Heritage Interest" [†], a method was devised that gauges the Historic, Landscape and Sociocultural Value of the 31 gardens studied (see Table 1). Parametric analysis of each value, using various quality indicators and a scoring system, made it possible to quantify each value and rank Public Gardens of Heritage Interest. The methodology developed and tested by the authors is based, among other principles, on surveys carried out by the National Trust of England and English Heritage.

The Historical value of each garden was evaluated by Landscape Architects, according to several indicators: origin, evolution, historic style, architectural and artistic integrity.

Public surveys were conducted to determine the Socio-cultural value of the gardens role in creating healthy communities through recreation and economic sustainability (tourism), leading ultimately to better management.

Table 1 - Methods of Characterization and Classification of Lisbon's Public Gardens of Heritage Interest
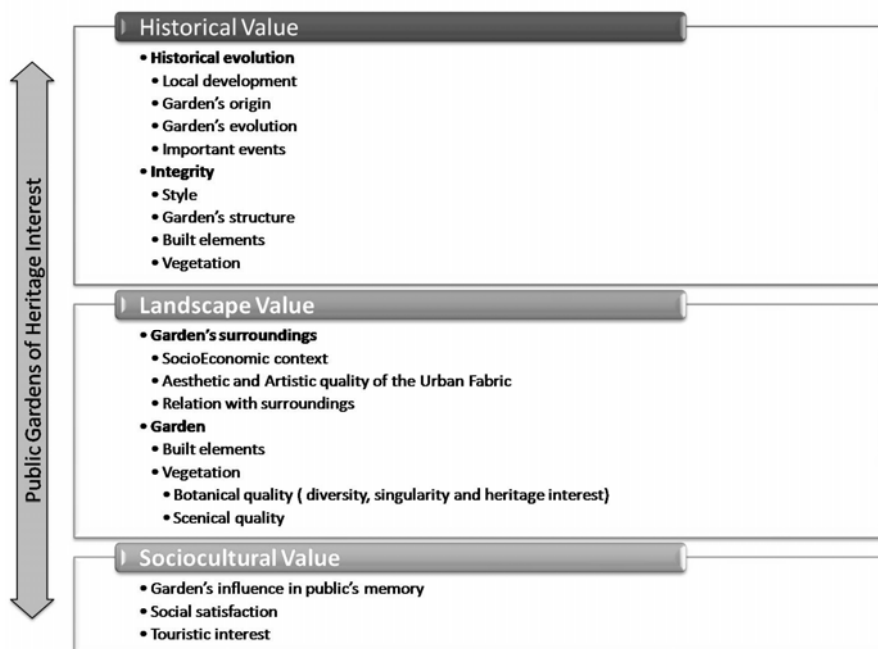
[†] In 2009, under an agreement between the Institute of Agronomy (Technical University of Lisbon) and Lisbon Municipal Council, final year Landscape Architecture students, Elsa Isidro and Isabel Silva, under the supervision of Professors Ana Luísa Soares and Cristina Castel-Branco and the Landscape Architect Mafalda Farmhouse, developed a Method of Characterization and Classification of Lisbon's Public Gardens of Heritage Interest, as part of the end of course work.

In this paper the authors have created a broad scope concept that covers all the garden components which have been consciously designed to create a piece of Landscape art. This "Landscape Value" concept is arrived at through the evaluation of various elements such as artistic quality, aesthetic beauty, vegetation and landscape, and built elements.

The Landscape value

Landscape value is a broad scope concept that includes all the components under the influence of the garden's author in a process that leads to a piece of Landscape art, through the evaluation of the aesthetic beauty, artistic quality and value of the built elements or vegetation. This value includes also the garden's external characteristics, such as the socioeconomic context of the garden's location which acts as a parameter restricting the garden's public to a certain kind of users, the aesthetic and artistic quality of the urban fabric, where we consider the state of conservation, and, finally, the visual relation between the garden and the surroundings, through a study of the series of views.

As regards Landscape Value, which is a broad item, features were assessed such as the aesthetic and artistic quality of the built and botanical composition elements. As for botanical quality, following a survey[‡] of the tree species in the garden, their diversity and singularity were evaluated by means of specific scientific formulae. Since plants are a fragile element, easily lost, altered or replaced over time, it was also important to value those trees which because of their size, rarity or quality are deemed notable and classified as being of Public Interest[§]. In addition to these criteria the garden's scenic quality was assessed by studying its plant composition in terms of trees, shrubs and flowers.

Botanical quality pertains to the vegetation's richness, uniqueness and heritage interest. The latter is based on each individual specimen's size, rarity, age and health. The richness and uniqueness of each specimen was obtained through accepted methods, as explained below.

The Botanical Diversity parameter for each Garden was quantified using a average of four formulae: the Shannon index (1), the evenness index (2), the proportion of different species in the garden relative to the total number of specimens, and the ratio of the number of species in the garden compared to the total number of species in the set of gardens studied.

Botanical Diversity Method:
- Index 1: (Total of the tree species/ total of the garden's tree specimens) (%)
  - a) Class 1 Botanical Diversity Index: (1 if [0-33%]; 2 if [34-66%]; 3 if [67-100%])
  - b) Class 1 Botanical Diversity Index: (1 if [0-15%]; 2 if [16-31%]; 3 if [32-50%])

- Index 2: (Total of the tree species/Total of tree specimens in the set of gardens) (%)
  - a) Class 2 Botanical Diversity Index: (1 if [0-0,6%]; 2 if [0,7-1,2%]; 3 if [1,3-2%])

- Index 3: Shannon index
$$H = -\sum_{i=1}^{S} p_i \ln p_i \quad (1)$$
  - Class 3 Shannon Index: (1 if [0-1,33]; 2 if [1,34-2,66]; 3 if [2,67-4])

- Index 4: Evenness
$$E_s = H / H_{max} = H / \ln S \quad (2)$$

- ▪ Class 4 Evenness Index (1 if [0-0,33]; 2 if [0,34-0,66]; 3 if [0,67-1])

- ▪ Average of Botanical Diversity Indices

ni : number of individuals in each species; abundance of each species.

$$\sum_{i=1}^{s} ni$$

S : number of species (richness)

$$\frac{ni}{N}$$

N : total number of all individuals:

p_i : relative abundance of each species, calculated as the proportion of individuals of one species to the total number of individuals in the community:

The Botanical Singularity score was based on the occurrence of one, two or three individuals of a particular species in the set of gardens studied.
Singularity Evaluation Method:
- ▪ 3 – contains the only specimen of a species;
- ▪ 2 – contains one/two of the only two specimens of a species;
- ▪ 1 - contains one/two/three of the only three specimens of a species;
- ▪ 0 - if there are more than three specimens of a species

The characterization of 31 public gardens according to the defined indicators enabled the acknowledgement of their social, historical and aesthetic features, and their ranking.

3. Result and discussion

A total of 3751 trees were recorded in the 31 gardens studied, and the following results were obtained: 46 families, 83 genus and 139 different species, of which 58% are evergreen and 42% deciduous. As regards their origin, 48% are exotic, 35% naturalized, 13% indigenous and 4% exotic invaders. The dominant species are *Celtis australis*, *Olea europaea* var. *sylvestris*, *Pinus pinea* and *Phoenix canariensis* (see figure 1). The following species stand out because of their singularity: *Erythrina crista-gallis*, *Firminiana simplex*, *Koelreuteria paniculata*, *Melaleuca stypheliodes* and *Pawlonia tomentosa*.
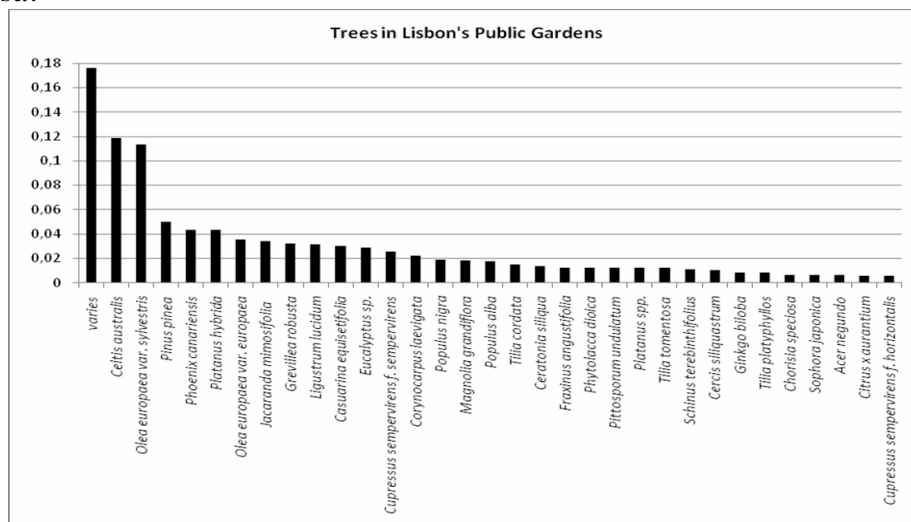
Figure 1 - Trees in Lisbon's Public Gardens

As for the gardens, the following are of special note due to their botanical diversity (see figure 2): Estrela (Guerra Junqueiro), Príncipe Real, Campo de Santana (Braamcamp Freire), Amoreiras (Marcelino Mesquita), and Vasco da Gama. The least diversity was found in São Pedro de Alcântara (António Nobre) and Campo Pequeno (Marquês de Marialva).
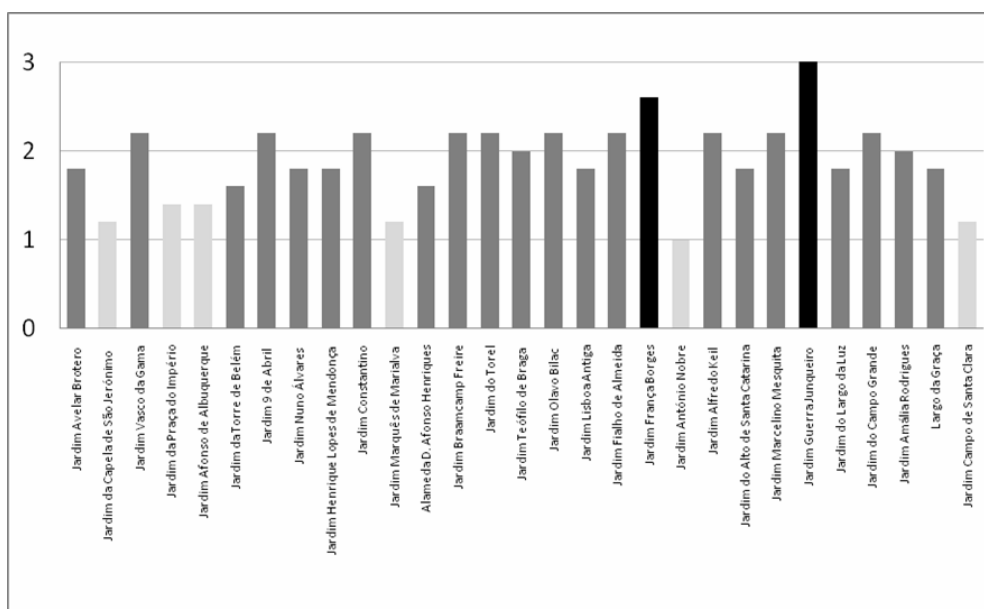
Figure 2 – Botanical diversity in Lisbon's Public Gardens

Singularity analysis (see figure 3) showed that most gardens had unique specimens for different species, thus each garden on its own contributes to the overall diversity of trees present.
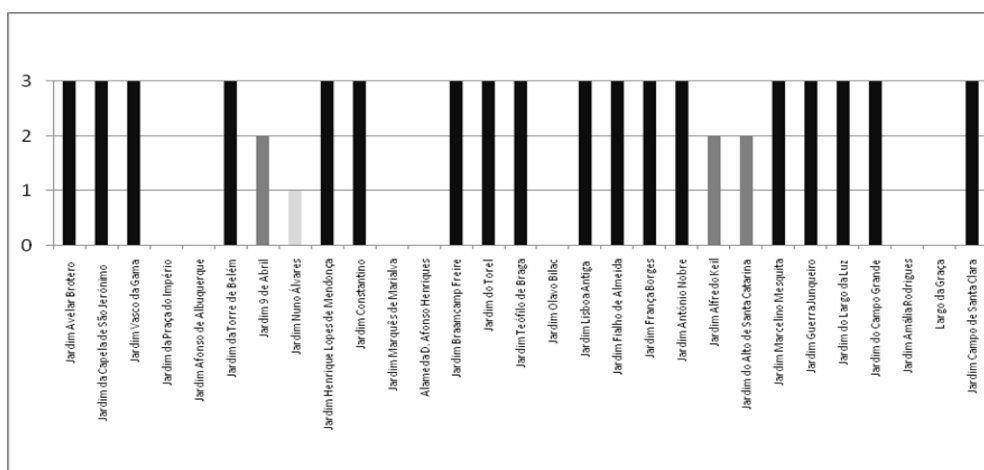
Figure 3 – Botanical Singularity in Lisbon's Public Gardens

4. Discussion

Lisbon's Mediterranean climate allows for the coexistence of different tree species, in addition to the gardens aesthetic value, this diversity is key to creating a healthy urban environment, with

increasing biodiversity and sustainability. Besides their historic and cultural value, the public gardens studied are showplaces for plants from all over the world and bring an aesthetic value and high bio-climatic comfort to the city, as well as contribute to biodiversity. They have an unquestionable tourist and recreational value.

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Section 9
Symposia

Quantifying the effects of forest fragmentation: implications for landscape planners and resource managers

Taking into account local people's livelihood systems for a better management of forest fragments

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Abstract

During the last few decades, a large extent of tropical rain forest has been cleared in the East of Madagascar through agricultural activities. Larger cohesive forest massifs are increasingly fragmented and forest fragments of various sizes remain in a landscape mosaic dominated by agricultural patches. Until now, only little is known about how these fragments are perceived by the local population and what role they play in the local livelihood systems. We therefore tried to get a holistic understanding about the human-forest interface in this fragmented landscape and based our methodology on the sustainable livelihood approach. The research has been conducted in four villages which differ in their distance to the cohesive forest massif and therefore in their access to forest resources. We recognized that the perception of forest fragments and their importance for the local population changed with increasing distance to the forest massif. Not only they became more important to satisfy people's daily needs, but they also had an increasing potential to cause conflicts between villagers. For a possible improvement of forest management designs, we should therefore take into account what role forest fragments play in local livelihood systems and how they can vary with changing access to forest resources.

1   Introduction

On a global level, the planet is continuously loosing its original tropical forests. Most tropical landscapes not only suffer from deforestation but also from fragmentation, which often leads to decreasing vitality of remaining forest patches (Shvidenko et al. 2008). This is also the case in Madagascar, where forests are increasingly fragmented by agricultural activities such as slash-and-burn cultivation (Harper et al. 2008). Nevertheless, these fragments are of increasing importance, not only for the diversity of mosaic landscapes but also for the local inhabitants in the vicinity of these landscapes (Pfund et al. 2006). Currently, in Madagascar forest resources are managed without separation between larger forests and fragments and without a broad consideration of local people's livelihood strategies. We therefore aimed to explore the effective importance of forest fragments in local livelihood systems with our research. We combined quantitative and qualitative analyses about opportunities resulting from forest resources for people's livelihood and the local perception about the importance of forested landscapes. To explore the role of forested landscapes, we divided them into two different categories; massif and fragments. This short paper will present two aspects of the role of forest landscapes in local people's life; the role of monetary income and the changing perception of forest fragments related to the distance to large non-fragmented forests.

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2   Methodology

As a basis and general framework for our socioeconomic analyses we employed the Sustainable Livelihood Approach (SLA) (NADEL 2007). This approach allowed us to recognize the complexity of local people's livelihood systems and strategies at individual, family and community levels in relation to forest fragments. Diverse methods were used for data collection, based on the SLA. In general, our aim was to compare the perception of different landscape types by the local population with concrete quantitative information, as for example about the income. We therefore worked with interviews and scoring exercises. All in all, we spent 11 months in four villages during the two field periods of the project.

2.1   Village selection

For our research, we worked in four villages situated around the forest massif. The territories of the four villages have a different forest cover and differ especially in their distance to the forest massif, what correlates to the distance to markets (see Table 1). The villages Ambofampana and Maromitety are situated near the massif in a remote area, whereas the villages Bevalaina and Antsahabe are farther from the massif in a territory of lower forest cover and are less remote. The category near or far the massif is defined by the walking time to reach the border of the massif. The differences of the distance to the massif allowed us to analyse the influence of a changing landscape on the human-forest interface.

Table 1: The four selected villages

Characteristics of village territories	Ambofampana	Maromitety	Bevalaina	Antsahabe
Distance to forest massif [walking time in h]	0.25	0.5	2	3
Category of distance to forest massif	near	near	far	far
Forest cover [%]	86	75	43	21
Market proximity [walking time in h]	6	8	2	1
Number of households interviewed	25	22	32	31
Number of groups for scoring exercises	6	4	6	6

2.2   Interview methods

We began with open-ended discussions with several households in each of our villages to get a general overview. We then conducted the first semi-structured household interviews to deepen particular topics. In these interviews we gathered more specific and also quantitative information about the importance, income, perceptions, products collected from and uses of forest fragments. To complete our data we held discussions with people who have specific knowledge or play a key role in the social context. These included older persons, loggers or traditional authorities.

2.3   Scoring exercises

To deepen the information on the perception of importance, we conducted scoring exercises with focus groups, separated by wealth levels and gender (Sheil and Liswanti 2006). To express their own perception of value, each group had to distribute 100 pebbles on 9 different landscape types (Table 2) according to their importance. This had to be done 8 times for 8 different categories of goods and products (Table 3).

Table 2: Categories of landscape types

Landscape types	Definition
River	Water and riverside
Irrigated rice fields	Irrigated, permanent rice fields
Tavy	Cultivation of rice and other products on slopes after slash-and-burn
Safoka	Secondary vegetation without cultivation
Marsh	Wet and periodically or permanent flooded ground
Forest massif	Permanent natural tree cover connected to the forest massif.
Fragments	Permanent natural tree cover not connected to the forest massif.
Village garden	Trees and plants cultivated in the village around the houses
Tanimboly	Traditional agroforestry system with trees and annual crops

Table 3: Categories of goods and products

Categories	Definition
Food	Plants, products or animals which can be eaten
Medicine	Natural products used for medicine and health
House construction	Materials to build houses
Tools	Materials to build tools for agriculture, hunting
Fire wood	Fuel
Weaving	Plants used for weaving products, such as mats, hats, baskets
Income	Products which can be sold
Hunting	Animals (lemurs, tenreks, fish etc.)

3   Results

3.1   The general importance of fragments

Forested landscapes are of indisputable high importance for the rural people living in the presented research area. But the local population perceive the massif and fragments as two types of landscapes with different importance. As illustrated in Figure 1 the importance of fragments becomes significantly higher with increasing distance to the massif (Analysis of variance: $F_{3,18}=$ *4.21, P = 0.02*). The relatively high importance of fragments in the nearest village to the massif (Ambofampana) can be explained by the qualitative and quantitative still high availability of NTFPs and timber in these fragments. Because the population density is low, fragments are not much degraded and the difference of diversity between the massif and the fragments is not very high.
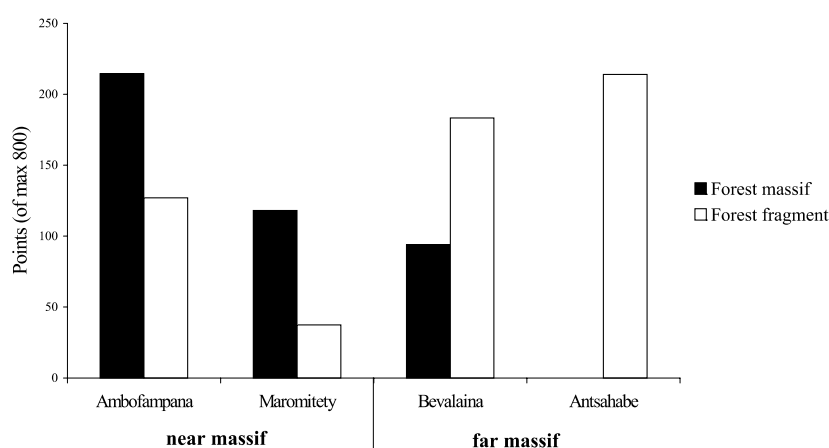

Figure 1: The perceived importance of forested landscapes, including all categories of goods and products
(see Methodology, 2.3 Scoring exercises)

Moreover, in our research area we found an important traditional rule concerning the right to convert forest fragments into agricultural land. Only farmers being owners of the land surrounding the forest fragments have the right to clear these forests. This is a crucial rule as it is depending on the individual household whether a fragment will be cleared or not. Therefore we asked households which still have forest fragments situated next to their agricultural territories why they did not clear their fragment until this day. Figure 2 indicates the obvious changing interest for forest fragments with increasing distance to the massif. Households near the massif see fragments mainly as a soil reserve for future conversion into agricultural land. Interesting is that this can not be a question of land availability, as households near the massif have around twice as much available agricultural land per households as families far from the massif do. Thus households far from the massif should be more interested in forest conversion, but they do not seem to be. Households far from the massif are more interested in the goods produced by forest fragments.

Therefore our conclusion suggests that the perception of the importance of forest fragments changed with increasing scarcity of forest resources. On the one hand, people living far from the massif notice the growing concurrence on products from forested landscapes. On the other hand they have already been aware that forests are disappearing and are exhaustible. People near the massif generally think that forests are inexhaustible and they still have more than enough to satisfy their principal needs related to forests.
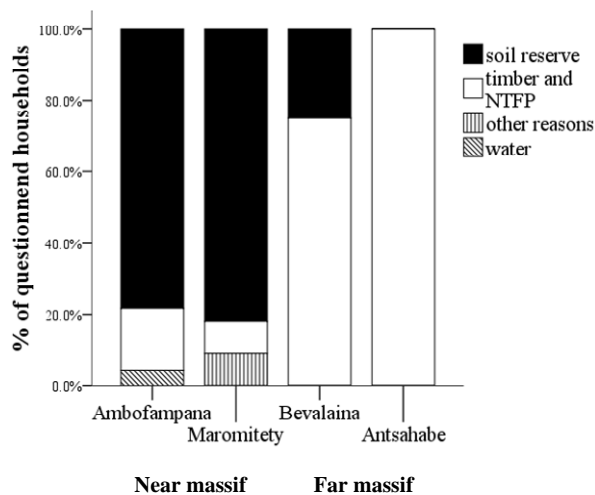
Figure 2: Reasons for the preservation of forest fragments

3.2 Changing importance of forests for income

In this section we explore the importance of forested landscapes more through the lense of monetary income resulting from forest products (see Table 1). Especially during periods of rice shortage, households are strongly depending on alternative income to buy food. Then, logging and timber transport become important sources of income. Farmers living near the forest massif still find precious wood in the massif, whereas farmers living far from the forest massif have to find wood in the surrounding fragments, where precious woods are already becoming scarce. Nevertheless, as shown in Figure 3, farmers living far from the massif have the higher income by timber activities than farmer living near the massif (Analysis of variance: $F_{3, 102} = 2.86, P = 0.040$).

This is comprehensible as timber is tradable much better in villages far from the massif than near the massif. This existing trade far from the massif can be explained by the increasing scarcity of wood and the growing population farther away from the massif. Additionally, timber can be sold to families in other villages which can not walk this far to find wood. Another reason for the better trade far from the massif is the proximity to markets. If they live near the massif, farmers have to walk for 6-8 hours to reach the next market to sell their wood. This is almost impossible because farmers have to carry the wood on their shoulders.

Contrary to the case of timber, the trade of non-timber-forest-products (NTFPs) is not significantly related to the massif proximity. On the one hand, NTFPs are still available in a higher amount and better quality in the massif than in the fragments (Fedele 2010), what allows a better trade for people living near the massif. On the other hand, NTFPs are easier to carry for long distances thus people living near the massif can walk 8 hours to the next market.
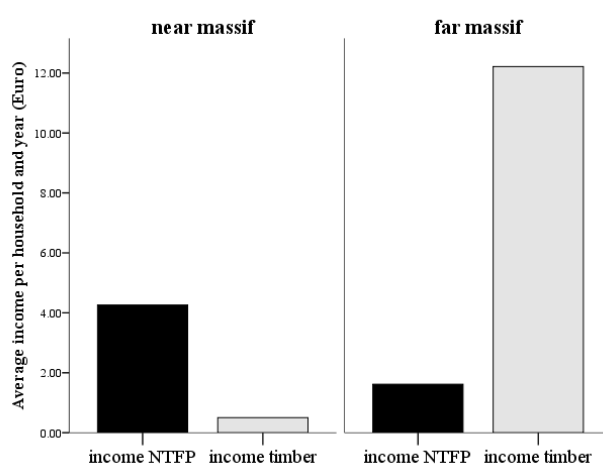
Figure 3: Income generated by NTFP and timber from forested landscapes

From the results presented in Figure 3 we would assume that people far from the massif perceive forested landscapes more important for income than people living near the massif. But this is not the case. People living near the massif perceive forested landscapes (including both categories massif and fragments) not less important than people far from the massif. This can be seen in Figure 4, which shows the results of the distribution of 100 pebbles according to the perceived importance of different forested landscapes for income (see 2.3 Scoring exercises). The results showed no significant difference for the relation between distance and importance of forested landscapes. Obviously, the quantification of importance by income (Figure 3) does not reflect the actual perception of the local population (Figure 4). We asked the different groups for reasons explaining the given importance of forested landscapes, even though the effective income from forest was not that high. The explanation was that the continuous availability of forest products was more crucial than the effective income. Products from forested landscapes are always available and, although to a limited extent, always tradeable. This is a significant characteristic for crisis and periods of rice shortage. Forest products can not all be destroyed by cyclones, whereas crops are always in danger.

Nevertheless, Figure 4 points out the increasing importance of fragments (Analysis of variance: $F_{3,18} = 4.01, P = 0.024$) and decreasing importance of the massif (Analysis of variance: $F_{3,18} = 3.23, P = 0.047$) with growing distance between village and massif. These trends go into the same directions as already shown in Figure 1. While the results in Figure 1 are related to the importance of forested lands for all different categories of goods and products, Figure 4 is only related to products that can be sold.
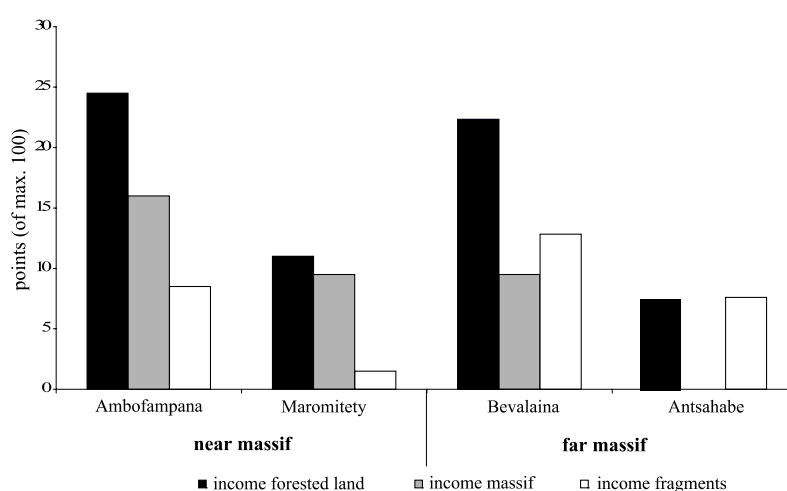
Figure 4: The perceived importance of forested landscapes for income, including only the category income (see 2.3 Scoring exercises)

4   Discussion

This short paper has strived to explain that by the local population, forest fragments and forest massifs are not perceived as the same. The importance of fragments is related to quantitative opportunities and local livelihood strategies, which must be understood in a holistic view of livelihood systems. We assume that if forest fragments are not taken into account in future forest management plans, this can lead to social conflicts between villagers. Forest management plans in Madagascar normally consider wider areas, including villages far and near the massif in the same management plans. Furthermore, there is no differentiation between fragments and the massif. But we observed that people make the difference between fragments and the massif. Additionally, farmers do perceive the importance of forest fragments differently with increasing distance to the massif. These different views and following strategies can lead to conflicts between villages. Therefore, we recommend that in regional planning of natural resources, different views and strategies must be identified and considered to counter possible sources of conflicts. Thus forested landscapes should be explored in a holistic context of local people's livelihood.

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Measures of landscape structure as ecological indicators and tools for conservation

Multiscale analysis of land use heterogeneity and dissimilarity as a support for planning strategies

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Abstract

The analysis of landscape structure is commonly oriented to the comprehension of pattern:process relationships and the evolution of such across spatial and temporal scales. Nevertheless, an important – and often neglected – aspect of landscape analysis is its potential to use the derived information as a support for planning, design and decision making in landscape management processes. The results of quantitative analysis of the spatial variation of landscape's composition and configuration across scales can help to identify areas distinctive regarding their heterogeneity, thus indicating different needs for spatial planning.
In this work, a methodology is explored for the analysis of forest landscape pattern oriented to planning applications. In it, a series of sequential steps are taken in order to guide analysis into a diagnosis useful for decision making. It starts by defining heterogeneity areas at different scales by means of multiscale approach. It is expected that such an approach, based in a "multi-level" structural analysis, would be useful for the spatial design of planning strategies.

Keywords: multiscale analysis, landscape metrics, land use heterogeneity, dissimilarity, landscape ecological planning

1. Introduction

The analysis of the spatial arrangement of landscapes is generally adopted as a major tool for the comprehension of processes and dynamics of the landscapes, and the relationship among their constitutive elements. Beyond the utility of pattern analysis for the understanding of landscapes, it can constitute a strong support of landscape planning strategies. In this work, the utility of two different landscape indices to analyse heterogeneity in order to derive conclusions for spatial planning is explored. To do so, simulated landscapes are used to test the behaviour of the indices at multiple scales, and ideas of their application to real planning cases are derived.

2. Methodology

2.1. Artificial landscapes

Artificial landscapes were generated using Simmap software (Saura, 2003), based on the Modified Random Clusters Method (MRC) (Saura and Martínez-Millán, 2000). This method generates more realistic landscapes than other neutral model software (Saura and Martínez-Millán, 2000), due to the patchy, irregular shape of the results, which made it adequate to simulate land use planning scenarios. The programme allows to control the degree of patchiness by the variation in the generation parameters p, n, Ai, and both the Minimum Mapping Unit and

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the extension of the map (Saura, 2003). We generated artificial landscapes for three values of p: the value above which the size of the largest cluster in the map starts to vary (0.45), an intermediate value (0.50), and the value immediately below the percolation threshold (0.58). Values beyond the percolation threshold generated almost complete dominance of one of the land cover classes in preliminary tests.

We considered five land cover classes, the proportion of each class following two types of distributions: "equiprobable" (each class 20%), and "non-equiprobable" (with classes distributed 50%; 30%; 10%; 5% and 5%). In the latter case, the aim was to resemble a real distribution of land cover with one land cover clearly, but not completely, dominant, being the respective modeled land cover types Planted forest, Agriculture, Urban, Natural forest, and Shrubland. The "equiprobable" distribution is aimed to obtain results for an even distribution of results which can be used as a theoretical. In the "non-equiprobable" distributions, a more realistic landscape response is expected. For each of these cases, four different MMUs were considered, for 1 pixel, 10 pixels, 50 pixels and 99 pixels, i.e. a total of 24 different landscape cases. Each case was coded with a sequential number representing the generation parameters, e.g.: "N5m1-58a" for 5 classes, MMU=1; p= 0.58; "a" type of class proportion, being "a" equiprobable, and "b" non-equiprobable.

2.3. Analysis of landscape heterogeneity and dissimilarity

A common approach for the analysis of landscape heterogeneity is the application of landscape pattern metrics to a categorical map (O'Neill et al., 1988; Botequilha-Leitao and Ahern, 2002; McGarigal et al., 2002; Botequilha-Leitao et al., 2006). Although landscape metrics are extensively used, careful consideration is required as to which are the most adequate as regards the aims of the study and the spatial data available (Li and Wu, 2004; Corry and Nassauer, 2005; Diaz-Varela et al., 2009b; Dramstad, 2009). One of the problems with application of landscape metrics to an entire study area lies in that metrics do not reveal the spatial distribution of the variables studied, and their scale-dependence, making necessary a system for subdivision into intermediate scales. Previous studies on the subject made by the authors revealed the utility of moving-window approaches in calculation of landscape indices (Botequilha-Leitao and Díaz-Varela, 2009; Díaz-Varela et al., 2009a), namely those related to information theory, like the Shannon-Wiener index. The Shannon-Wiener index was developed as a measure of the information content in a code (Shannon and Weaver, 1949), and is calculated by the expression (1):

$$SHDI = -\sum_{i=1}^{m} p_i \cdot \log p_i \tag{1}$$

Where p_i is the proportion of the landscape occupied by the class type i, and m the total number of classes.

Dissimilarity was analysed by means of contrast metrics, namely the Contrast Weighted Edge Density (CWED). CWED is calculated following the expression (2) (McGarigal et al., 2002):

$$CWED = \frac{\sum_{i=1}^{m} \sum_{k=i+1}^{m} (e_{ik} \cdot d_{ik})}{A} (10000) \tag{2}$$

Where e_{ik} is the total length (m) of edge in landscape between patch types (classes) i and k; includes landscape boundary segments involving patch type i; d_{ik} is the dissimilarity (edge contrast weight) between patch types i and k; and A, the total landscape area (m^2). d_{ik} was estimated by our subjective criteria over the dissimilarity among land cover types, and represented in the following table:

Table 1: Contrast weights among modeled land cover types

Land cover	Agriculture	Planted forest	Natural forest	Urban	Shrubland
Agriculture	0.0	0.6	0.4	0.2	0.3
Planted forest	0.6	0.0	0.8	0.7	0.2
Natural forest	0.4	0.8	0.0	0.7	0.3
Urban	0.2	0.7	0.7	0.0	0.1
Shrubland	0.3	0.2	0.3	0.1	0.0

For its calculation, FRAGSTATS software (McGarigal et al., 2002) was used, and a circular window shape was chosen. Window radii of 10, 20, 30… 100 cells were applied in the calculations. When a window covers no data, a border effect is caused producing null areas proportional to the window radius. To avoid it, the original map dimension was fixed so as to obtain at least a result map of 600x600 cells. Further post-processing was carried out with ESRI's ArcGIS 9.2 software.

3. Results

A total of 24 of simulated maps were obtained, showing different spatial patterns corresponding to the initial generation parameters. From them, the calculation of the indices using the moving window approach resulted in a total of 240 different maps, showing the scale behavior of spatial distribution of landscape heterogeneity at different scales (see Figure 1 for examples on the different indices). In those maps generated by lower window sizes, homogeneous zones (i.e. lower index values) are shown corresponding with patches with extensions larger than the window size. For the same landscapes, complex borders or fine-scaled landscapes (i.e., areas with patches with extensions lower than the window size) correspond to peaks in the heterogeneity values. Maps generated for larger window sizes tend to average local effects.

Forest Landscapes and Global Change-New Frontiers in Management, Conservation and Restoration. Proceedings of the IUFRO Landscape Ecology Working Group International Conference, September 21-27, 2010, Bragança, Portugal. J.C. Azevedo, M. Feliciano, J. Castro & M.A. Pinto (eds.) 2010, Instituto Politécnico de Bragança, Bragança, Portugal.
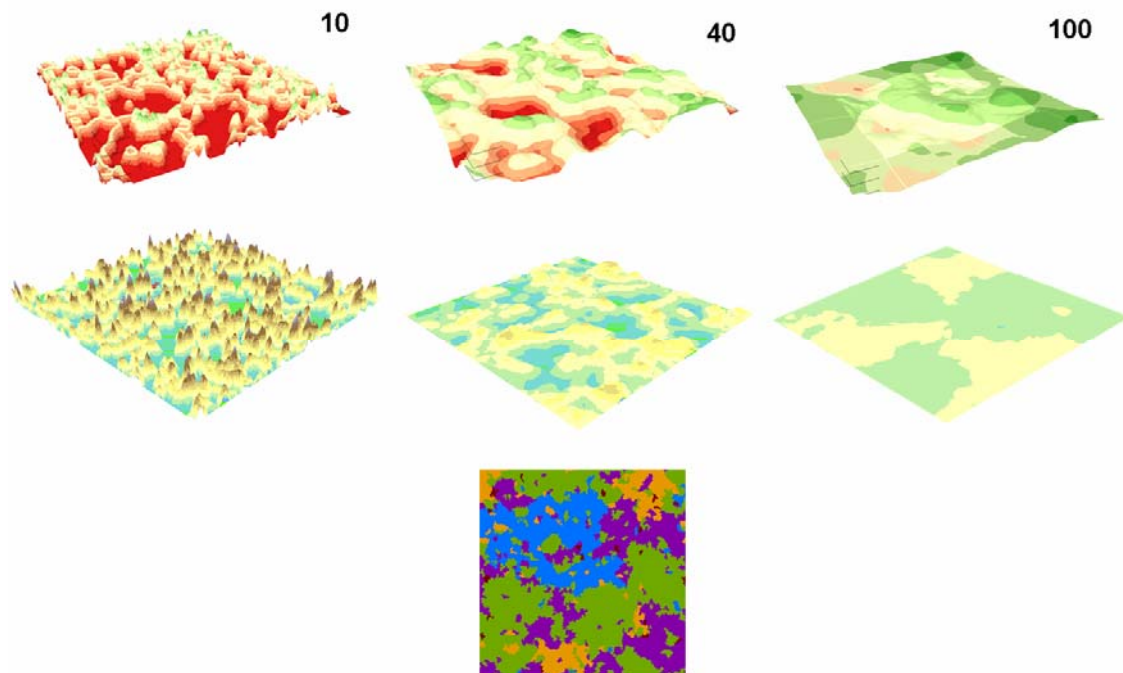
Figure 1: 3D representation of heterogeneity landscape N5m99-58b (see text for interpretation of code) at diverse scales for SHDI (up) and CWED (down). The original landscape and the corresponding window size are illustrated for comparison..

This general response can be summarized as lower mean values for the smaller window sizes, where also the greater variance is attained, followed by a trend to stabilization in values corresponding with a decrease in variance, as window sizes grow. Figure 2 shows how this general trend is reflected in SHDI depending in the generation parameters (i.e., arrangement of landscape elements) for three different examples. Equiprobable landscapes with low values for m and p show a swift trend to stabilization in index values, following an asymptotic trend (Fig. 2, upper left). A similar trend towards stabilization, but showing least decrease in variance is shown for non-equiprobable landscapes (Fig. 2, lower). Some situations can also show a smother trend towards estabilization, corresponding with more complex structures in the landscapes, as patches diverging in size and different interspersion patterns (Fig.2, upper right).
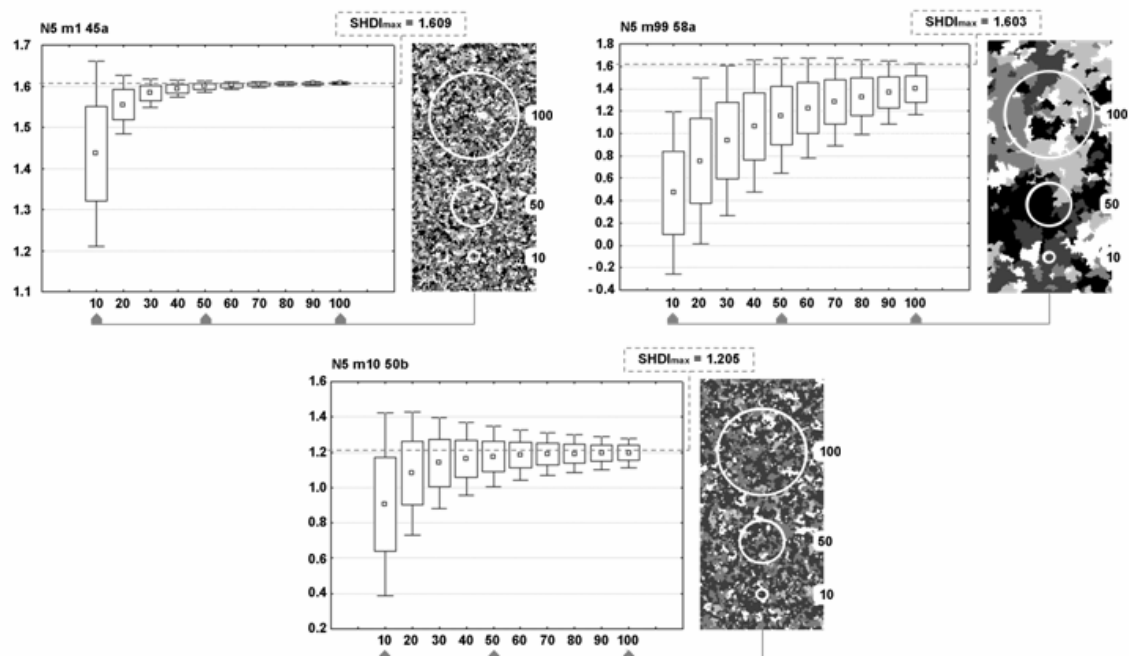
Figure 2: Different scale behaviour of landscapes as shown by changes in SHDI values with the window size. Dots represent mean values, boxes standard deviation (SD) values, and whiskers 1.96*SD. A portion of the landscape is illustrated, and the window sizes super-imposed for comparison. See text to interpret the generation parameters by the landscape code.

For the case of CWED, the response shown by the index is slightly different, due to the calculation parameters of the indices (Figure 3). The maximum value of SHDI is attained for a equiprobable distribution of land cover proportions. Nevertheless, as CWED calculates edge density, the effect of growing window area is translated in decreasing values for standard deviation, and initially decreasing, then increasing values for the mean.
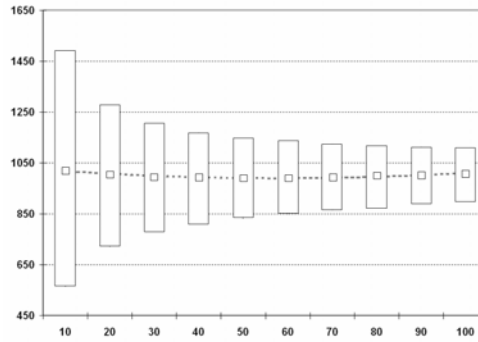
Figure 3:Scale behaviour of landscape N5m99-58b as interpreted by CWED. Though stabilization of values towards the higher window values is evident, this is not clearly asymptotic with a maximum value as in the case of SHDI. Dots represent mean values, and boxes standard deviation (SD) values

4. Consequences and applicability in landscape planning

The utility of the approach is derived from three different consequences of the analysis.

First, the behavior of the indices with changes in scale allows the detection of self-similarity in landscapes. In figure 2 (upper left), this would correspond with the stabilization of the trend of the mean values of SHDI. For such cases, the heterogeneity as detected by the index presents little variation with the scale, thus landscapes can be considered as self-similar. This would allow to identify characteristic scales for landscapes, and areas where planning actions should be independent from the scale of application. However, this case would be rarely verified in real scenarios, and trends are more similar to the graphic shown in figure 2 upper right. In those cases, variability as shown by standard deviation, and the smooth trend of the mean can be interpreted as several types of landscape sharing the same area, which should be identified.

Second, comparison between results of SHDI and CWED shows that landscape heterogeneity analysis could not be confined to spatial composition and configuration. The use of dissimilarity values in the calculation of landscape indices integrates a semantic perspective in the analysis of landscape pattern, and allows for a qualitative approach. By using contrast weights among land cover types, we can identify possible conflicting areas, to which specific planning actions can be targeted.
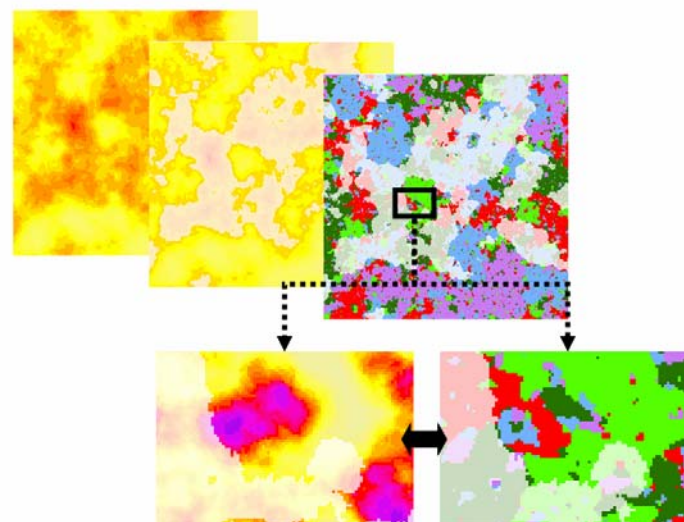
Figure 4:Multi-scale application of the heterogeneity analysis. In the upper part, sequential process for delimitation of heterogeneity trends based in dissimilarity among land cover types. In the part below, micro-scale heterogeneity detected as high-dissimilarity sites inside low-dissimilarity areas. See text for details

Finally, the third consequence, related to the previous ones, derives from multi-scale effects in the composition, configuration, and semantic structure of the landscape. Figure 4 shows how high-contrast and low-contrast areas can be identified in a landscape, taking the map created with the window size from which the stabilization trend is established, and using the mean value of CWED as a reference. Nevertheless, for more detailed scales, possible points of conflict can be detected as high-contrast areas. Such differences in dissimilarity among land cover can be addressed in planning by the adoption of different strategies corresponding with the planning spatial level. For instance, the general map can resemble a regional approach to heterogeneity detection, while the more detailed scale can refer local effects. This kind of analysis presents a powerful field of application when multi-scale strategies of planning are developed.

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Effects of landscape structure and stand age on species richness and biomass in a tropical dry forest

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Abstract

Tropical dry forests are the terrestrial ecosystem with the largest extent in the Yucatán Peninsula, but have been scarcely studied and are poorly represented under protected areas. This study aims to characterize relationships between structure of vegetation and landscape structure and habitat type (stand age) considering different spatial scales. Species richness and biomass were calculated from 276 sampling sites, while land cover classes were obtained from multi-spectral satellite image classification using Spot 5 satellite imagery. Species richness and biomass were related to patch age, landscape metrics of patch types (area, edge, shape, similarity and contrast) and principal coordinate of neighbor matrices (PCNM) variables using regression analysis. PCNM analysis was performed to interpret results in terms of spatial scales as well as to decompose variation into spatial, age and landscape structure components. Results indicate the best landscape configuration to promote biodiversity conservation and to support carbon sequestration.

Keywords: Biomass; variation partitioning; Species diversity; Spatial scales; forest succession

1. Introduction

Tropical dry forests (TDF) are the most extensive land cover type in the tropics. More than half of tropical dry forests occur in the Americas, and Mexico contains 38% of the TDF in the continent. However TDF are the most threatened ecosystem in the world as a consequence of human activities (Portillo-Quintero and Sanchez-Azofeifa, 2010). Consequently, information about the ecological drivers of community structure at various spatial scales is fundamental to fully understand and design effective strategies for conservation and management.

Compared to other ecosystems, ecological studies in TDF are relatively new. In addition, most studies on the effects of fragmentation and landscape patterns on plant communities focus on particular patches and on local species richness (α-diversity), while few studies examine different patch types at the whole landscape level and address effects on attributes of community structure such as abundance or biomass (Hill and Curran, 2003). In this study we assess woody species density and biomass, and their response to landscape structure and stand age to address the following questions: Which landscape configurations and stages of forest succession maximize biological diversity? What is the relative importance of landscape structure and stand age for carbon storage?

Most research examining the effects of landscape structure on species diversity and structure of vegetation has focused on a single spatial scale. Yet, the degree to which landscape

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configuration affects the structure and composition of plant communities depends on processes occurring at different spatial scales (Cushman and McGarigal, 2004). In order to assess the relationship between community attributes and landscape structure across different scales it is necessary to consider scale-dependent ecological processes (Bellier et al, 2007). Thus, the goal of this study was to relate plant species density and biomass with landscape structure, stand age and spatial variation of ecological structure at different spatial scales.

2. Methods

2.1 Study Area

The study was conducted in a landscape mosaic of 22 x 16 km^2 in Yucatán, México. The climate is tropical, warm, with summer rain and a dry season from November to April. Mean annual temperature is ca 26ºC, and mean annual precipitation between 1000 and 1200 mm, concentrated between June and October. The landscape consists of Cenozoic limestone hills with moderate slope (10-25°) alternating with flat areas, and the elevation ranges from 60 to 160 m.a.s.l (Flores and Espejel 1994). The landscape is dominated by seasonally dry semideciduous tropical forests of different ages of abandonment after traditional slash-and-burn agriculture (Figure 1).

2.2 Remotely sensed data and imagery processing

A Spot 5 satellite image acquired on January 2005 was geo-referenced to Universal Transverse Mercator Projection (WGS 84) and radiometrically corrected to minimize the effect of atmospheric scattering. A false color composite image was created from bands 2 (red), 3 (near infrared), and 4 (mid infrared). This composite image was used as a spatial reference framework for selecting suitable training sites. At least three training sites were selected for each of the following land-cover types: 1) 3-8 y-old secondary forest; 2) 9-15 y-old secondary forest; 3) >15 y-old secondary forest on flat areas; 4) >15 y-old secondary forest on hills; 5) agricultural fields; 6) urban areas and roads. The training areas and the false color image were used to perform a standard supervised classification of the Spot 5 bands using the maximum likelihood algorithm (Idrisi Kilimanjaro V14.1, 2004). The overall accuracy and Cohen's Kappa statistic were used to assess the accuracy of the map (Campbell, 1987).

2.3 Calculation of landscape pattern metrics

We selected the following metrics that have been found relevant in landscape studies (Mazerolle & Villard, 1999): patch density (PD), edge density (ED), mean area weighted shape index (SHAPE_AM), mean area weighted proximity index (PROX_AM), mean area weighted Euclidean nearest neighbor distance (ENN_AM) and total edge contrast index (TECI; see McGarigal et al. 2002 for a description of each metric). To calculate the proximity index, a search radius of 10 pixels (300 m) was used, which coincides with empirically derived evidence about the average size of a patch type. The weighted edge contrast between vegetation cover classes, required to compute the total edge contrast index, was calculated as the inverse of the Morisita-Horn similarity index between each pair of vegetation cover classes.

2.4 Species density and biomass data

Field data were recorded from a hierarchical plant survey conducted during the rainy season of 2009. First, 23 landscapes of 1 km^2 were selected encompassing the whole range of forest fragmentation; within each landscape, 12 sample sites were located following a stratified random design considering each of the four secondary forest cover classes (276 sampling sites in total). Each sampling site consisted of two concentric circular plots: all woody plants > 5 cm

in DBH (diameter at breast (1.3 m) height), hereafter referred to as adults, were sampled in a 200 m^2 plot; whereas 1-5 cm DBH woody plants, hereafter referred to as juveniles, were sampled in a nested 50 m^2 subplot. In each site, we identified all woody plants, and measured their diameter and height. The number of adults, juveniles and all woody plant species was computed. To calculate above-ground biomass, two equations were employed: one for individuals ≥ 10 cm in *DBH* (Cairns et al, 2003) and the other for individuals < 10 cm in *DBH* (Hughes et al, 2000).

2.5 Data analysis

Multiple regression and variation partitioning methods (Bocard et al, 2004) were used to quantify the effects of landscape structure and spatial dependence on species density and biomass. First, a model using landscape structure and stand age variables was fit to the response variables using multiple regression. Then, a multiple regression model using spatial variables derived from a principal coordinate of neighbor matrices (PCNM) analysis of plot locations was fit to the response variables. Finally, the two models were combined into an overall regression model and variation partitioning was performed to determine the relatively importance of landscape structure variables, stand age, pure spatial dependence and shared variation on species density and biomass.

PCNM analysis and multiple regressions were used to identify landscape structure and stand age variables related to response variables at different spatial scales (Bocard et al, 2004). First, we partitioned the spatial model for each response variable into several additive submodels, and run a variogram analysis of significant PCNM vectors to identify their scale and assign them to one of three groups: very board scale (distances of 8001 to 10500 m), broad scale (distances of 2001 to 8000 m), and local scale (distances of 0 to 2000 m). Then, we calculated predicted values of species density and biomass corresponding to each spatial submodel. Finally, a multiple regression model using stand age and landscape structure metrics was fit to the predicted response variables for each submodel (very broad, broad and local scale).

3. Results

The land cover thematic map of the study area is shown in Figure 1. This landscape covers a total area of 37 242 ha; 94.3% is covered by forest in any of the four vegetation classes, and only 5.7% is covered by agriculture, urban areas and roads. The overall accuracy calculated for the map was 75.6%, and the Kappa index was 0.7.
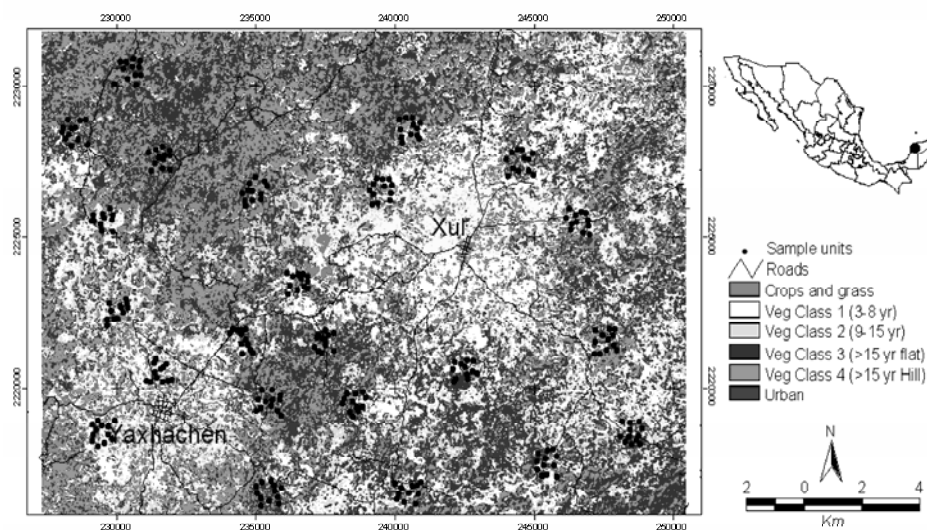

Figure 1: Location and land cover map of the study area obtained from a supervised classification.

Multiple regression results indicated statistically significant relationships between species density and stand age, PD, ED, SHAPE_AM and TECI (Table 1). Relationships involving PD and SHAPE_AM were consistently negative, indicating that plant diversity decreases as the number of patches increases and as the shape of a patch type becomes more irregular. On the other hand, biomass was best explained by stand age, PROX_AM, ENN_AM and TECI (Table 1). Biomass in all groups consistently responded negatively to ENN_AM and TECI and positively to PROX_AM, indicating that biomass decreases with distance between patch types of the same vegetation or as the perimeter of the focal patch type increases its contrast with other patches types. For all groups of plants, stand age was positively associated to species density and biomass, except for juvenile biomass (Table 1).

Table 1: Regression standardized coefficients for predicting species density and biomass from stand age and patch type metrics

DEPENDENT VARIABLE	PREDICTOR VARIABLE	ALL WOODY PLANTS	ADULT PLANTS	JUVENILE PLANTS
Biomass		$(R^2 = 0.68)$	$(R^2 = 0.68)$	$(R^2 = 0.16)$
	AGE	0.725*	0.734*	-0.316*
	PD			
	ED			
	SHAPE_AM			-0.181*
	PROX_AM	0.110*	0.110*	0.107***
	ENN_AM	-0.095**	-0.096**	
	TECI	-0.080**	-0.081**	
Species density		$(R^2 = 0.26)$	$(R^2 = 0.44)$	$(R^2 = 0.09)$
	AGE	0.444*	0.634*	0.254*
	PD	-0.218**	-0.128***	
	ED	0.322*	0.248**	0.190**
	SHAPE_AM	-0.363*	-0.349*	-0.260*
	PROX_AM			
	ENN_AM			
	TECI			-0.175**

Variables included in the model with * $p<0.001$, ** $p<0.05$, *** $p<0.1$

The variation explained by stand age, landscape structure and spatial dependence varied between response variables, and between adults and juveniles (Figure 1). Total variation explained by the models was consistently higher for biomass (34-71%) compared to species density (28-52%), and highest for adults, lowest for juveniles, and intermediate for all plants (Figure 1). Variation partitioning for adults and all individuals revealed that stand age was the single most important factor accounting for 47% of the total variation in biomass. In contrast, for species density, landscape structure and spatial dependence combined had a comparable or even stronger effect than stand age (Figure 1). On the other hand, variation partitioning for juveniles showed a strong influence of spatial dependence on biomass and species density, accounting for 18% and 19% of the total variation, respectively.

Species density and biomass displayed spatial variability across PCNM vectors. For all individuals, adults and juveniles, these vectors accounted for 20%, 20% and 26% of among-site variability in biomass, and for 12%, 18% and 19% of among-site variability in species density, respectively. The relationships between explanatory variables and species density and biomass are given in Table 2. At the very broad scale, explanatory variables accounted for 4 to 14% of variation. For all individuals, stand age was the variable that contributed most to the model for biomass, whereas landscape structure metrics contributed more than stand age to the model for species density. At the broad scale stand age is the explanatory variable that contributed most both to species density and to biomass. Finally, at the local scale, only one landscape metric contributed significantly to among-site variation in biomass, whereas no significant relationship was found between environmental variables and species density.
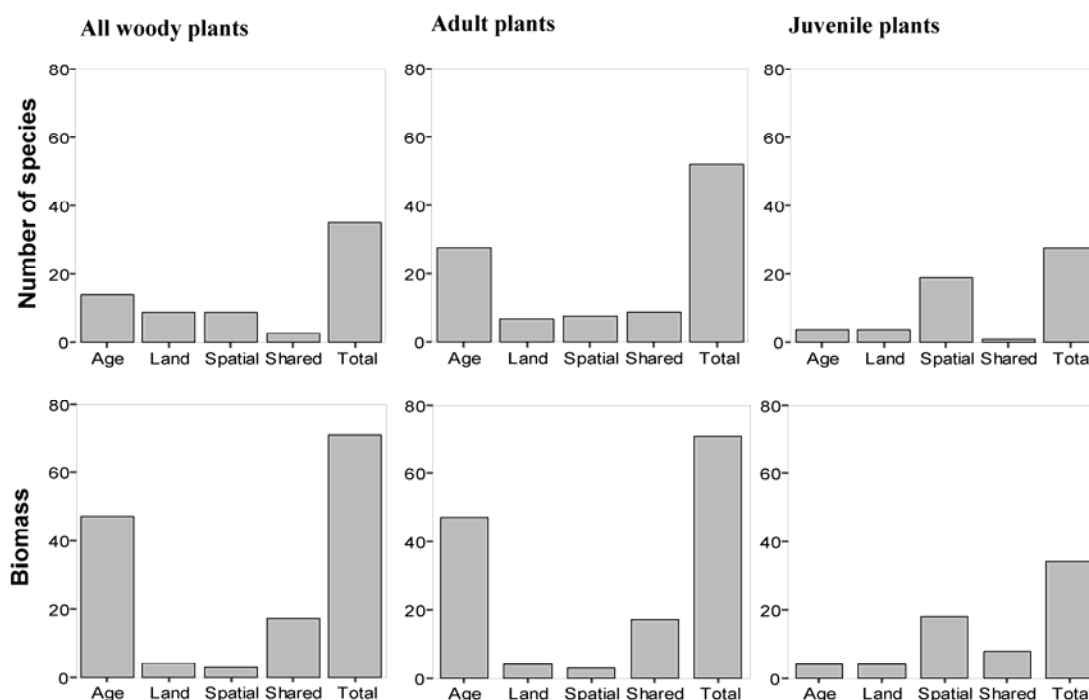
Figure 2: Partitioning of the variation of species density and biomass using landscape structure variables (Land), stand age (Age) and PCNM variables (space) for different groups of plants

Table 2: Regression standardized coefficients of predictor variables (age and landscape structure) that explain significant components of spatial patterns of biomass and species density at different scales

DEPENDENT VARIABLE	PREDICTOR VARIABLE	ALL WOODY PLANTS			ADULT PLANTS			JUVENILE PLANTS		
		Very Broad	Broad	Local	Very Broad	Broad	Local	Very Broad	Broad	Local
Biomass		($R^2 = 0.04$)	($R^2 = 0.07$)	($R^2 = 0.09$)	($R^2 = 0.04$)	($R^2 = 0.07$)	($R^2 = 0.09$)	($R^2 = 0.04$)	($R^2 = 0.04$)	($R^2 = 0.02$)
	AGE	0.192*	0.271*		0.192*	0.271*		-0.187*	-0.202*	
	PD									
	ED									
	SHAPE_AM									
	PROX_AM			0.112***			0.112***			0.124**
	ENN_AM	-0.147**		-0.254*	-0.147**		-0.254*			
	TECI		-0.105***			-0.105***				
Species density		($R^2 = 0.14$)	($R^2 = 0.07$)		($R^2 = 0.05$)	($R^2 = 0.05$)		($R^2 = 0.10$)		
	AGE	0.266*	0.231*		0.154**	0.224*		-0.256*		
	PD		-0.134**							
	ED	0.413*			0.201**			0.332*		
	SHAPE_AM	-0.277*			-0.208*			-0.231*		
	PROX_AM									
	ENN_AM									
	TECI									

Variables included in the model with * p<0.001, ** p<0.05, *** p<0.1

4. Discussion

Exploring how patterns of species richness and biomass change across spatial scales is important for conservation and management of TDF as it may reveal the factors that create or maintain biological diversity and promote carbon storage. The results of this study allow us to draw several conclusions. First, considering all individuals and adults, stand age was the most important variable for biomass and showed a positive association. In contrast, landscape

structure and spatial dependence had a comparable or even stronger effect on species diversity than stand age. These results are consistent with recent findings in tropical forests showing that long-term monitoring data follow chronosequence patterns for basal area, but not for species density, indicating that stand age largely determines basal area –and biomass, whereas species density seems to be strongly affected by other factors operating at the local and landscape level (Chazdon et al. 2007).

Our results also show that, for juveniles, pure spatial dependence appears to be the most important predictor of both species density and biomass. This result could either imply strong dispersal/recruitment limitation, or be due to an environmental component that was not considered, such as topographic or soil variables (Jones et al, 2008).

PCNM submodels allowed us to link the spatial distribution of species density and biomass to stand age and landscape structure at different spatial scales. At the very broad scale, stand age contributed most to biomass, and landscape structure to species density. At the broad scale, stand age contributed most to both species density and biomass.

Finally, we found a strong negative association between species density and PD and SHAPE_AM, as well as a positive association between species density and edge density (ED). These results may suggest that moderate levels of disturbance may enhance species richness in a forest-dominated landscape. However, high levels of disturbance resulting in a high degree of fragmentation can have a strong negative impact on species richness (Hill and Curran, 2003).

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Spatial gradients of landscape metrics as an indicator of human influence on landscape

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Abstract

Landscape metrics have been widely used for mapping of land cover/use change and analysing relationships between landscape pattern and processes. Natural factors and human activity diversify and homogenize landscape simultaneously. The aim of our study was to analyze the extent and magnitude of human influence on landscape along landscape gradients near main roads. We calculated several landscape metrics for gradients along main roads of Tartu and Tallinn on Estonian Basic Map (1:10 000) from different years (1997/1998 and 2004/2005). We compared the gradients of landscape metrics to determine how the anthropogenic areas have expanded in 10 years and whether the housing and infrastructure tend to expand more quickly on fertile soils. The results showed that the housing has mostly expanded on fields eliminating the possibility to use fertile soils for agriculture or foresting. The pressure on forest areas was not as intense as on agricultural areas. The gradients enable to compare the changes in landscape structure in time and space at the same time.

Keywords: spatial gradients, landscape metrics, settlement structure

1. Introduction

Changes in landscape are caused by natural and anthropogenic factors. Natural changes occur during a long time, mostly due to climate change. The anthropogenic impact on landscapes is expressed by changes in land use related primarily to changes in the settlement structure.

Natural factors and human activity diversify and homogenize landscape simultaneously. Landscape metrics that means all parameters that quantify the spatial pattern of landscape from topographic measures (Vivoni et al. 2005) to proportions of land use/cover, shape and area metrics (Palmer 2004) have been suggested for measuring landscape diversity. These metrics enable to evaluate habitat suitability for animals and birds (Weiers et al. 2004), nutrient fluxes and losses (Uuemaa et al. 2005). Attempts to relate landscape metrics to human perception of a landscape have been made as well (Antrop and Van Eetvelde 2000). Both human activities and those of other biota in landscape may be generalised as landscape consumption (Oja, Prede 2004).

Different software has been developed to calculate landscape metrics like FRAGSTATS (McGarigal and Marks 1995) but there are no unambiguously interpretable indicators and there can be found numerous researches on the issue of the use/interpretation of landscape metrics (Wu 2004, Uuemaa et al. 2005, Oja et al. 2005, Uuemaa et al. 2007).

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Land use changes caused by urbanization can severely affect biodiversity, energy flows, biochemical cycles, and climatic conditions (Baker et al. 2001). A systematically effective approach to analyze the effects of urbanization on ecosystems is to study the changes of ecosystem patterns and processes along an urban-to-rural gradient (McDonnell et al. 1997) focusing on the recognition of unique urban texture from the landscape types (Weng 2007). Spatiotemporal gradient analysis enables to determine how urban centres have been enlarged in space and time.

The aim of the study was to analyse how the housing areas have expanded in 1997–2005 in Estonia near two Estonian largest cities – Tartu and Tallinn and how is this process influenced by major roads. Second aim was to determine whether the new housing areas tend to expand on fertile soils or not.

2. Methodology

We chose two study areas around two largest cities of Estonia (Figure 1). The size of the study areas was limited by the availability of the Estonian Basic Map (1:10 000) for two different years set: 1997/1998 and 2004/2005. Estonian Soil Map (1:10 000) was used for soil data. Soils were reclassified according to their suitability for agriculture (Kõlli 1994). This classification takes into consideration the fertility of soils and how suitable they are for agricultural activities.

For determining whether the new housing has expanded mainly on fertile soils or not, we distinguished new settlements by using centroids of the buildings and spatial join. Analysis was performed with vector data as buildings require high accuracy of the map.

For analysis of the influence of the roads on housing structure and landscape structure we calculated several landscape metrics with moving window method in Fragstats 3.3 (McGarigal and Marks 1995). We used edge density (ED), patch density (PD), mean shape index (SHAPE_MN), Simpson's diversity index (SIDI) on landscape level and patch density on class level. On these landscape metric maps we calculated gradients along main roads 100m, 200m... 1900m, 2000m from the road for different years to see how the settlement and landscape structure has changed in time.
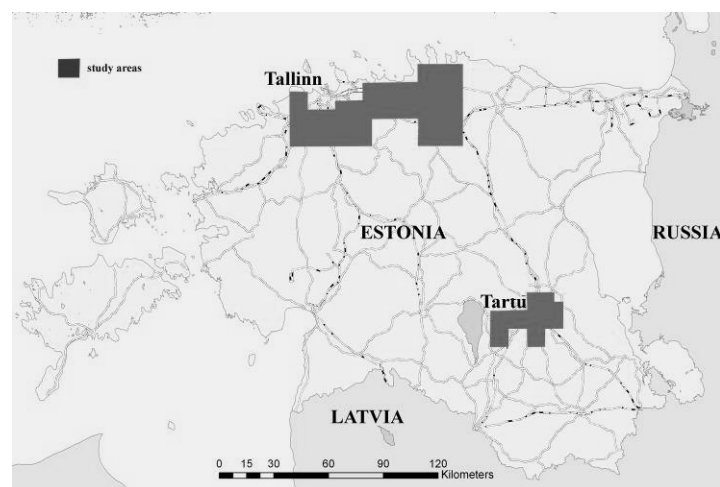
Figure 1. Study areas near Tallinn and Tartu

3. Results and discussion

The analysis showed that on the Tartu study area most of the new buildings were built on fields (45,5%) in 1997−2005 and 33,3% of the new buildings were built on the yards. On the Tallinn study area most of the buildings were built on the yards (51,4%) and only 23,9% on the fields. 74,7% of the Tartu study area had soils with good suitability for agricultural activities and 81,6% of the new buildings by area were built on these soils. In Tallinn study area only 56,2% had soils with good suitability for agricultural activities and 79,8% of the buildings by area were built on these soils in 1997−2005. The results showed that most of the new buildings are located on fields with good suitability for agricultural activities and the housing tended to expand near main roads (Figure 2 and Figure 3).
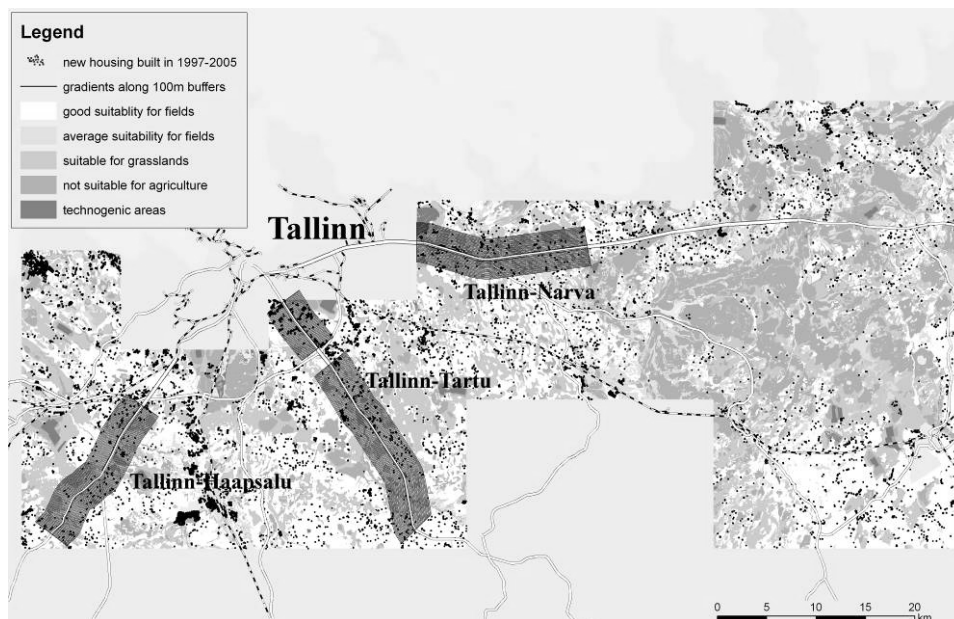
Figure 2. New housing areas on the study area of Tallinn and gradients along main roads (Tallinn-Narva, Tallinn-Tartu, Tallinn-Haapsalu). Soils are classified according to their suitability for agricultural activities (Kõlli, 1994).
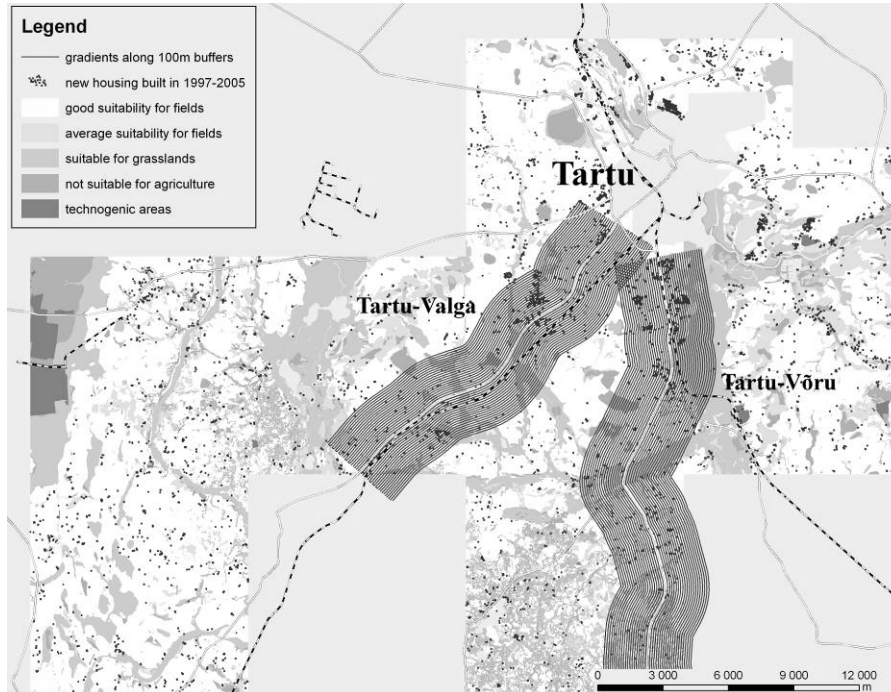
Figure 3. New housing areas on the study area of Tartu and gradients along main roads (Tartu-Valga, Tartu-Võru). Soils are classified according to their suitability for agricultural activities (Kõlli, 1994).

The analysis of gradients showed that all the landscape metrics analyzed indicate very well housing density as edge density, patch density and Simpson's diversity index had higher values with higher housing densities and in case of mean shape index it was vice versa. The distance from the road appeared to play more important role than distance from the city in existing patterns of housing (Figure 4). However it can be assumed that housing densities decrease as we move away from the city and from the road but these results not show very clear trends. Part of it was beacause small settlements near roads that give higher peaks of edge density, patch density and Simpson's diversity index. Nevertheless the landscape was more fragmented in 300m − 1000m then in 0m − 300m and 1000m − 2000m. This shows that the housing tends to expand not directly near the main road but a little bit farther. People prefer to get quickly out of the city by main road and then move up to 1km away from the main road.
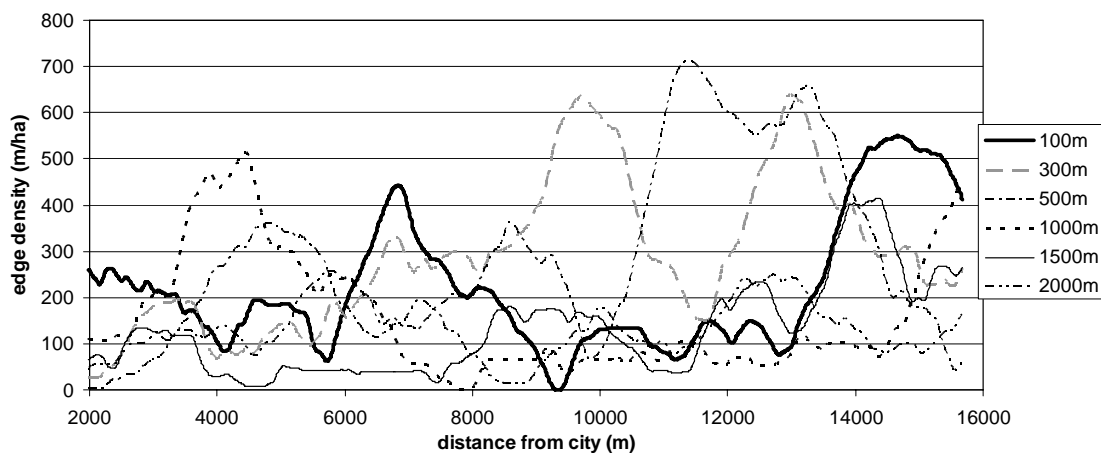
Figure 4. Gradients of edge density for Tartu-Valga road in Tartu study area in year 2005. 100m, 300m, 500m, 1000m, 1500m and 2000m mark the distance of the gradient from the road.

The temporal analysis showed that spatial fragmentation has increased significantly from 1997 to 2005 near main roads. The fragmentation has increased more quicly from 0m −1000m of the road and up to 10km from the cities (Figure 5). In distance 2000m from the main road the landscape structure has not changed significantly (Figure 6).
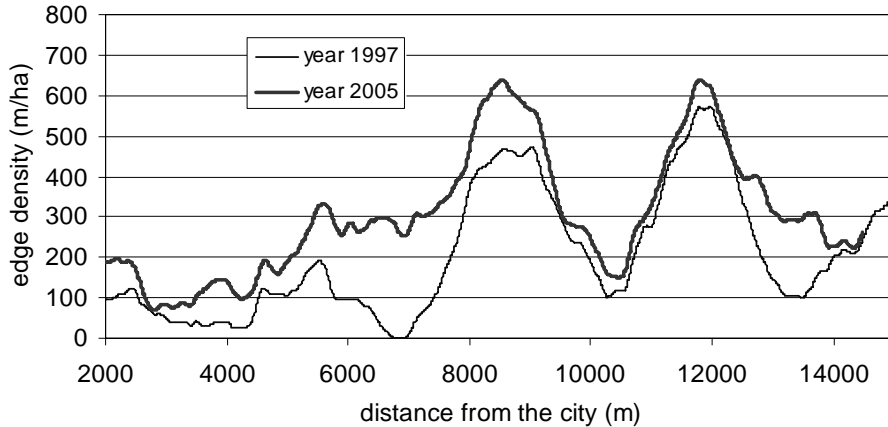
Figure 5. Gradients of edge density for Tartu-Valga road in Tartu study area for years 1997 and 2005 at 300m from main road.
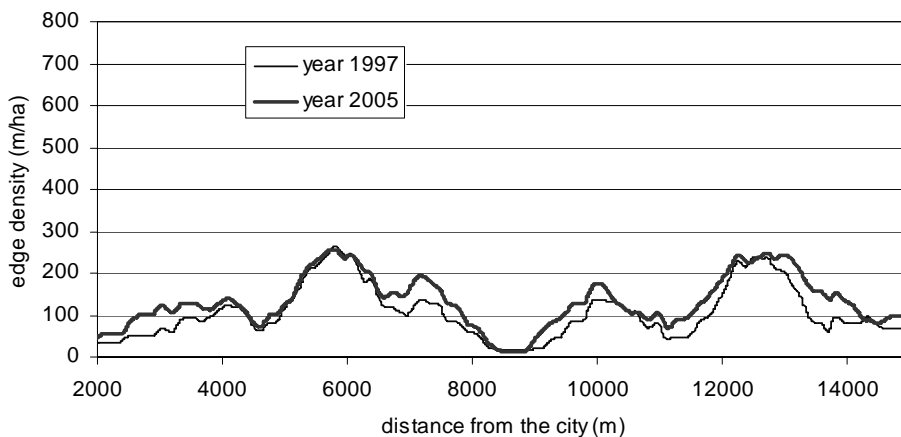
Figure 6. Gradients of edge density for Tartu-Valga road in Tartu study area for years 1997 and 2005 at 2000m from main road.

These results enable to better understand the importance of infrastucture in suburbanisation process and use this knowledge in planning process. Housing areas built on fields have already faced serious problems because of the ruined amelioration systems and these problems with loss of fertile soils may deepen unless local municipalities do not direct planning process more effectively.

4. Conclusions

The housing areas have expanded significantly during years 1997–2005 and the landscape fragmentation has also therefore increased. Housing areas also ted to expand on fertile soils that are very suitable for agricultural activities. Therefore the area of the fertile soils is decreasing due to suburbaisation in Estonia. The housing areas expand more quicly within 10km radius of the cities and within 1000m radius of the main roads. These methods and results can be used in planning process for decision suport.

Acknowledgements

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Landscape assessment tools for adaptive management of tropical forested landscapes

Socio-economic diagnosis of a small region using an economic farming system modeling tool (Olympe). An approach from household to landscape scales to assist decision making processes for development projects supporting conservation agriculture in Madagascar

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Abstract

Two agricultural development projects based on conservation agriculture and agriculture/livestock integration are implemented in Madagascar with both a "watershed approach" and a "farming system approach": the BV-lac project in the area of Lake Alaotra and the BVPI-SEHP project in Vakinankaratra (Central highlands) and South-East. A farming systems reference monitoring network (FSRMN) has been set up with two objectives: i) to help the project in decision making processes for choosing appropriate technologies that will be developed according to a farmer's typology using prospective analysis, ii) to monitor the project's economical impact in the short and medium term. The farming system modelling approach is based on a software developed by INRA-CIRAD-IAMM ("Olympe", JM Attonaty, INRA), The approach is based on partnership (smallholder, farmers' organizations, project operators and local administration), farming system analysis, and modelling for a Decision Support Systems (DSS) project orientation. Adoption of conservation agriculture (CA) represents both a real change of paradigm for local farmers and a real challenge for agriculture and natural resources sustainability.

Keywords: Farming system modelling, DSS (decision support system), conservation agriculture, Madagascar.

Introduction

A model has two main roles: a figurative role in representing the system (how it functions) and a demonstrative role (possibilities and strategies). Combining these two roles leads to an explanatory model whose function is to represent a specific phenomenon that derives from general phenomena (management, accounting, and so on) as a function of the local conditions that characterise the farming systems. To understand farming systems as a "productive system" and the logic behind technical choices recalls the "systemic approach", widely used in the classical farming systems approach. The approach described here is based on partnership, farming system analysis and modelling for a Decision Support Systems (DSS) for development projects. In the past, methods and instruments were developed to help individual farmers make decisions (Attonaty et al., 1999). Today, we are faced with an increasing number of problems in which the several different stakeholders involved have also different interests. The aim is not to find THE optimal solution as do models based on linear programming or game theory but to create models that lead to acceptable compromises between the different stakeholders.

1 Method; rationale for using the software "Olympe" for Farming Systems Modelling (FSM)

Detailed knowledge of local farming systems and farmers' strategies in different contexts such as pioneer zones, rehabilitation areas or traditional tree-crop belts can contribute to building improved and better adapted solutions to help farmers make the right decision about their future

investments at the right time. In collaboration with INRA and IAMM, CIRAD developed a software called " Olympe " that enables the modelling of farming systems (Penot 2003). Olympe is an economic modelling tool to develop farming simulations in order to help individual decision-making at farm level and may be used for project decision making. There is also a module at regional level with farm groups that allow the assessment of various types of flows between groups (farmers' organisation, villages ….).

Farming systems modelling associated with a farm typology can therefore be used to help projects in testing scenarios with various types of technologies (and risks) in order to assess what is the right technology for the right farmer at the right time according to farmers' strategies. Then, it aims to provide guidelines for agricultural and development policies for institutions and/or donors. Olympe can be used in a variety of situations and with different methodological approaches: comparison of cropping systems, the economics of farming systems and resource management ("farm management counselling"[*]), prospective analysis, regional approach, and even for "role game."

Olympe simulator has been developed by J-M Attonaty (INRA Grignon, France) and associated partners from CIRAD and IAMM. It builds simulations by series of 10 years for one or more stakeholders, provides results and summarizes the results as a function of the needs of each stakeholder (Figure 1). Olympe is based on the systemic analysis of farming systems. The overall objectives of using Olympe are the following: i) to identify smallholders' constraints and opportunities in a rapidly changing environment in preparation for the adoption of new cropping systems or any other organisational innovation and to understand farmers' strategies and their capacity for innovation., ii) to assess their ability to adapt to changing economic conditions, price crises and technological change, iii) to provide a tool to understand the farmers' decision-making process and to put information about farming systems in the social and economic context (through a regional approach), and iv) to undertake prospective analysis and build scenarios based on climatic risks and fluctuating commodity prices.

It is also possible to calculate impact at the regional scale on various groups of farms (as a function of a given typology). Building scenarios trough prospective analysis allows to test the robustness of any decision or technical choice. Data analysis obtained with Olympe should be discussed with farmers in partnership in order to validate scenarios and guarantee a high degree of representativeness and accuracy. For instance, a network of selected representative farms can be monitored for several years to diagnose constraints and opportunities and to measure the impact of technical change. One of the main outputs of such an approach is the assessment of the impact of technical alternatives or choices from an economic and environmental point of view.

Fig. 1: An iterative analysis of the problem.
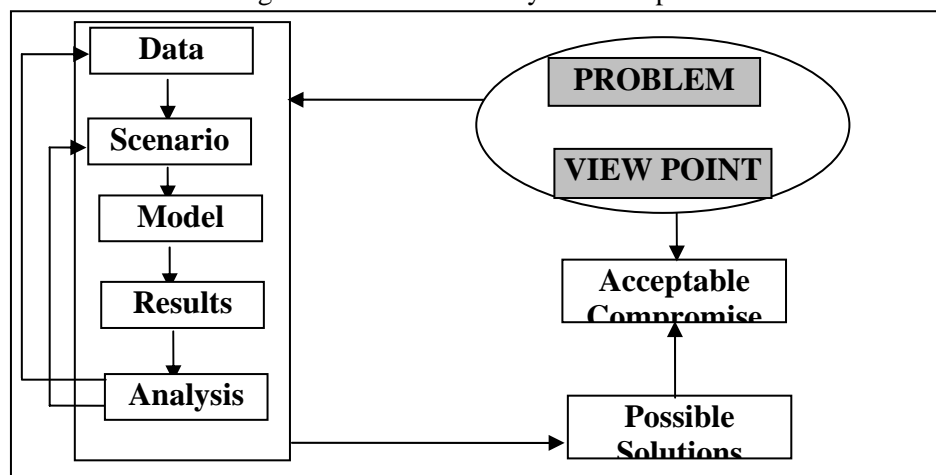
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[*] "Conseil de gestion" in French.

2 Diversification and CA (Conservation Agriculture) as alternatives for sustainable development

The sustainability of agriculture is becoming a major concern. Ecological and agricultural sustainability are linked trough degraded environment, fragile soils, fertility, biodiversity, and the protection of watersheds. Crop diversification and rapid technical change characterise the evolution of existing farming systems. It is important therefore to analyze and understand the key elements of the history of innovation processes so as to be in a position to make viable recommendations for development. Among other technologies, CA techniques are based on 3 main items: no tillage, associated permanent covercrops and crop rotation. CA triggers a real change of paradigm for local farmers. Besides those constraints, CA techniques, though yields might not be significantly above that of tillage systems, provide a more sustainable production pattern through the climatic buffer effect of mulching and cover-crops.

The notion of "economic sustainability" places emphasis on the profitability of specific technical choices such as analysis of margins, generation of income, return to labour and capital as a function of a specific activity, analysis of constraints and opportunities, etc...From the point of view of farming systems, both at the regional scale, and at the level of the "community" where there are serious constraints in land availability, and in access to capital and information. Analysis of farming systems and knowledge about smallholders' strategies in the different contexts are key factors that should be taken into account.

Negotiations between stakeholders and better knowledge of the relations between the State and farmers are essential if we are to improve the effectiveness of future projects and development actions. The main objective of topic-oriented research centred on the analysis of decision-making processes at different levels (farms, community, projects, and regional or national policy makers) would thus be to provide socio-economic information to policy makers to improve decision-making processes in agricultural development. The processes of innovation (farmers) and of decision-making (both farmers and developers) are key research topics in sustainable development. And the analysis of farming systems, the characterisation of agrarian systems and the identification of stakeholders' strategies are key components to a better understanding of these issues. The factors that determine change in a sustainable development perspective need to be related to each specific context. Important issues such as the effect of decentralisation, globalisation and its effects on prices, as well as on local economies and public policies, environmental topics (biodiversity, sustainability) are impossible to circumvent. One expected output would be the clear identification of the conditions required to ensure future projects are viable at the decision-making level. Farming system modelling through a farming system reference monitoring network provides a tool for technical choices made by decision makers with respect to agricultural policy.

The main aim of this paper is to describe a possible global approach using a modelling tool which includes the identification of knowledge gaps and opportunities to promote actions and projects or the implementation of policies that respect the need for sustainable development, as well as those of local stakeholders, developers and researchers. The historical dimension is very significant in this type of analysis even if economic commodity cycles can be very rapid. So far, rebuilding the past with a modelling tool and creating new evolution scenarios through prospective analysis can be linked to improve the efficiency of development-oriented research. The impact of technical change should take into account the effect of sustainability on both farmers' livelihood and on the environment. Success in diversification strategies requires a certain number of conditions: access to capital or credit, technical options (innovations), access to information, markets, and to farmers' organisations in order to improve marketing, and so on.

From farmers to developers

The use of Olympe enables a comprehensive understanding of how a given farming system functions and provides as well a tool to model prospective technical choices, price scenarios, and even ecological scenarios to test the robustness of technical choices. These tools can be used at different scales: that of the local community or that of regional, national or international scale, depending on the stakeholders and on the commodity involved. Emphasis should be on the farmers and on the other people directly involved in the farmers' environment, including the government (development policies at the national level). Participatory and partnership approach, Action–Research (RD) are the main methodologies used in the approach.

A prospective tool to assess the resilience of systems in the face of risk
In this case the focus is on providing decision-making aid to administrators, projects, and decision makers as well as to farmers themselves. Analysis of climatic events or the impact of price volatility, or any other economic risk allows the definition of scenarios where the resilience of a given farming system can be quantified. Care needs to be taken into account for the possible or induced perverse effects of "playing with scenarios" whose only validity is how representative they are. Olympe can also be used to reveal such induced or perverse effects. A typical example is that of the introduction of drop irrigation to save groundwater that eventually leads to over-consumption of water. The "revealing character" of FSM leads to enhanced sensitivity by stakeholders to problems that are not initially obvious. In this case, its use is very close to that of role game. Farming systems modelling can be used as a prospective tool to build scenarios about potential farm pathways, and to define agricultural policies, recommendations, to test the viability of recommendations as a function of local constraints, to assess different impacts, and the matching of policies to the real situation faced by the farmers. Risks analysis is a key component in this approach. Farming system modelling through a FSMN enables to effectively assess at the farm level risks and expected outputs from a choice.

3 The References Farming System Monitoring Network (RFSMN): a comprehension tool of farmers' strategies and follow-up evaluation.

A References Farming System Monitoring Network (RFSMN) is a set of representative farms that show various agricultural situations dependent on soil/climatic units as well as socio-economical situations, resulting from a typology. Farms are surveyed in-depth then followed and updated every year in order to measure i) the impact of the projects' implementations, ii) the development policies in progress, iii) the resulting innovations' processes (Penot, 2008). The objective through a follow-up is to measure the impact, the evaluation, the prospective analysis and decision-making process inside projects (choice of technologies to be promoted and level of intensification according to farm types for example…). A prospective analysis allows the comparison between potential scenarios and reality. The final objective is to allow development operators in contract with projects to measure impacts and re–orientate rapidly their actions.

Parallel to the RFSMN, the project sets up procedures of plot and farms levels data acquisition whose objective is to obtain detailed and precise data allowing simulation and further prospective analysis,. A "plot database" common to all contracted operators allows the identification of cropping pattern, with data effectively observed in the fields that will feed the simulation. With the adoption of "farming system level approach", rather than the traditional "plot level", the project sets up "farming books", on a voluntary basis in order to record farm evolution, description of cropping systems and main simple economic factors and analysis (gross and net margin, return to labour) and to observe tendencies and farms' trajectories.

Identification of a regional operational typology:
The criteria of discrimination for the farm typology are the following: i) access to various types of soil with referring cropping systems (irrigated rice plantation, poor water management rice fields, upland crops on "tanety"), ii) rice self-sufficiency and farm size, iii) level of

intensification and use of inputs and production target (subsistence farming, sale…), iv) off-farm activities and diversification (agricultural productions and non agricultural activities, v) type of labour and material (manual, animal traction, motorization or combined traction) and type and use of labour (familial and external).157 farms were surveyed in 2007/2008. For each identified type, four farms were modelled with the Olympe software, in 2007/2008, and were supplemented by a series of additional farms essential for a good follow-up/evaluation. The final network was composed of 48 farms. The databases of local operators (AVSF, BRL, SD-Mad…) provide reliable indicators on farmers' technical plot pathways which are monitored by the project so as to build average standard cropping patterns. We need at least a minimum of 10 plots with a homogeneous average of production (Coefficient of variation lower than 30%). The most complete database (from BRL/Madagascar), integrates 2800 plots. A complete review of the main results of these databases led to the identification of more than 120 cropping patterns that took into account: varieties, plot position on the transect and practices.

Construction of standard cropping patterns according to the system of dichotomic keys.
The use of simple dichotomic keys for selecting the right technologies apparently most adapted to local plot conditions (soils, climax, etc…) are currently used. Modelling "step by step" with Olympe is done in the form of a prospective analysis by testing scenarios differentiated according to the farming and socio-economic situations. The definition of the dichotomic keys remains a big step in the process of choosing technologies promoted by projects. We currently use several modalities to identify the adapted cropping pattern to be recommended: i) the use of local plot databases as presented above. ii) the use of the official recommendations from GSDM, synthesized in tables of description of cropping patterns from the CA handbook (O Husson et al., 2009) with generic dichotomic keys, iii) The use in the long term (2010) of a software tool specifically developed for selection of cropping patterns according to morpho-pedological constraints, "PRACT" developed by K Naudin (CIRAD/URD SCRID) in 2010.

Indicators of management and measurement of risk
The software enables the creation of scenarios based on various types of adoption and modification of technical patterns (cropping or livestock), more or less intensive. Then, the objective is to test the robustness of technical choices, and then the impact on production systems caused by climatic risks (cyclones, output lower due to the attack on a plant's health, excess or lack of water, etc…) or economic (impact of the volatility of the farm prices and the inputs). Indicators (standard formula Excel type) allow to calculate ratios and traditional economic variables of management. The identification of simple ratios and the consequent analysis of the financial farm situation after a technical choice, a real or simulated one, largely facilitated the appropriation by operators and led to a better integration of their recommendations, while taking into account the concepts of risk for the farmer. Such an approach allows operators to better include and understand farmers' strategies in production factors allowance and finally in the farmers' priorities of resource allocation according to their knowledge, their own experimentation, their potential opportunities and their current situation.
Risks lead to shocks and disturbances. Impact strength can be regarded as the capacity of a system to overcome disturbances while maintaining its vital functions, its structure and its capacities of control. It is thus important for the capacity of a system to be able to resist by maintaining the essence of its structure and "modus operandi" while including the possibility of any change. It is based on the conditions which maintain an initial balance though potentially unstable which can lead to another balance. One can measure it by the magnitude or the level of disturbances a system can resist or absorb until the rupture or the change of that system's structure. The robustness can then be interpreted like a particular impact strength according to a definition close to that used in statistics. Risks are assessed through the use of the "hazard

module" in Olympe which enables the creation of scenarios with any changes in inputs/output prices as well as production and yield.

Conclusion

3 RFSMN's are currently been set up (lake Alaotra and Vakinankaratra). Farming system analysis, training and modelling with a simple tool (Olympe), linked with the use of existing plot databases managed by operators contributed largely to the effective development of a real "farming system approach" in these projects. Training and the use of the tool lead to a real pedagogic impact on various operators. Extentionists and staff managers start to adapt their recommendations and feel more empowered to take responsibility in their extension activities. Processes of innovations are better recorded and integrated into the analysis. The farming system approach allow as well to better consider other level of action such as farmers' organisations for services (required for CA adoption such as information, credit, access to inputs or marketing…) or the regional level (watershed, village area, community territory…).

The case of CA is a strong example that has also largely contributed to the adaptation of its very particular and specific agricultural systems towards a stronger more encompassing adaptation (simplification, adaptation, medium/low intensification, increase of the possible range of the techniques functioning for the local specifics). The idea for support of the different services for agriculture (dispersion, credit, supply, commercialisation) were changed and their importance finally accepted by the operators whose initial goals were simple and concise: to have the maximum of parcels improved without regard for the type of exploitation. The installation of tools has therefore vastly contributed to the strengthening of the approach itself and its usage and acquisition by the development operators in a type of "learning by doing" training approach. A key element was equally the participation of the genuine partners since the beginning of the operation in July 2006 at Lac Alaotra. The concept, the approach, the donations, and the results were all explored, analyzed, and validated by the operators which in turn strengthen their will to understand, master, and use the tools presented in this text.

There still is a need to implement a value analysis in the near future of the results obtained from the more interesting scenarios compared to what effectively happened in the last 5 years.

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Network theory to conserve and reconnect forested landscapes

Connectivity loss in human dominated landscape: operational tools for the identification of suitable habitat patches and corridors on amphibian's population

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Abstract

Landscape connectivity is a key issue for biodiversity conservation. Many species have to refrain to move between scattered resources patches. This is particularly the case for the common frog, a widespread amphibian migrating between forest and aquatic habitats for breeding. Face to the growing need for maintaining connectivity between amphibians' habitat patches, the aim of this study is to provide a method based on habitat suitability modelling and graph theory to explore and analyze ecological networks. We first used the maximum entropy modelling with environmental variables based on forest patches distribution to predict habitat patches distribution. Then, with considerations about landscape permeability, we applied graph theory in order to highlight the main habitat patches influencing habitat availability and connectivity by the use of the software's Conefor Sensinode 2.2 and Guidos. The use of the JRC Forest/Non Forest European map for the characterisation of common frog terrestrial habitat distribution combined with the maximum entropy modelling gives promising results for the identification of habitat discontinuities within a regional perspective. This approach should provide an operational tool for the identification of the effects of "landscape barriers and corridors" on populations structure. Then, the method appears as a promising tool for landscape planning.

Key words: common frog, landscape connectivity, habitat suitability modelling, graph theory, maximum entropy modelling

1. Introduction

Landscape connectivity is considered a key issue for biodiversity conservation and for the maintenance of natural ecosystems stability and integrity. Landscape connectivity defines the degree to which the landscape facilitates or impedes movement among resource patches (Taylor and al. 1993). In fragmented and heterogeneous human dominated landscapes, movements across the landscape matrix area are key process for the survival of plant and animals species. Maintaining or restoring landscape connectivity has become a major concern in conservation biology and land planning (Pascual-Hortal and Saura 2008) and especially for amphibians. Indeed, amphibian's life cycle involves seasonal migrations between terrestrial and aquatic

habitats which constrain them to regularly cross an inhospitable fragmented landscape matrix making them vulnerable to land degradation and connectivity loss (Allentoft and O'Brien 2010). Anthropogenic barriers as railways and major roads limit amphibians' migrations and movements. Many species have to refrain to move between small, scattered patches of different resources, instead of one, large patch. In this sense, habitat fragmentation constitutes the main driver of gene flow reduction (Allentoft and O'Brien 2010). This is particularly the case for the common frog *Rana temporaria*, a widespread amphibian in Europe occurring in various habitat types and migrating between forest and aquatic habitats for breeding (Miaud and al. 1999). The study focus on habitat availability and landscape connectivity, under the assumption that connectivity is species specific and should be measured from a functional perspective (Saura and Torné 2009). The focus is on viable habitat patches, in relation to the ongoing need for a holistic approach to landscapes and habitats. The overall goal is to find a continuum for habitat suitability of the species in question. Graph theory and network analysis have become established as promising ways to efficiently explore and analyze landscape or habitat connectivity. However, little attention has been paid to making these graph-theoretic approaches operational within landscape ecological assessments, planning, and design. We are working towards a methodological approach to address habitat quality assessment and connectivity from an operational point of view in order to support planning. To illustrate the basic principles of the proposed method, an ecological example using the European common frog *Rana temporaria*, in the French Alps region is presented. The approach is based on three main steps: i) Achievement of a probability of occurrence distribution map by the use of presence data and maximum entropy modelling ii) Simulation of dispersal areas in order to define the main connections between common frog ponds iii) Assessment of the main connected ponds by the use of graph theory and the software Conefor Sensinode 2.2 (Saura and Torné, 2009). We present here preliminary results on undergoing research, in order to exchange ideas in relation with this approach.

2. Methodology

2.1 Study site and sampling

This study focuses on the French departments Isère and Savoie (French Alps). This area is about 1415126 km² (see figure 1). The common frog is a typical species within this region where it breeds in various types of aquatic habitats. Because at the subalpine belt landscape connectivity is not the main driver of the frog dispersal patterns due to environmental constraints (*i.e.* climatic variables), we focused on the common frog populations occurring under the tree line (1400-1600 meters). The common frog was detected in 97 ponds under the tree line within this area. The sample design followed a genetic sampling strategy framework based on tadpoles between 1999 and 2002 (Pidancier and al. 2002). The geographic location of each sampling is known. For this preliminary study, we reduced the area to a surface of 4067 km² including 47 located ponds (see figure 1).
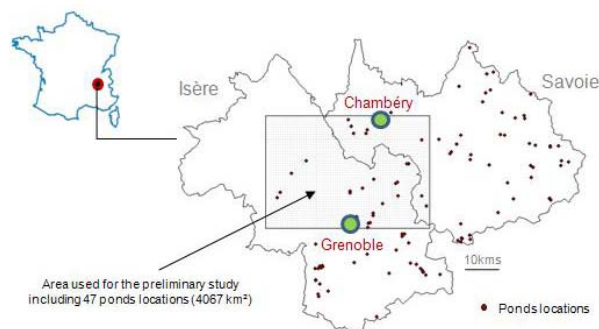

Figure 1: The study area.

2.2 Probability of occurrence distribution

We considered the 47 genetic sampling locations as presence data. It must be noted that the approach is based in present information only of the common frog within the study area. We used the maximum entropy modelling approach. In order to assess the distribution of the probability of detection of the common frog, we used in particular the software MaxEnt (Philips and Dudik 2008). Different environmental variables were analyzed and used to develop the probability of occurrence distribution map with MaxEnt. The common frog during its terrestrial cycle is very sensitive to the type of land cover to cross in order to reach its required forest habitat for summer and winter (Miaud and al. 1999). Based on radiotracking surveys and expert knowledge, the common frog seems to be very sensitive to the distribution of small forest patches around the pond area. Consequently, we computed and integrated in the analysis different environmental variables in relation to ecological and spatial requirements of the common frog. The forest habitat distribution around the aquatic habitat was also considered within the modelling:

1. Land cover based on Corine Land Cover 2006 (level 3).
2. Slope and elevation derived from a 50m DEM (French National Geographic Institute).
3. Landscape indices based on forest patches distribution from the European Forest/Non Forest map (resolution: 25m) provided by the Join Research Centre JRC. For this, we used Fragstats (McGarigal and Marks 1995) with a moving window of 3000m and we selected the following basics landscape indices: Mean Forest Patch Area, Largest Forest Patch Index and Forest Patch Density.
4. Distance to forest patches crossed by a river derived from a combination of the hydrological network map (French National Geographic Institute) with the European Forest/Non Forest map.

2.3 Connections between ponds

We quantified the connection between the ponds in relation with landscape matrix permeability by the use of a friction map and the least cost modelling. Least cost modelling allows to simulate the dispersal of the common frog in relation to the landscape matrix permeability between habitat patches. The matrix permeability is considered with the use of a friction map that provides inputs in terms of the ability of the common frog to cross the landscape matrix. The friction map layer is a raster map where each cell (landscape unit) expresses the relative difficulty of moving through that cell (Fulgione and al. 2009). In this study, the present friction map was computed by inversing the previous probability of occurrence distribution map from MaxEnt (Fulgione and al. 2009). Indeed, a fundamental assumption is that habitat suitability and permeability are synonyms, and that both are the inverse of ecological cost of travel (Beier and al. 2007). We added the highways and the urbanized areas to this friction map in order to integrate the main "impermeable barriers" for the common frog (i.e. high friction value). For the calculation of the least cost paths between each pond, we used the ArcView extension Path Matrix (Ray 2005).

2.4 Assessment of ponds' importance for connectivity

We considered all the located ponds as nodes in order to use graph theory, in particular Conefor Sensinode software (Saura and Torné 2009). The least cost paths distances between the ponds allowed to calculate a set of quantitative connectivity rules between ponds. The software calculates a Number of Components NC index which identify a set of connected nodes (*i.e.* components) in which a path exists between every pair of nodes. The software also allows to calculate a Probability of Connectivity index (PC), which combines the attribute of the nodes with the maximum product probability of all the possible paths between every pair of nodes

(Saura and Torné 2009). All the more, the software provides to assess node importance for connectivity by removing systemically each node and recalculating the PC when that node is not present in the landscape. Node importance is quantified by an index dPC which corresponds to the importance of an existing node for maintaining landscape connectivity according to the PC index variation when the node is removed (Pascual-Hortal and Saura 2008). In our case study, we used a threshold dispersal distance of 1500m based on radiotracking surveys of common frog migration pattern between ponds and suitable terrestrials' habitats.

3. Results

3.1 Probability of occurrence distribution map and habitat suitability map

The use of 15% of the dataset for cross validation gives an Area under the Curve (AUC) of 0.75 for the ROC curve analysis which corresponds to a good discriminative capability between predicted presence and absence according to Pearce and Ferrier (2000). The figure 2 shows the resulting common frog probability of occurrence distribution map. The environmental variables with highest gain when used in isolation are Elevation and Largest Forest Patch Index in the jackknife test of variable importance in MaxEnt. MaxEnt also calculates several threshold values at each run and values exceeding them may be interpreted as reasonable approximation of the potential distribution of the considered species suitable habitat. As suggested by Phillips and Dudik (2008), we used the 10 percentile training presence (mean = 0.339) in order to obtain the potential distribution of the common frog in relation to suitable terrestrial habitat distribution (see figure 2). The potential distribution of the common frog obtained (see figure 2) allows to identify the effect of the dense urbanized areas and highways as main barriers and unsuitable habitats. This distribution also suggests the potential presence of discontinued potential suitable areas for the frog depending on forest patches distribution impacted by human activities. In this context, further genetic considerations will help to quantify and identify the disconnections between frog populations in relation to human dominated areas distribution.
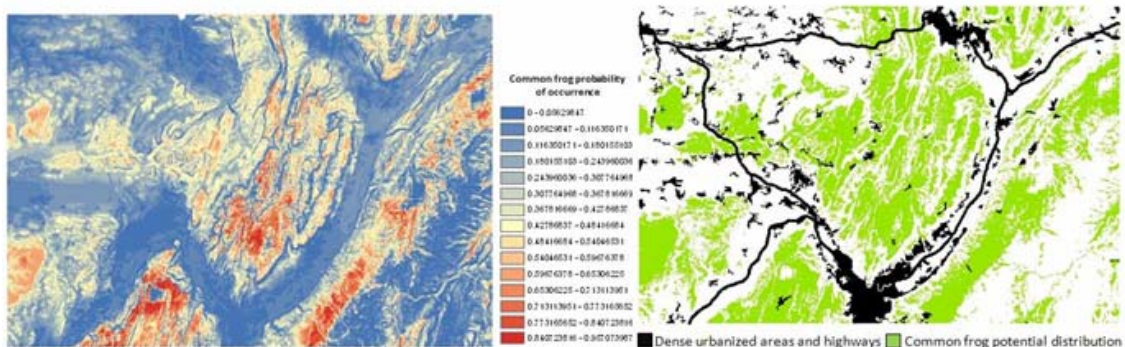
Figure 2: Probability of occurrence distribution for the common frog with the maximum entropy modelling and resulting potential distribution of the common frog (10 percentile training presence of 0.339 as the probability threshold) (area of 4067 km²).

3.2 Ponds' importance for connectivity

The use of the NC index (see figure 3) provides a rapid identification of the connected ponds in relation with landscape matrix. In our case study, most of the ponds are isolated by distance and few ponds can be considered as connected in term of seasonal migration patterns. All the more, most of the connected ponds identified are located in homogenous suitable habitat. This is due to the orientation of the ponds location dataset for genetic analysis (genetic isolation by distance). Within this context, we plan to improve the analysis using a more detailed pond' distribution dataset in order to assess local connectivity in the near future. On figure 3, some ponds isolated and closed to urbanized areas appear as important for regional connectivity (high

dPC value). This may suggest that these ponds could be considered as critical isolated ponds in relation with barriers in a human dominated landscape context (presence of disconnections between suitable large areas for the common frog). For the moment, this interpretation of the dPC has to be considered with caution given that we did not use yet all the exisiting ponds locations within the area (missing nodes). We plan to complete the study with the computation of a dPC index based on genetic distance between ponds for the quantification of the potential genetic connections.
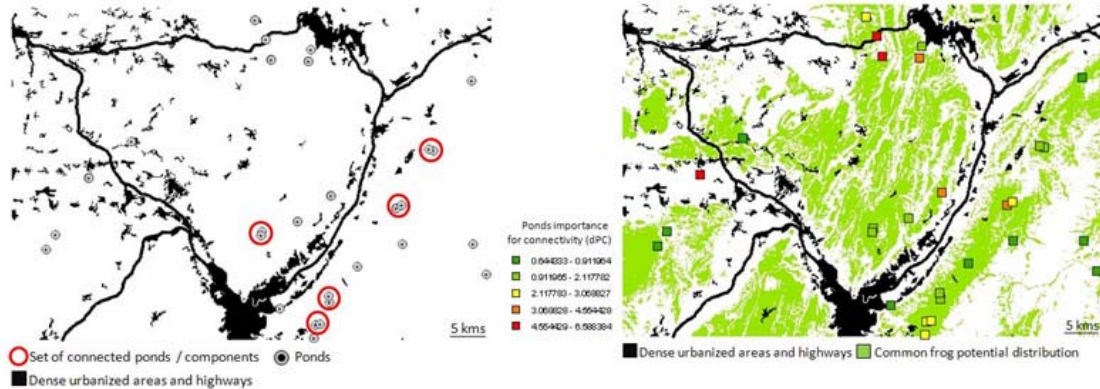
Figure 3: Set of connected ponds (components) identified with the computation of the Number of Components index (NC) and ponds importance for connectivity based on the computation of the dPC index (warmer colours correspond to a highest importance for connectivity).

4. Discussion

In this preliminary study, the use of the JRC Forest/Non Forest European map for the characterisation of common frog terrestrial habitat distribution combined with the maximum entropy modelling gives promising results for the identification of discontinuities in distribution within a regional perspective. This approach in tandem with genetic considerations should provide a tool for the identification of the effects of "landscape barriers and corridors" on populations structure in relation to common frog and its terrestrial habitat requirements. The use of a friction map combined with least path modelling appears also as a crucial key issue for the quantification of connections between habitat patches when dealing with landscape matrix permeability. Even if an efficient calibration of a friction map is possible for a local approach (Janin and al. 2009), the computation of a relevant regional friction map remains quite difficult for the common frog given the existence of heterogeneity in dispersal patterns driven by local environmental conditions. This suggests that it should be more efficient to consider regional connectivity for amphibians from the point of view of genetic and spreading diseases as the chytrid fungus (Rödder and al 2009). Landscape connectivity should be better considered for a local perspective in relation with common frog migration patterns between its aquatic and terrestrial habitats. In this context, the use of a graph theoretical approach appears as a promising tool for the assessment of local landscape connectivity for the common frog given that the Conefor Sensinode software provides a powerful tool integrating considerations about habitat patches distribution and suitability in a landscape matrix context surrounding habitat patches. Moreover is proven as an operational tool to identify barriers and important patches for planning purposes.

Acknowledgements

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Landscape genetics

GEOME
Towards an integrated web-based landscape genomics platform

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Abstract

The aim of the GEOME project is to develop a WebGIS-based platform for the integrated analysis of environmental, ecological and molecular data through the implementation of an original set of combined databases, spatial analysis and population genetics tools, in a High Performance Computing context. GEOME will support tasks of landscape ecologists and resource conservation managers who increasingly have to use geo-referenced data but are not trained to efficiently use Geographical Information Systems together with appropriate geo-environmental information and spatial analysis approaches. Preliminary developments (three first applications) are already available here: http://lasigpc8.epfl.ch/geome/

Keywords: landscape genomics, geocomputation, environmental data, adaptation, GIS

1. Introduction

Since 2000, we are witnessing a progressive integration of the fields of ecology, evolution and population genetics (Lawry 2010). The combination of landscape ecology with population genetics led to the advent of landscape genetics whose goal is to understand how geographical and environmental features structure genetic variation in living organisms (Manel 2003). Recently, landscape genomics (Luikart 2003; Joost 2007; Lawry 2010) emerged as a research field at the interface of genome sciences, environmental resources analysis and spatial statistics. The combination of these fields permits to assess the level of association between specific genomic regions and environmental factors to identify loci responsible for adaptation to different habitats (Lawry 2010). Henceforth, knowledge of geo-environmental data and skills in GIS are a necessity to develop research or management activities in these landscape sciences. To favor the use of landscape genomics and to facilitate access to necessary geo-environmental data, GIS and spatial analysis tools, the development of a robust and efficient computer infrastructure is required. Therefore, GEOME will constitute a robust, easy-to-use and powerful internet platform based on High Performance Computing (HPC), able to handle and process very large genome and environmental data sets, and offering facilities for the statistical and (geo)visual analysis of results (http://lasigpc8.epfl.ch/geome/).

The GEOME platform will support access to free geo-environmental data (database) and provide dedicated GIS tools to scientists and professional users (e.g. landscape ecologists or resource conservation managers) who often do not have a background nor a training in

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GIScience (Geographic Information Systems and spatial analysis), and do not have time to acquire them. To be able to carry out their investigations, these users need support to i) find appropriate geo-referenced environmental data sets to address their research problematics, ii) integrate their own data sets (e.g. presence/absence of genotypes, of species) with the geo-environmental information mentioned here above, iii) benefit from specific analytical tools implemented within a simple GIS environment.

Several web-based platforms already exist in the domain of genomics or other genetic topics (population genetics, phylogenetics). An interesting example is the BIOPORTAL platform (http://www.bioportal.uio.no), a web-based service platform developed at University of Oslo for phylogenomic analysis, population genetics and high-throughput sequence analysis. BIOPORTAL is the largest publicly available computer resource with 300 dedicated computational cores in a cluster named TITAN. Currently, applications in chemistry and economics have been integrated, but other applications will be added along the way. Another example is GeneGrid, a web-based collaborative industrial grid computing solution developed in the United Kingdom. It was initiated by the Belfast e-Science Centre (BeSC) under the UK e-Science programme and supported by the UK Department of Trade & Industry (DTI). This platform gives access to collective resources, skills, experiences and results in a secure, reliable and scalable manner through the creation of a "Virtual Bioinformatics Laboratory". GeneGrid provides seamless integration of a series of heterogeneous applications and data sets that span multiple administrative domains and locations across the globe, and presents these to the scientist through a simple user friendly interface (Kelly et al. 2005).

It has to be noted that no existing Web-based platform includes the combination of services to be implemented within GEOME. This combination will permit to address the issue of local adaptation through the complementary implementation of a theoretical approach in population genomics (Foll and Gaggiotti 2008) and of a spatial analysis approach (Joost et al. 2007).

2. Main issue addressed: local adaptation

In the present context of rapid global climate change, ecologists and evolutionists show a renewed interest to study adaptation (Holderegger et al. 2008). Local adaptation in particular is an important issue in conservation genetics. For example, this process has to be better understood in order to correctly consider the effects of transfers of individuals between populations, which is often a technique proposed to replenish genetic variation and to reduce negative effects of low genetic diversity. The study of local adaptation is also likely to provide objective and unambiguous criteria to characterize conservation areas – in combination with models of predictive habitat or Species Distribution Models (SDMs, Guisan and Thuiller 2005) – which are the most worthwhile preserving.

In parallel, development of low impact sustainable agriculture as well as husbandry based on adapted breeds is of priority to most countries in the world, and is of key importance to emerging countries in particular. The genetic basis and the level of adaptation of livestock breeds to their environment has to be investigated, in order to reach better understanding of the relationship between environment and the adaptive fitness of livestock populations, and to favor sustainable production systems based on adapted breeds.

During the last decade, "tremendous advances in genetic and genomic techniques have resulted in the capacity to identify genes involved in adaptive evolution across numerous biological systems" (Lowry 2010). There is now an important need to provide tools allowing the acceleration of the study of how landscape-level geographical and environmental features are involved in the distribution of functional adaptive genetic variation, as highlighted by recent publications (Lowry 2010). A few years ago, Holderegger and Wagner (2008) already stated that "Novel approaches linking spatially explicit environmental analysis with molecular genetics could offer effective means to study the spread of adaptive genes across landscapes".

Landscape genomics is one of these approaches, and GEOME will facilitate its use by means of a database providing access to the many geo-environmental data sets available worldwide.

3. Access to remote environmental data

Joost et al. 2010 provided a non-exhaustive list of the many environmental data sets available on the Internet. Different initiatives at the regional and global levels influence and promote the creation of Spatial Data Infrastructures (SDIs) to access these data. They also work on the harmonization, standardization, interoperability, and seamless integration of the different GIS layers constituting these data. An example is the Global Earth Observation System of Systems (GEOSS), which is a worldwide effort to connect already existing SDIs and Earth Observation infrastructures. Through its developing GEO portal and related Common Infrastructure, GEOSS is foreseen to act as a gateway between producers of environmental data and end users, with the aim of enhancing the relevance of Earth observations for global issues and to offer public access to comprehensive information and analyses on the environment (GEO secretariat 2007).

Today's effort on the technical development of SDI components clearly focuses on the exchange of geodata in an interoperable way (Bernard and Craglia 2005), which is highlighted by the concept of web services and the related Service Oriented Architecture (SOA). Web services constitute a "new paradigm" allowing users to retrieve, manipulate and combine geospatial data from different sources and different formats using HTTP protocol to communicate (Sahin and Gumusay 2008). Web services enable the possibility to construct web-based application using any platform, object model and programming language. The Open Geospatial Consortium (OGC) has specified a suite of standardized web services. Two of them are of particular interest for data providers and users: the Web Feature Service (WFS) that provides a web interface to access vector geospatial data (like country borders, GPS points or roads) encoded in Geographic Markup Language (GML) and the Web Coverage Service (WCS) that defines a web interface to retrieve raster geospatial data of spatially distributed phenomena such as surface temperature maps or digital elevation models (DEMs). In addition, the Web Map Service (WMS) defines an interface to serve georeferenced map images suitable for displaying purpose based on either vector or raster data. GEOME's Web services will provide the geocomputational context with the support of an indispensable High Performance Computing (HPC) infrastructure to enable the processing of associations models between millions of loci (see section 4) and hundreds of environmental parameters (see section 5).

4. GEOME's challenge: whole genome scan

One of the next major steps in evolutionary biology is to determine how landscape-level geographical and environmental features are involved in the distribution of the functional adaptive genetic variation (Lawry 2010). This challenge will take place in a context where the amount of molecular data to be analyzed will expand very rapidly. Indeed, after the long (13 years) and expensive (3 billion dollars) human genome sequencing project (completed in 2003), the American National Institutes of Health (NIH) proposed in 2004 the challenge to sequence one human genome for $1'000 (Service 2006). And future generation of sequencers will allow researchers to get to genomic data faster and at a lower cost. For example, the theoretical potential of single-molecule/nanopore sequencing is undeniable (Tersoff 2001). Based on this technology, with a 100 nanopores in parallel, a mammalian genome could be sequenced in 24 hours with the main cost being the chip itself, probably around $1'000 (Blow 2008). Several alternative low cost sequencing technologies are under way, even decreasing to $100 in the case of the Pacific Biosciences technology (Eid et al. 2009).

Thus, any research project in landscape genomics will very soon be given the opportunity to investigate the entire genome of sampled individuals, meaning that from now on HPC is required to process these huge quantities of data when compared to eco-climatic parameters. To be ready to handle such volumes of data, the GIS laboratory (LASIG) involved in the

development of GEOME is also a partner within the EU FP7 NEXTGEN, the first project in the area of conservation genetics that proposes a comparative analysis of whole genome data at the intraspecific level (http://nextgen.epfl.ch). NEXTGEN will also need GEOME's expertise in the area of remote sensing, digital elevation models and other environmental data in general.

5. Geo-environmental data in a HPC environment

Environmental sciences are a data-intensive domain in which applications typically produce and analyze a large amount of geospatial data. Moreover, due to the multi-disciplinary nature of environmental sciences (e.g. ecology, climate change, etc.), scientists need to integrate large amount of data distributed all around the world in different data centers. A local cluster is the first mean to upscale computational capacities when the workflow can be distributed into many independent jobs.

When the number of jobs is very large and/or users do not belong to the Institution owning the cluster, grid computing can be an efficient solution. Following Foster et al. (2008), a grid is a parallel processing architecture in which computational resources are shared across a network allowing access to unused CPU and storage space to all participating machines. Resources could be allocated on demand to consumers who wish to obtain computing power. Recent studies have had a successful approach to extend grid technology to the remote sensing community (Muresan et al. 2006), as well as in the field of disaster management (Mazzetti et al. 2009) making OGC web service grid-enabled.

One of the largest scientific grid infrastructures currently in operation is the Enabling Grids for E-sciencE (EGEE) infrastructure bringing together more than 120 organisations to provide scientific computing resources to the European and global research community. The currently 120'000 CPUs available in EGEE are essentially used by the High Energy physics community, but part of EGEE is also opened to other disciplines such as environmental sciences or genetics. A grid environment federates its users through Virtual Organizations (VOs), which are sets of individuals and/or institutions defined by a set of sharing rules (e.g. access to computers, software, data and other resources). One particular VO of interest is named Biomed; it has currently access to 20'000 CPUs and is willing to accept the envisioned GEOME on the Biomed VO.

6. Conclusion

No software tool presently exists to answer challenges of developing better approaches for linking ecologically relevant data sets to specific loci or genes. Moreover, no software tool can currently integrate geo-environmental variables and molecular data within a WebGIS environment, with analysis modules included i) to detect loci under selection according to two complementary approaches, ii) to analyze and characterize the spatial distribution of these loci, and iii) to produce predictive habitat maps derived from them. Thanks to a robust HPC infrastructure, GEOME's existing and future Web services will be useful to a very large number of users, and will possibly contribute in understanding how landscape-level geographical and environmental features are involved in the distribution of the functional adaptive genetic variation.

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Road ecology: improving connectivity

The effect of highways on native vegetation and reserve distribution in the State of São Paulo, Brazil

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Abstract

Highways affect the environment in different distances and intensities. This work aims to: 1) estimate areas which have been ecologically affected by highways in the whole state of São Paulo, for each type of vegetation, and in all nature reserves; and, 2) investigate the influence of highway distance on the native vegetation cover and on the reserve distribution. The area of study was the state of São Paulo (southeastern Brazil), where two biodiversity hotspots biomes occur: the Brazilian Atlantic Forest and the Brazilian Cerrado. About 10% of São Paulo has been ecologically affected by highways, being the dense ombrophylous forest and most nature reserves greatly impacted. Native vegetation and reserve areas have increased nearly logistically with the increase of highway distance. We suggest that in order to improve conservation and restoration strategies, highways should be carefully considered, prioritizing remote areas.

Keywords: road ecology, tropical forest, biodiversity conservation, tropical savanna, South America.

1. Introduction

Highways connect cities and facilitate transportation of products and services. They are a symbol of development for people living in remote areas (Pfaff et al. 2007). However, highways also affect air, soil, vegetation, wildlife (Forman et al. 2003). In tropical forest, the first effect of a highway construction is the forest fragmentation (Freitas et al. 2010), which cause edge effect and isolation of sensible species populations (Murcia 1995; Develey and Stouffer 2001; Fuentes-Montemayor et al. 2009; Laurance et al. 2009). Moreover, highways cause road kill, pollutants emission and facilitate fire events (Forman *et al*. 2003; Fahrig and Rytwinski 2009; Laurance et al. 2009). Some species show an road avoidance behavior, which reduces functional connectivity (McGregor *et al.* 2008; Fahrig and Rytwinski 2009), that is, the capacity of landscape to facilitate biological flux (Taylor *et al.* 1993).

The extension of the highway effects depends on the considered biotic or abiotic factor (Forman and Deblinger 1999). For instance, exotic plant species can reach up to 100 m from the road, whereas traffic noise can affect birds a hundred of meters far away from the road (Reijnen *et al*. 1995; Forman and Deblinger 1999; Trombulak and Frissel 2000; Palomino and Carrascal 2007). Roads near to forest fragments can affect their species richness and composition (Hansen and

Clevenger 2005; Palomino and Carrascal 2007; Fahrig and Rytwinski 2009; Laurance et al. 2009).

Understanding the relationship between highways and native vegetation would improve methods to select priority areas for conservation and restoration and the effectivity of those new wildlife nature reserves. This work aims to: 1) estimate areas which have been ecologically affected by highways, in the whole state of São Paulo, for each type of vegetation, and in all nature reserves; and, 2) investigate the influence of highway distance on the native vegetation cover and on the reserve distribution.

2. Methodology

The study area was the State of São Paulo, in the southeastern of Brazil. In that State, there are two biomes considered as biodiversity hotspots for conservation: Atlantic Forest and Cerrado (Myers et al. 2000).

We used the state's road map, produced by DER (2008) and classified by road types: non-paved roads, paved roads with two lanes, highways (paved roads with four lanes) and expressways (paved roads with at least four lanes and high traffic). We also used a native vegetation map with the following vegetation types: Savanna and Semideciduous Seasonal Forest (both from Cerrado biome), and Serra do Mar Coastal Forests, Araucaria Moist Forests, Mangroves and Atlantic Coast Restingas (from Atlantic Forest biome).

We included only the nature reserves classified as Full Protection in the Brazilian Environmental Legislation (SNUC) performing 62 nature reserves in the State of São Paulo.

We estimated the areas which have been ecologically affected by roads in the whole State of São Paulo, in each type of vegetation and in the nature reserves following the methodology used by Forman (2000). The area ecologically affected by roads was evaluate using the distance where the sensible bird species are affected because they are negativelly affected by roads (Reijnen *et al*. 1995, Forman 2000, Develey e Stouffer 2001). Roads with high traffic flow were considered those with the higher ecological effect, thus the buffer width varied to road type (Forman 2000, Liu *et al*. 2008): non-paved roads have 200 m buffer width, paved roads 365 m, highways 810 m and expressways 1000 m.

The relationship between native vegetation and road distance was evaluated using 10 non-inclusive buffers: 0-50 m, 50-100 m, 100-250 m, 250-500 m, 500-750 m, 750-1000 m, 1000-1250 m, 1250-1500 m, 1500-1750 m, 1750-2000 m. In each buffer, we measured the total area of native vegetation.

3. Result

Road density in the São Paulo State was 0.145 km/km^2. Paved roads were the most abundant (0.070 km/km^2), followed by non-paved roads (0.060 km/km^2), highways (0.010 km/km^2) and expressways (0.006 km/km^2).

More than 2,375,600 ha (10%) of the territory was affected ecologically by roads. The State of São Paulo was most affected by paved roads (4.7%), followed by non-paved roads (2.2%), highways (1.5%) and expressways (1.2%).

About 5.4% of the native vegetation cover were affected by roads. The Atlantic Forest biome has about 5.3% of its cover affected by roads, whereas 5.9% of the Cerrado biome were affected

by them. Between the ecoregions (Olson et al. 2001), Serra do Mar coastal forests were the most affected by roads (51%). However, in relation to its cover, mangroves have more of its cover affected by roads (16%). About 55% of nature nature reserves were affected by roads. Five of them showed more than 30% of their territory affected by roads.

There is more native vegetation cover as road distance increases (Figura 1). This relationship was nearly logistic for expressways (Figure 1).

4. Discussion

The State of São Paulo has a lower road density (0.15 km/km^2) than that considered as maximum for sustain populations of big predators (0.60 km/km^2; Forman and Alexander 1998). However, those roads affect the distribution of native vegetation and threat the efficiency of nature reserves. Near roads could cause a significant increase of mortality rates for many wildlife populations, even overcoming hunting (Forman and Alexander 1998).

Almost 10% of State of São Paulo is ecologically affected by roads. Forman (2000) found a double proportion (about 20%) to United States of America. However, the State of São Paulo has a very lower road density than USA (0.41 km/km^2; Forman 2000), indicating that more native vegetation is under threat of roads in our study area. Even many states of USA have higher road densities than State of São Paulo (0.15 km/km^2): Misouri (1.89 km/km^2), Arkansas (1.23km/km^2) and Oklahoma (1.18 km/km^2; La Rue and Nielsen 2008).

Laurance et al. (2009) state that non-paved roads represent a lower impact on vegetation and wildlife in tropical forests than paved roads because they usually are inaccessible during raining season (summer). However, our study showed that non-paved and paved roads affect more than highways and expressways because they are more abundant and spread all over the territory, showing higher densities (0.06 km/km^2 and 0.07 km/km^2 respectivelly) than highways (0.01 km/km^2) and expressways (0.01 km/km^2).

As expected, the dominant vegetation type - Serra do Mar Coastal Forests - was the most affected by roads. Serra do Mar Coastal Forests is distributed along coastline as well as many of road network in Brazil, representing one of the most important connection axis for national transportation (north-south). However, in proportion mangroves are highly affected by roads for the same reason.

Half of natural reserves is affected by roads. Five of them have more than 30% and three of them have more than 60% of their territory affected by roads, which represents a threat for their biodiversity. Roads facilitate hunter access and increase the probability of collision by vehicles (Laurance et al. 2009). Nature reserves near roads are probably under more conflicts with human population and more vulnerable to environmental degradation.

There is more native vegetation as far as the road is. Roads act as atractor to land use and deforestation (Nagendra et al. 2003; Freitas et al. 2010). For instance, in the Amazon Forest, about 95% of deforestation occurred at most 50 km far from roads (Laurance et al. 2009). Expressways are not too densely distributed as other road types, however they show a nearly logistic relationship to native vegetation cover indicating a strong negative effect to the nearby native vegetation. Thus, road distance could be used as indicator to predict the distribution of native vegetation in the future. We suggest that in order to improve conservation and restoration strategies, the effect of highways should be carefully considered, prioritizing remote areas.

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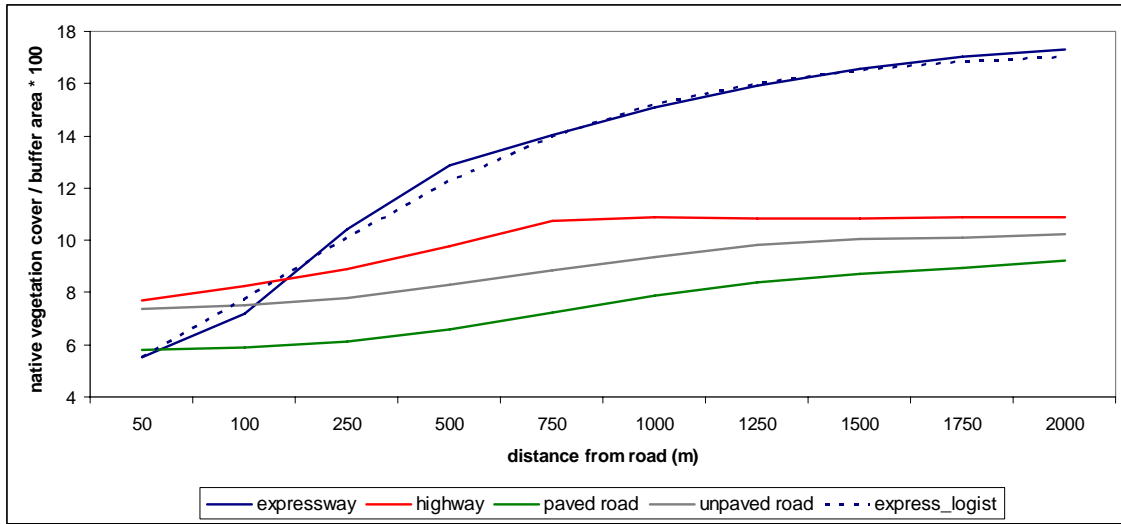

Figure 1: Native vegetation cover (%) in different distances from roads for each road type. Native vegetation cover increases nearly logistically (express_logist) in function to distance of expressways.

Detecting vulnerable spots for ecological connectivity caused by minor road network in Alicante, Spain

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Abstract

Applying land conservation planning allows to maintain and restore the ecological connections among natural remnants and protected areas in the territory. Roads increase the problem of habitat fragmentation, breaking large habitat areas into smaller ones, creating isolated habitat patches and decreasing connectivity in the territory.

Functional connectivity in Alicante's Province was analyzed using least-cost models. Applied connectivity models for the study of ecological processes and animal movements is a tool of great utility for landscape planning and Protected Areas management. Connectivity models are based in the creation of a friction surface that indicates the relative cost of moving target species across the landscape. Ecological corridors between the main protected areas and conflictive points that intersect with minor road network were identified.

Keywords: ecological connectivity, landscape model, cost-distance, road ecology.

1. Introduction

Land use changes in landscape are the main cause of fragmentation processes of natural habitats and populations of wild organisms, and it is recognized as one of the most important threats to the biodiversity maintenance (Harris 1984; Wilson 1988; Saunders and Hobbs 1991; McCullough 1996; Pickett *et al.* 1997; Fielder and Kareiva 1998; Fahrig 2003). Linear infrastructures like roads and railway networks are important barriers that limit movement and dispersion of terrestrial vertebrates, increasing the problem of habitat fragmentation and creating isolated habitat patches in the territory. The presence of a road may modify animal's behaviour and alter patterns of animal movement (Trombulak 2000).

It is fundamental for wildlife survival to maintain and restore the ecological connections among natural remnants and Protected Areas in the territory. The concept of ecological connectivity is shown as an essential element in the land-use planning. Landscape connectivity could be defined as the degree to which the landscape facilitates or impedes movement of organisms among resource patches (Taylor *et al.* 1993). This definition considers that connectivity is

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species and landscape specific, because it depends not only on characteristics of the landscape, but also on aspects of the mobility of the organism (Tischendorf and Fahrig 2000).

Application of connectivity models for the study of ecological processes and species movement is a useful tool in conservation planning (Adriansen *et al.* 2003; Nikolakaki 2004; Marulli and Mallarach, 2005; Driezen *et al.* 2007) and it can be an interesting tool for predicting the effect of changes in the landscape on connectivity in a quantitative way (Adriansen *et al.* 2003). These models produce a map of the relative cost of reaching particular areas in a landscape from a source.

This work presents a methodological spatial approach based on Geographical Information System (GIS) that (1) enables a connectivity diagnose of terrestrial landscape ecosystems and (2) makes possible the identification of vulnerable spots that have a critical importance for ecological connectivity. These results will provide useful guidelines for landscape conservation planning at local level (Municipalities and Local Administrations).

2. Methodology

2.1 Habitat maps

We created a land use map for Alicante's Province compiling information about land use and vegetation cover from different sources. The original map was the Spanish Forest Map (MFE50), which was reclassified. We used CORINE land cover map, road and railway network and urban areas cartography to complete it. The final map recognized 32 land-use types, of which 7 are linear structures. In order to improve a finer analysis resolution and to incorporate barriers and connection spots at landscape level, we also created derived cartography, as road network impact and urban areas impact maps (decreasing connectivity), and hydrological network map and tunnels and bridges map (improving connectivity). These maps were converted to raster format, with a cell resolution of 20x20 meters.

2.2 Least-cost analysis

Connectivity models are based on the creation of a friction surface that indicates the relative cost of moving for target species across the landscape (Figure 1). We used raster format, from ArcGIS software, with a cell resolution of 20x20 meters.
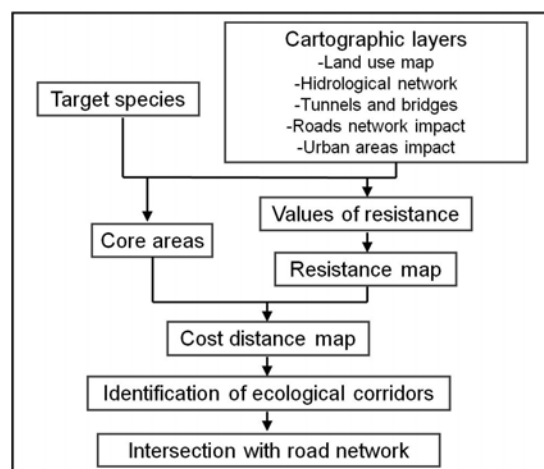
Figure 1: Methodology of the process followed.

We defined target species as forest mammals present in Alicante's Province, such as the stone marten (*Martes foina* Erxleben, 1777), the red fox (*Vulpes vulpes* Linnaeus, 1758), the wildcat (*Felis silvestris* Schreber, 1777) and the wild boar (*Sus scrofa* Linnaeus, 1758). These species use mainly riversides and ravines to move along the landscape, while urban areas and road network are the main barriers to their movements. We identified the core areas of target species as dense forested areas inside Sites of Community Interest (SCI) of Natura 2000, with a minimum area of 20 ha (McDonald and Barret 2008).

We determined the main landscape factors that have more influence on the resistance to forest mammals movement, creating a final friction map on GIS with a relative set of resistance values for land use covers and the other cartographic information layers (Figure 2), based on previous works (Sastre *et al.* 2002; Campeny *et al.* 2005; Gurrrutxaga 2005).
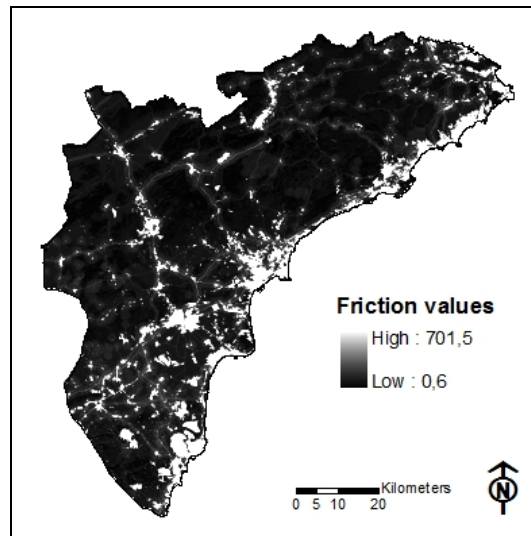
Figure 2: Friction map for Alicante's Province, with a relative scale from 0.6 to 701.5.

With this information, we created a cost-distance surface and calculated the least-cost route between natural areas. Finally, we carried out an identification of landscape linkages and ecological corridors and their intersection with the minor road network, in order to propose restoration activities to improve connectivity.

3. Results

We obtained a final map of the cost distance from habitat sources for target species (Figure 3). With this map, we were able to analyze the relative cost of reaching points in the landscape from a determined source. In this case, we analyzed the problem with connectivity between the Natura 2000 areas, and their intersections with the road network.

Results showed that core areas in the North of the Province were more connected than core areas in the South, caused by the presence of more natural areas and forests in the North.
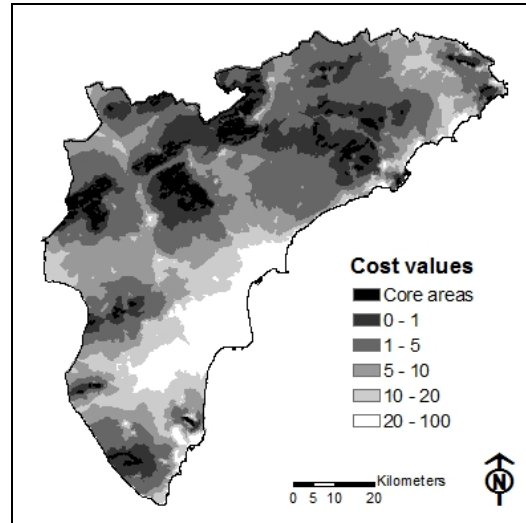
Figure 3: Cost distance map for Alicante's Province, in a relative scale from 0 to 100.

The cost distance values for the Alicante Province surface are showed in Table 1. The 20% of the area of Alicante's Province was classified with a very high level of connection and only the 9% of area was disconnected.

Table 1: Cost values in a categorical relative scale (from 0 to 100) of the Alicante's Province.

Category	Cost values	Total Area (Km^2)	%
Very high connectivity	0 – 1	1211.23	20.84
High connectivity	1 – 5	1975.92	33.99
Medium connectivity	5 – 10	1335.85	22.98
Low connectivity	10 – 20	765.31	13.17
No connectivity	20 – 100	524.28	9.02

Based on the cost distance map, we selected the areas with the lowest values in travel cost between the Natura 2000 areas, and then we proposed the main corridors between protected areas. We detected also the intersections between these corridors and the road network. Then, we used the cartography of transversal structures along the roads (tunnels and bridges) as connection spots, and searched for the conflictive areas for connectivity.

A good example of the application of this work, it can be observed in the North area of the Province, in the *Maigmó i Serres de la Foia de Castalla SCI* in a fragmented landscape (Figure 4). This Protected Area is surrounding by other natural areas, which are core areas for the target species. CV-80 and A-31 are two highways that limited connections by North and West. In these highways there are several transversal structures that could be adapted for improving connectivity. In the East area there are two minor roads (CV-802 and CV- 803) that are limiting connectivity, but the cost values are lower than in the other areas.
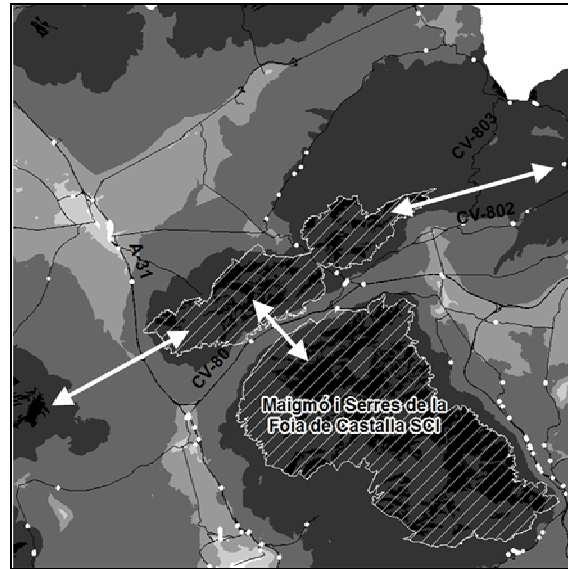
Figure 4: Detail of cost surface map of the *Maigmó and Serres de la Foia de Castalla SCI*, with the road network in black, bridges as white points, and arrows defining the main areas for wildlife movements.

4. Discussion

The methodology we use for evaluating ecological connectivity at a regional scale allows obtaining quick assessments, which can be very effective for land-use planning, and it is also a flexible research tool. This methodology has a lot of potentials to study connectivity problems with a wide range of applications (Adriansen *et al.* 2003; Pinto and Keitt 2009).

This analysis allows to identify important points for ecological connectivity such as vulnerable spots and areas with high value for ecological connectivity. The generated maps will provide useful guidelines for landscape conservation planning at local level (Municipalities and Local Administrations).

Connectivity between Natura 2000 Network sites in Alicante's Province is heterogeneous. The North of Province shows the highest values of cost distance, meanwhile there are many areas disconnected in the South. The 22% of the Province surface have low or no connectivity. These areas would need the target of restoration and permeability actions, but also areas with high connectivity in order to solve existing conflicts between ecological and road network.

Roads and urban areas appear as one of the most important problems for connectivity in Alicante's Province. The intersection of proposed corridors based on cost distance surface maps, with the road network cartography would be a good tool for selecting conflict spots in order to propose restoration activities to improve connectivity.

Acknowledgements

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A landscape approach to sustainable forest management

Is it possible to combine adaptation to climate change and maintaining of forest biodiversity?

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Abstract

An EU-level review of the climate change adaptation measures in forestry shows that there are adaptation measures that support maintaining biodiversity, but also adaptation measures that have the potential to decrease the level of biodiversity. A choice of the adaptation measure might thus involve trade-offs between efficient adaptation and maintaining biodiversity at the stand level. The landscape approach allows building a combination of highly adaptive stands with simultaneous high level of biodiversity and stands where adaptation measures do not support biodiversity. This is however a complex task and gets even more complicated since also economic and social standpoints have to be taken into account. A successful realisation is possible only if all policy makers at different levels, affected stakeholder groups, forest owners and forest workers are aware what measures are suitable and why they are used.

Keywords: European forests, climate change, adaptation measures, landscape approach, biodiversity

1. Introduction

Rising levels of greenhouse gases are already changing the climate. According to the IPCC WGI Fourth Assessment Report, the global average temperature has increased by about 0.76 ℃ from 1850 to 2005, and a further increase in temperatures of 1.4°C to 5.8°C by 2100 is projected. Thus, merely mitigation of the climate change is not enough but also adaptation of forest management is essential to avoid negative impacts for the forestry sector and to ensure the continuation of the mitigation effect that forests have. In addition to changes in mean climate variables, European forests will have to adapt also to increased climate variability; there is expected to be greater risk of extreme weather events like prolonged drought, storms and floods (Maracchi et al. 2005, Salinger et al. 2005).

European forests are diverse, with each region featuring different tree species, ecological conditions, management goals, and required goods and services by the society. Thus, the adaptive capacity of the European forests differs and also the climate change adaptation strategies should be developed in different ways. Main goals of the adaptive management include maintaining the wood production (boreal region), minimizing the impacts of disturbances (temperate and Mediterranean region) and ensuring the ecosystem services (Mediterranean region) (Lindner et al. 2008).

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Furthermore, also biodiversity has to be taken into account when planning the adaptive management of the forests. In addition of having intrinsic value, biodiversity can also play an important role in enhancing the adaptive capacity of the forest ecosystems, i.e. increasing the ecosystem capacity to recover and adapt to the impacts of climate change (Secretariat of the Convention on Biological Diversity 2003).

Existing knowledge of the observed and projected impacts of the climate change on European forests, and options for forests and forestry to adapt to climate change were reviewed on a study commissioned by the Directorate General for Agriculture and Rural Development of the European Commission (Lindner et al. 2008). This EU-level study shows that there are adaptation measures that support maintaining biodiversity, but also adaptation measures that have the potential to decrease the level of biodiversity. A choice of the adaptation measure might thus involve trade-offs between efficient adaptation and maintaining biodiversity at the stand level. Consequently, planning and management of the adaptation measures should be carried out at the landscape level. The aim of this study is to review adaptation options in forestry and their effect on biodiversity and then assess how landscape approach might be a solution to combine adaptation to climate change and maintaining of forest biodiversity.

2. Adaptation options in forestry and interaction with biodiversity

Species or stand composition of forest can be manipulated in a regeneration phase. Because the genetic composition of the populations needs to be enhanced to cope with environmental changes, diversity should be set at higher levels than under standard regeneration conditions, i.e. without environmental change. Thus, in the regeneration phase, a highly recommended option to secure the adaptive response of established regeneration is to raise the level of genetic diversity within the seedling population, either by natural or artificial mediated means. In order to raise levels of genetic diversity, seedlings coming from different seed stands of the same provenance region can be mixed at the nursery stage. This introducing of new reproductive material should however be seen as complementing local seed resources, not replacing local material (Lindner et al. 2008).

Adaptation measures in early stand development stages i.e. tending and pre-commercial thinning) should support mixed stands of suitable, adapted tree species, inter alia to distribute risk via diversification (Spiecker 2003). Silvicultural adaptation actions aiming at the establishment of ecosystems with highly diverse tree composition and ground vegetation will be inevitable in pests and disease risk management. Because of increasingly dry periods, fire risk is expected to increase in the already fire-prone Mediterranean zone, but also in the boreal and central European regions. Current fire prevention policies need to be adjusted to cope with longer and severe fire seasons and larger areas exposed to fire risk, especially in the Mediterranean region (Moreno 2005). Adaptation measures include, for example, modification of forest structure (e.g. tree spacing and density, regulation of age class structure) and fuel management, like thinning, pruning and biomass removals. To decrease risk of pests or fire, removal of forest residues, wind throws clearings, sanitation felling and removing standing dead trees and coarse woody debris on the forest floor are recommended. However, mature trees and decaying wood, for instance, are elements favouring diversity in forest ecosystems.

With term harvesting we refer to production-target oriented cutting of mature trees, ranging from single individuals (e.g. selection cutting) to larger spatial scales (e.g. clear cut). Small scale harvesting interventions and the promotion of harvesting systems which support natural

regeneration of suitable species increase spatial heterogeneity (e.g. Spiecker 2003). A dense forest road network is the prerequisite to small-scale, structurally diverse thinning and harvesting practices under adaptive management. In complex terrain such as mountain forests, the vital forest functions are depending on such measures (Brang et al. 2006; Woltjer et al. 2008). Moreover, infrastructure supports the mitigation of large scale disturbance impacts. This however leads to fragmentation of ecosystems and has adverse effects to the biodiversity.

Reducing forest fragmentation by establishing connecting corridors between densely forested regions contributes to increasing the natural adaptive capacity. Establishing a network of corridors and stepping stones connecting protected areas has been suggested as an adaptive strategy to assist species as they migrate in response to climate change (Halpin 1997; Harrington et al. 2001). Corridors should be built to aid in the migration of species to other protected areas when an extreme event has occurred (Bridgewater and Woodin 1990).

Forest management planning describes the processes of problem identification, development of alternatives and selection of alternatives, embedded in an adaptive management cycle (cf. Rauscher 1999). One significant selection is the length of rotation, i.e. the period of years between when a forest stand is established and when it receives its final harvest. A shortening of rotation length is an adaptation option in regions with increasing forest growth, like in mountainous or boreal environments. The reduced rotation length will also lower the risk of financial losses due to calamities and counteract the reduced management flexibilities induced by excessive levels of sanitation felling (e.g. Wermelinger 2004). However, structural changes of lower rotation lengths need to be considered with regard to other forest services, like biodiversity via loss of large diameter trees.

3. Landscape approach may be a solution

Landscape level approach would allow building a combination of highly adaptive stands with simultaneous high level biodiversity and stands where adaptation measures do not support biodiversity. This is however a complex task and gets even more complicated since also economic and social standpoints have to be taken into account. The measure might be relevant from ecological point of view, but not in economic or social point of view.

Since disturbance agents will gain more importance under the climate change, landscape level forest planning, balancing stand level management goals and integrated forest protection measures, is of increasing importance. A key approach in risk management is diversification of tree species mixtures and management approaches between neighbouring forest stands or within a forestry district to increase adaptive capacity (Lindner 2000; Bodin and Wiman 2007; Lindner 2007).

In developing alternative management strategies, forest planning aggregates stand scale management options and aims for concerted application at the landscape level. Promotion of diversity in landscape structure is seen as a strategy to promote resilience of forest ecosystems. At larger geographical scales of management units and forest landscapes, various strategies can be combined. For example, preferring natural regeneration in mixed forests with long rotation cycles is incompatible with planting productive genotypes managed in short rotation cycles.

Identifying suitable landscape level management strategies can be facilitated with decision support systems which include necessary simulation models. Integrated ecosystem models, for instance,

offer means to consistently project effects of adapted management on a variety of sustainable forest management indicators. The development of integrated, model-based decision support tools relying on multi-criteria analysis as a means to integrate stakeholders could offer means to improve the science – policy –practice interface.

A benefit of the landscape approach is that it includes also socio-economic aspects. The socioeconomic adaptive capacity of some region can be improved by investing into infrastructure, research and increasing awareness of suitable adaptation measures. One example of a link between ecological and social aspects is conservation areas; two or more protected areas can be linked to one another with corridors, which aim to help protect the biodiversity. Biological corridors are sections of land managed via a combination of voluntary agreements or compensation packages with the owners of the land (McNeely 1994).

4. Discussion

There are quite many examples of adaptive management measures to climate change which are supporting biodiversity of forests. But there are also measures which are harmful from biodiversity point of view. Thus, is it possible to combine adaptation to climate change and maintaining of forest biodiversity? The landscape approach is a good solution to this complex situation. If a measure provides win-win –situation for adaptation and biodiversity, it should be certainly used. Otherwise we should choose our object either adaptation or biodiversity for a stand, and at landscape level have a good balance of the measures to achieve good level of biodiversity as well as adaptation.

A successful realisation of adaptation measures is possible only if all policy makers at different levels, affected stakeholder groups, forest owners and forest workers are aware what measures are suitable and why they are used. It is of utmost importance to disseminate the knowledge on suitable adaptation measures and their impacts on biodiversity to all stakeholder groups, who need to implement the measures on the ground. For example, risk management in forestry can be promoted by educational efforts (Zebisch et al. 2005). Appropriate tools and systems are also necessary to support dissemination.

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Ecosystem services from forests at the watershed scale

Forests in landscapes: modelling forest land cover patterns suitability for meeting future demands for landscape goods and services

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Abstract

Forests deliver a range of landscape functions being thus of utmost importance to study the effects of forest land cover patterns on the provision of landscape functions, particularly when considering both land use and climate change scenarios. However, the explicit effects of forest spatial patterns on landscape functions provided have not been well studied (Turner, 1989, 2005). Based on the Portuguese Cávado and Sado catchments as case-studies, the overarching goal of the research project presented in this paper is to i) link forests spatial patterns with selected non-commodity functions provided by the landscape: water flow regulation, flood prevention, carbon sequestration, recreation and territorial identity, ii) develop a new framework for prioritizing a set of landscape functions at river basin scale, considering different scenarios, that derive from both land use and climate change. The conceptual framework, based on the integration of different disciplines as well as the methodological construction of the work , are presented and discussed. This work is undergoing; therefore, comments and suggestions regarding methodological issues are welcomed.

Keywords: watershed scale, forest land cover, landscape functions, goods and services provided by forests

1. Introduction

Goods and services provided by forests can be included in a broader category of goods and services provided by the environment (de Groot et al., 2002; Slee, 2007; Turner and Daily, 2008). Despite the large body of literature on ecosystem (or landscape) functions, goods and services, there is still not a clear consensus on the final definitions of these concepts (de Groot and Hein, 2007). The last report of the Millenium Ecosystem Assessement in 2005 made an attempt to bring order to the many definitions of "functions", "goods" and "services". Agreement was reached to define services as "*the benefits people derive from ecosystems*", and in order to avoid lengthy texts in scientific literature the term "services" is used, for both goods and services as well as the underlying functional processes and components of the ecosystems providing them (de Groot and Hein, 2007). Nevertheless, in other spheres, as management and policy design, the term public goods is often used for identifying the non-commodity goods and services that society expects from landscapes (Cooper et al 2009). Many authors have highlighted a principal difference between the function and service. For example de Groot et al (2002:394) defined function as "*...the capacity of ecosystems to provide goods and services that satisfy human needs either directly or indirectly*". Functions are seen as the actual (functional)

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processes and components in ecosystems and landscapes that provide or support, directly or indirectly, goods and services which benefit human welfare (de Groot and Hein, 2007).

Figure 1 show that the manner in which forest services are provided (P) and benefits (B) delivered may occur in at least three different ways: 1) in situ, 2) omni-directional and 3) directional (Fisher et al., 2004). This is particular relevant for the understanding of spatial relations between the landscape pattern and the functions.
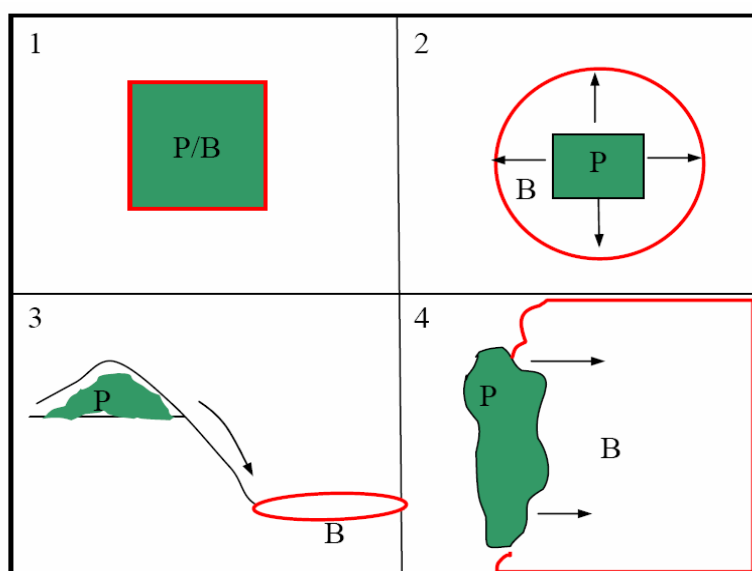
1. In situ. The services are provided and the benefits are realized in the same location (e.g. soil formation, provision of raw materials).
2. Omni-directional. The services are provided in one location, but benefit the surrounding landscape without directional bias (e.g. carbon sequestration, pollination)
3. and 4. Directional. The service provision benefits a specific location due to the flow direction. In 3 down slope units benefit from services provided in uphill areas, for example water. In 4 the service provision unit could be coastal wetlands (or forests) providing storm and flood protection to a coastline.

Figure 1. Places where services are provided (P) and benefits delivered (B).Source: Fisher et al (2004) p. 12

The overarching goal of the research project to which this paper refers to, is to link landscape pattern with landscape function, considering particularly the role of forests for the provision of landscape functions at the watershed scale. Preventing floods, regulating water flows, sequestering carbon and enhancing recreational activities and the role of landscape in local identity, are likely to be important landscape functions in the future and there is a need to model land cover patterns able to support such landscape functions. Because the former three functions are ecological and the latter two depend on human preferences and choices both ecological modelling and public preference methods will be used.

In order to progress in the spatial analysis of landscape functions, the Index of Function Suitability (IFS) developed by Pinto-Correia et al will be applied and tested (Pinto-Correia et al., 2009a). IFS is an innovative tool aiming at assessing the capacity of different   landscapes to provide different landscape functions(Pinto-Correia et al., 2009a). It is based on the analysis of

the land cover pattern, as expression of the landscape composition and change. The IFS is based on the use of indicators for gauging the differences between best possible land cover pattern for a certain function and the land cover patterns likely to occur in contrasting scenario storylines. Therefore, it is a step further in the provision of ex-ante evaluations of the impacts of different trends of change in the provision of different functions (Fig 2). By using the same set of indicators to characterize both the best possible land cover pattern for a certain activity and the land cover pattern likely to occur in different scenario storylines, the IFS allows for a quantification of the distance in the provision of functions, from one to another land cover pattern. As such, it provides an indication of the suitability of landscapes and their respective land cover combinations, in the future, in delivering selected functions. The IFS is still under development and has so far been used exclusively for amenity functions. Throughout the present project, an improvement of the tool is expected, as well as a further adaptation to this Index, incorporating also "ecological" functions such as carbon sequestration, water flow regulation and flood protection by means of ecological modelling and expert based knowledge.
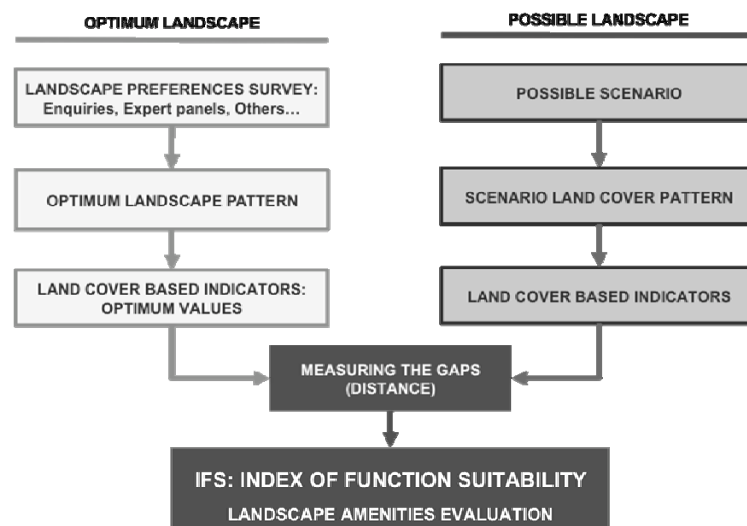
Fig. 2 – The Index of Function Suitability is calculated measuring the distance between thepreferred landscape (denominated as best possible land cover pattern, as it depends on the existing lands cover classes and possible combinations and compostions of those) to develop a given non-commodity function, and the landscape being tested.

2. Methodology

This project uses a territorial approach looking at the Cávado and Sado catchments as Socio-Ecological Systems (Folke et al., 2005). The spatial nature of this analysis is needed, as the goods and services here considered are provided at the landscape scale. The watershed has been defined as the unit of analysis, as it is the most comon and acknowledged level of organization of the landscape *per se*, when all factors, both physical, biological and human, are considered (Selman, 2006). Both watersheds have rural-urban gradients from inland to sea coast, and a landscape composed of both urban, agricultural and forest land covers, with predominance of forest and silvo-pastoral systems. Across these watersheds, the forests contribution for the lansdcape pattern and thus for human well-being certainly differ. By conducting a comparative study Sado catchment in South, Mediterrranean Portugal, and Cávado catchment in the Atlantic

Minho) the diversity of roles forest might play are highlighted. It is acknowledged that the landscape functions forests contribute to will be prioritized in different ways in each of the catchments. The criteria, factors and importance of forests to different landscape functions can be revealed by contrasting region characteristics.

2.1 Identifying appropriate forest spatial patterns for different landscape functions

2.1.1. Assess the landscape pattern, through the application of landscape metrics for Cávado and Sado catchments. The land cover base maps will be created in Arc/GIS and following exported to a spatial pattern software in order to quantify land cover patterns. A set of landscape metrics (Botequilha Leitao and Ahern, 2002) will be computed in FRAGSTAT (McGarigal et al., 2002) based on the Carta de Ocupacao do Solo COS 90. By computing the landscape metrics such as mean patch size (PS), number of patches (NP), patch density (PD) and percentage of landscape (PLAND) for agriculture, forests (by tree species) and urban, an understanding of the landscape pattern of the studied regions will be gained and a comparative analysis become possible. After quantifying the land cover patterns within the two catchments a modelling approach will be undertaken in order to create the best land cover pattern for different types of landscape function. This will be carried out in two different ways as there will be focus on ecological related functions such as water flow regulation, flood protection and carbon sequestration that require expert knowledge in order to identify a best land cover patterns within the catchments. On the contrary in the case of functions related with public preferences namely recreation and cultural identity a preferred landscape pattern will be based on questionnaire surveys assessing preferences of different groups of users of the landscape (hunters, farmers).

2.1.2. Expert panels. The best possible landscape patterns for the provision of landscape functions such as water flow regulation, carbon sequestration and flood protection will be created based on expert panels at the catchment scale. "Experts" are defined as "representatives of organisations which are affected by, or which significantly affect, interactions between regional landscapes and forests, or have skills and knowledge about the issue, or influence implementation instruments relevant to the topic". This task will be also based on a literature review.

2.1.3. Ecological modelling. Based on the data gathered suitability maps for carbon sequestration, flood protection and water regulation, will be created. Land use suitability analysis aims at identifying the most appropriate spatial pattern for land uses according to given suitability criteria (Malczewski, 2004). Based on the ecological thresholds for different tree species suitability maps will be first created for broadleaves (oak), coniferous (pine), eucalyptus, agriculture and pastures. The land use modelling criteria, as well as the weightings for factors will be discussed by the expert panels. These suitability maps will be combined through a Multi-Objective Land Use Allocation (MOLA) command in the IDRISI ANDES GIS (Eastman, 2006) creating optimal landscape patterns for carbon sequestration, water regulation and flood protection.

2.1.4.) Public preferences. The best possible land cover patterns for recreation and for cultural and identity preservation will be assessed through surveys to specific groups of landscape users. This survey is to be done through direct enquiries based on landscape photos used as visual stimuli for the expression of preferences. The results will be translated into the best possible landscape pattern, adapting themethodology of Pinto-Correia et al. (2009b). Data has already been, or is being collected in research projects such as Agrorreg, Mural, Rosa (Pinto-Correia et al., 2009b) and in the work by Carvalho Ribeiro (Carvalho-Ribeiro, 2009; Carvalho-Ribeiro and Lovett, 2009, 2010; Carvalho-Ribeiro et al., 2010) .

2.2 Developing new framework for assessing the suitability of different landscapes in providing landscape functions

After developing best possible forest land cover patterns for different landscape functions a following step intends to create a framework able to prioritize a set of functions according to predefined criteria. The conceptual models is based on the premises that not all landscapes are adequate to provide all functions being thus likely that certain areas are more suited to specific functions than areas with contrasting characteristics.

The LAM Landscape Amenity Model, developed together with the IFS (Pinto-Correia 2009a) will be further developed and tested in this project.. The LAM has been designed as the modelling tool that allows for a comparison between different land cover petterns, both those corresponding to the best possible combinations for selected functions and those resulting from identified scenarios of change, being this comparison supported on thre IFS. The landscape pattern (created from expert knowledge models (2.1.2 and 2.1.3) and from public preferences surveys (2.1.4)) will be compared for two scenario landscape patterns by using the LAM. In the LAM the Index of Function Suitability (IFS) evaluates the adaptatibility of a landscape to provide a function (Pinto-Correia et al., 2009a). By using the LAM best possible landscape patterns for different functions will be compared with scenario storylines in order to undertake an ex-ante evaluations of whether or not future forest land cover will be able to provide a set of pre-defined landscape functions. Also the suitability of Cávado and Sado in providing different landscape functions will be explored and contrasted.

3. Questions still to be solved

When needed, and if there will be data or knowledge that allows the identification of other best possible patterns, for other functions, the evaluation path hereby presented can be expanded. It is not the aim here to be exhaustive the functions selected have been chosen due to their relevance in the study areas considered. In addition to the previous it is also an aim of the project to contribute for the methodological development, through a successive conceptualization, testing and improvement of research approaches able to grasp with the linkages between land cover and land function independently if those functions are either ecological or based on social demand. ,

Identifying best possible landscape patterns, or preferred patterns, can easily be criticised, as those best patterns demand, on one side, a high degree of simplification concerning the landscape in itself, and, on the other, they are based on the assumption that a generalised best pattern can be identified, even for functions dependent on public preferences. But still, this approach has been built up step by step taking care of the relevant literature, and has the advantage of being flexible so that it can be applied to multiple landscapes, multiple functions, and multiple scenarios.

There is still much to play regarding the complex task of linking forest spatial patterns with landscape functions. This paper presents and explains a methodological framework able to deal with these issues. There is still uncertainty regarding the approach proposed and certainly there will be drawbacks, but the risk is taken in face of the urge imposed to the scientific community by policy makers. Policy makers are dealing with the formulation and targeting of public policies that should deal with the provision of public goods, and thus with their assessment for a given scale of analysis is of utmost importance. As previously referred this work is still in progress therefore comments, suggestions and discussion of alternative approaches will be very much appreciated.

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Impacts of wildfires on catchment hydrology: results from monitoring and modeling studies in northwestern Iberia

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Abstract

Wildfires have significant impacts on vegetation cover and soil properties, which in turn can lead to large increases in runoff, erosion and nutrient export from forested hillslopes. However, the impacts of these changes at the catchment scale are still poorly understood, mostly due to the difficulty of instrumenting burnt catchments with enough speed to capture hydrological processes at the early stages of forest recovery. Hydrological modeling remains therefore an important tool to assess wildfire impacts in ungauged catchments, but most existing models cannot reproduce hydrological processes in burnt soils.

This work will present results from ongoing research projects in the northwestern Iberian peninsula, including (i) multi-year runoff, erosion and soil properties monitoring in burnt and unburnt hillslopes and micro-catchments (0.1 to 10 Km^2), providing insights into the local-scale impacts of wildfires on hydrological processes; (ii) modeling approaches to simulate hydrological processes in burnt areas at the plot and watershed scales.

Keywords: hydrological modeling, burnt forests, upscaling

1. Introduction

Forested watersheds in northwestern Iberia provide important ecosystem services for water resources provisioning. According to the Millennium Ecosystem Assessment (Pereira et al., 2004), these include the regulation of runoff (preventing flash floods) and maintenance of downstream water quality. However, the planting of homogenous commercial forests has significantly increased forest fire risk in the Iberian Peninsula (Puigdefábregas, 1998); climate change is expected to increase the frequency and severity of these fires by enhancing the effect of environmental drivers behind them (e.g. Carvalho et al., 2001). This could lead to a disruption of ecosystem services during the post-fire window of disturbance (i.e. as forest vegetation regrows), leading to an increase in e.g. the likelihood of flooding or a degradation of water quality (Pereira et al., 2004). However, there is still a lack of knowledge on the effects of wildfires on hydrological processes, especially at larger spatial and temporal scales (Shakesby and Doerr, 2006).

The impact of wildfires on hydrological processes at small spatial (e.g. microplots, plots, hillslopes) and temporal scales (e.g. rainstorms, a few years) has received much attention from researchers in recent years. Shakesby and Doerr (2006) review some of the main conclusions from these studies. Wildfires reduce vegetation cover and can change soil properties, such as reducing soil aggregate stability and increasing soil water repellence. This can lead to an increase in overland flow generation and sediment detachment, and to the formation of an extensive rill and gully system in burnt areas with additional erosion impacts. These impacts were also observed in northwestern Iberian burnt forests (e.g. Ferreira et al., 2008; Keizer et al., 2008).

At larger spatial scales, especially catchments, Shakesby and Doerr (2006) report that forest fires can increase peak runoff rates, but there are few studies on consequences for total runoff. Erosion responses at this scale are more complex, as they appear to depend on smaller-scale changes to runoff and soil erosion, and are poorly studied. At larger temporal scales, studies have focused on the post-fire "window of disturbance" (c. 2 to 5 years in this region) during vegetation regrowth, but there have been few studies of long-term impacts, particularly the cumulative consequences of multiple wildfires.

There is therefore a knowledge gap when upscaling measured results to larger scales and impacts. Modeling has been viewed as an approach to overcome this difficulty (Shakesby and Doerr, 2006). Recent comparisons of existing hydrological models with measured data in burnt areas, however, have revealed their limitations in representing the most important processes (e.g. Larsen and MacDonald, 2007) although suggesting ways to improve them. This has limited modeling applications at large spatial and temporal scales to perform watershed-scale, long-term assessments. However, this assessment is feasible provided that existing measured data can be combined with modeling tools in a coherent approach.

This work will present ongoing research and results of research projects studying burnt catchment hydrology in northwestern Iberia, including:
1. research at the hillslope scale conducted in central Portugal (Albergaria, Vouga basin);
2. research at the micro-catchment scale in central Portugal (Mondego basin) and western Galicia (Esteiro), the latter focusing on a paired catchment study;
3. modeling for meso-scale watersheds in central Portugal (Águeda basin).

The results will be discussed in terms of their indication on the impacts of wildfires on watershed-scale water resources provisioning,

2. Study areas

The research presented in this work focuses on the northwestern Iberian Peninsula (Figure 1), a region characterized by a humid climate (aridity index, i.e. the ratio of rainfall over potential evapotranspiration, above 1) with a south-north transition from Wet Mediterranean to Maritime Temperate. There are good conditions for vegetation growth, and a large part of this region is covered by forests; in many cases, and especially in Portugal, there are large areas of commercial forestry where eucalypt and maritime pine are planted. However, the seasonal and interannual variability of climatic conditions, particularly the existence of a dry summer season (Figure 2), leads to the recurrence of appropriate conditions for wildfires.

3. Research at the hillslope scale

This research was carried out for six hillslopes close to Albergaria, central Portugal: four burnt in 2005 (Açores 1&2, Jafafe 1&2) and two burnt in 2006 (Soutelo 1&2). All slopes were covered by eucalypt prior to the wildfires, and represent different management options including terracing and downslope ploughing. Meteorology, runoff and erosion were monitored weekly in each slope; soil surface and subsurface conditions were monitored bi-weekly using 5-point transects. Figure 3 shows some measured results for the slope Açores 1, as reported by Keizer et al. (2008). They illustrate one of the main findings of this study regarding slope-scale hydrology in burnt hillslopes. Soils in these slopes are highly water repellent immediately after fires; the repellency decreases at the start of the wet season, and reappears during the following dry season (although it can reestablish during dry spells in the wet season, as shown in the figure for the winter of 2007). Repellency and soil water storage are closely related, and reasonable amounts of rainfall falling on repellent soils might not lead to an increase of soil water. Consequently, rainfall events at the start of the wet season (or during other periods with high soil water repellency) might lead to increased runoff rates when compared with events in the middle and end of this season; this has the potential for increasing flood risks at the catchment scale which might be difficult to predict if repellency is not taken into account.

4. Watershed-scale research: micro- and meso-scale catchments

Research at the watershed scale is shown for two micro-catchment sites, Colmeal (central Portugal) and Esteiro (Galicia); and one meso-catchment site, Águeda (central Portugal). Colmeal is a micro-catchment (60 ha) which burnt almost completely in 2008; it was instrumented with a number of slope-scale plots, while runoff and sediment data was also collected at the catchment outlet in a multi-scale sampling approach. Preliminary results indicate that runoff and erosion are concentrated in the first months after the wildfire, at the start of the vegetation disturbance and when soil water repellency is high. They also indicate a non-linear relationship between slope-scale and catchment-scale runoff, as the latter also depends on subsurface flow and saturation-excess runoff generation close to the water line.

The Esteiro fire occurred in 2007; two paired micro-catchments were instrumented, each with around 450 ha (Figure 5). The Maior catchment was partially burnt while the Arestiño catchment was not. Preliminary results indicate that runoff was more irregular in the burnt catchment, with higher values in the winter immediately following the wildfires and lower values in the subsequent summer (close to zero). These results might indicate an impact of wildfires on increasing the irregularity of water resources provisioning, although differences in the underlying geology of both catchments might also play a role in differentiating the hydrological regimes. The Águeda fire occurred in 1986, and burned c. 25% of the upper Águeda river basin. Given the scarcity of hydrological data for this wildfire (runoff was only measured at the outlet), a modeling approach is being used to estimate the impacts on runoff and water balance on subcatchments with different burnt areas. The approach relies on the SWAT model (Neitsch et al., 2005), capable of simulating a number of processes inside meso-scale catchments, including water balance, surface and subsurface runoff, soil erosion, nutrient exports and vegetation regrowth (including human management operations). The current modeling approach relies on simulating 5-10 years in both burnt and unburnt conditions, therefore evaluating the different impacts for dry and wet years as well as assess the relative importance of wildfires and climate variability for watershed-scale water yield.

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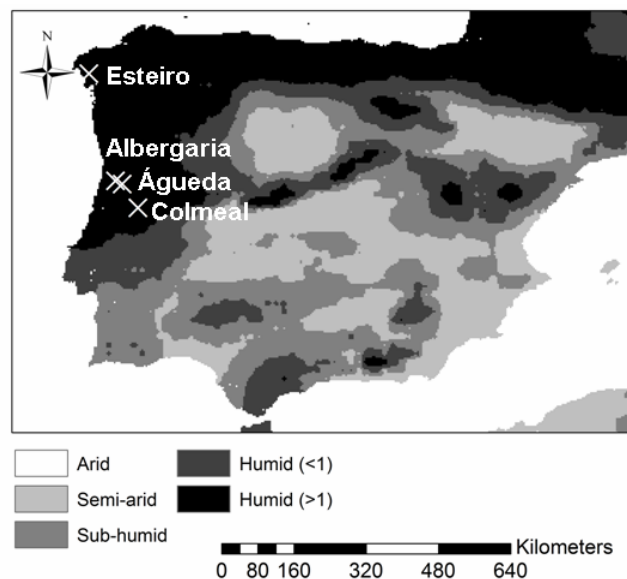
Figure 1: location of the study areas in the Iberian Peninsula, over a map of the aridity index (left).
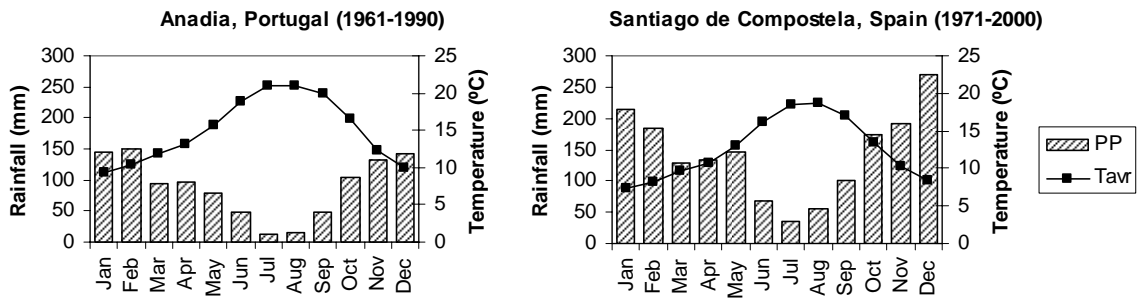
Figure 2: monthly climate normal for weather stations in central Portugal (left) and Galicia (right).
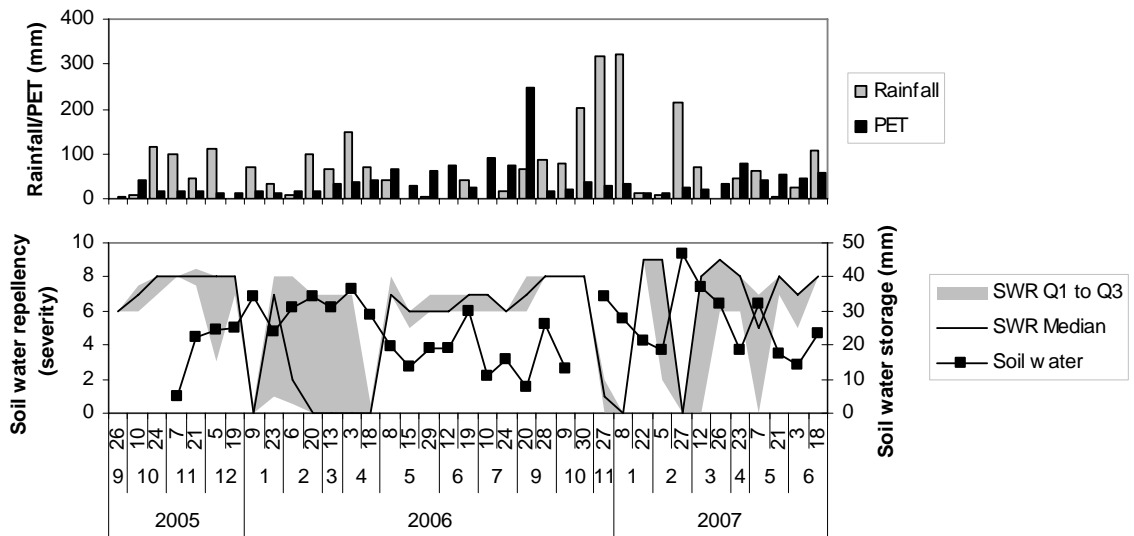
Figure 3: measured rainfall and potential evapotranspiration (top), and soil water storage and repellency (bottom) for the Açores 1 slope; soil water repellency is indicated as the severity class associated with the result of the Molarity of Ethanol Droplet (MED) test, and the shaded area represents the interquartile area (between the 1st and 3rd quartiles).

Figure 4: Colmeal micro-catchment and wildfire limits.
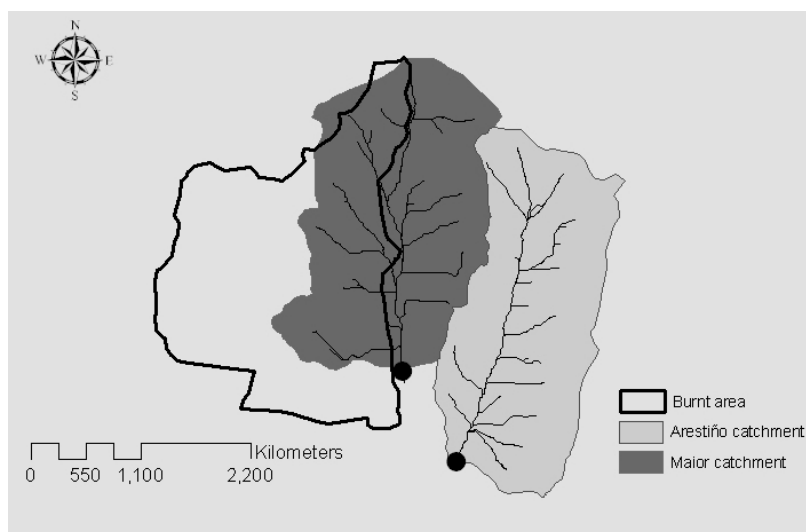
Figure 5: Esteiro study area, including the Maior (burnt) and Arestiño (unburnt) micro-catchments.
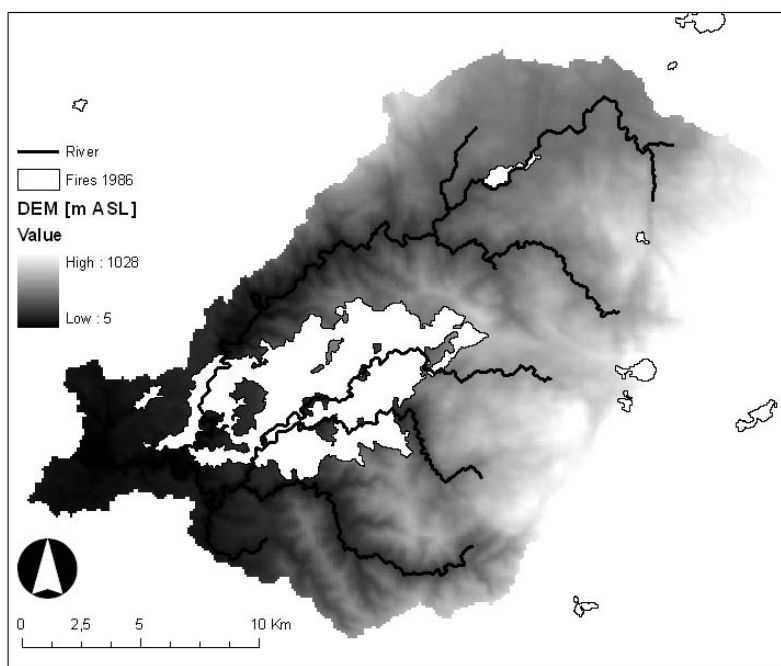
Figure 6: Águeda meso-scale catchment, showing the burnt area in the 1986 wildfires.

Management and conservation of Mediterranean forest landscapes

Testing the fire paradox: is fire incidence in Portugal affected by fuel age?

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Abstract

A well-known fire paradox states that fire exclusion and the resulting fuel accumulation leads to larger fires. To test this assumption for Portugal we analyzed fire frequency through survival analysis for the period of 1975-2008. The median fire-free interval is relatively short (12-16 years) but the hazard of burning increases exponentially with time since fire, denoting a fuel-age dependent system. Time-dependency did not change with fire size class, implying that young fuels delay landscape fire spread even under extreme meteorological conditions. Fire size and maximum fire size tend respectively to be less variable and lower where fire recurrence is higher. Hence, fuels exert a short-term but effective control on landscape fire spread. Our findings show that crown fire regimes can be time-dependent and support fuel treatments as key component of fire management.

Keywords: burn probability, fire regime, shrubland, Mediterranean-type ecosystems

1. Introduction

Controversy concerning the environmental drivers of wildfire incidence has gained momentum in recent years. If fire occurrence is time-dependent then exogenous factors such as weather will play a relatively minor role on fire incidence, which to a great extent will be controlled by the existing mosaic of fuel ages (Minnich 1983; Minnich and Chou 1997). This can be expressed as a "fire paradox" where fire suppression efforts will lead to increasingly larger fires as fuel builds up in the landscape. However, the opposing view is now prevailing in the literature and defends that fuel age is unrelated to the likelihood of wildfire in crown-fire ecosystems such as conifer forests and Mediterranean-type shrublands, particularly under extremely dry and windy weather conditions (Keeley et al. 1999; Moritz et al. 2004; Keeley and Zedler 2009). Because the question is difficult to be addressed empirically, more and more studies resort to simulation modeling (e.g. Finney et al. 2007; Cary et al. 2009). Fire frequency analysis has been proposed to judge whether vegetation is fire-adapted or not (Polakow et al. 1999) and has been used to better understand and describe how the fire return interval and fuel age affect fire incidence (Moritz 2003; Moritz et al. 2004; O'Donnell et al. 2008; Van Wilgen et al. 2010). Obviously, this debate has profound political implications, namely on the recognition (or not) of fuel management as a valuable component of fire management.

While extreme fire seasons significantly affected the country in 2003 and 2005, extensive tracts of Portugal are under a relatively frequent fire regime, especially in mountains and plateaus

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dominated by shrubland where fire is a tool routinely used in traditional land management. The existing spatial and temporal information can thus be analyzed to detect relationships between fuel age and fire incidence. Our objective is to analyze contemporary fire history data to determine how fire recurrence, hence fuel age, relates with burn probability in Portugal.

2. Methodology

The study area is the entire Portuguese mainland, 89×10^3 km^2. The analysis of burn probability was based on all wildfire events with an area equal to or larger than 10 ha occurring in Portugal from 1998 to 2008, i.e. during a 11-year period. We used the mapped fire history of the Portuguese Forest Service and GIS software to process the spatial information. Fire recurrence maps were created for each year under analysis, fire recurrence being the number of fires experienced by each 625-m^2 pixel (25 x 25 m) since 1975. For the area within each individual fire perimeter we have determined an area-weighed mean fire recurrence and the corresponding fire return interval (FRI). Then we used survival analysis by fitting a two-parameter Weibull function to the FRI distribution based on maximum likelihood. We have modelled FRI from individual fire events, rather than from patches defined by their unique fire history, because the former offers the possibility of assessing if the time-dependency of burn probability changes with fire size, i.e. with weather conditions.

A fire interval distribution can be described in a cumulative form, $F(t)$, the probability of fire occurrence before or at time t, and as a probability density, $f(t)$, which reflects the frequency of burning in a given time interval (e.g. Moritz 2003; Moritz et al. 2009):

$$F(t) = 1-\exp[-(t/b)^c] \tag{1}$$

$$f(t) = (ct^{c-1}/b^c) \exp[-(t/b)^c] \tag{2}$$

where $t > 0$, $b > 0$ and $c \geq 0$. Parameters b and c have ecological meaning. The scale parameter (b) has the dimensions of time and is the typical fire return interval (FRI) that will be surpassed 36.79% of the time. The shape parameter (c) is dimensionless and describes the change in fire probability through time. The negative exponential distribution is a special case of the Weibull model that corresponds to $c = 1$. The probability of burning increases with time when $c > 1$, increasing linearly when $c = 2$ and exponentially when $c > 2$. Vegetation types that are simultaneously fire-prone and fire-dependent are expected to have high c values (Polakow et al. 1999) and $c > 4$ qualifies a fire regime as highly age-dependent (Moritz 2003). The Weibull median fire-free interval (MEI) gives a probabilistic estimate of fire-return intervals for asymmetrical fire interval distributions (Grissino-Mayer 1999). The "hazard of burning" function $\lambda(t)$ gives the instantaneous probability of a fire occurring in a specific time interval and is useful to measure how time since the last fire event affects the subsequent likelihood of burning:

$$\lambda(t) = ct^{c-1}/b^c \tag{3}$$

Data was truncated to consider only those fires whose majority of pixels had burnt at least twice since 1975, thus reducing the existing asymmetry that otherwise would have biased parameters b and c (Moritz 2003); note that fire incidence in Portugal was quite low before the 1970s. The Weibull model was fitted separately to two sub-divisions of Portugal − northern and central-eastern (N-CE) and central-western and southern (CW-S) − mainly on the basis of their relative fire incidence, high in N-CE and relatively low in CW-S (Verde and Zêzere 2010).

3. Results

The Portuguese fire atlas contains 10197 burned patches with ≥10 ha in the 1998-2008 period, corresponding to a sum of 1.65 x 10^6 ha (of which 58% have burned just once) and a mean annual burned surface of 1.5 x 10^5 ha. The largest patch has 66071 ha and the mean and median patch sizes were 162 and 31 ha, respectively. The fire frequency analysis was restricted to the 2950 fire scars whose majority of pixels had burned at least twice before.

Examination of FRI data (Figure 1a) indicates a sigmoidal (S-shaped) trend in the cumulative fire probability curves, which indicates a fuel age effect on burn probability. Resistance to fire is nevertheless of relatively short duration. Region N-CE displays a steep slope (starting at age 6) with the result that more than 75% of the total burning is reached by age 15. Region CW-S exhibits low burn likelihood for about 11 years, followed by a sharp increase up to age 20.

Table 1 and Figure 1b respectively present the fitted Weibull model parameters for N-CE and CW-S and their corresponding hazard functions. The typical fire interval length is higher in CW-S. The likelihood of burning grows exponentially with time in both sub-divisions of the country, CW-S having a especially high degree of age dependency ($c = 4$). In N-CE the hazard of burning (% per year) increases by a factor of three from age 4 (1.9%) to age 7 (5.7%), and again at age 12 (16.8%), while in CW-S those rates are reached approximately at ages 7, 11 and 15, respectively; N-CE and CW-S hazards of burning are equal at age 23. The likelihood of burning is below that of an age-independent system (i.e. $c = 1$) for 10 years in N-CE and 18 years in CW-S.

Table 1 also includes a fire frequency analysis as a function of wildfire size class (< 100 ha, 100-499 ha, 500-999 ha, ≥ 1000 ha) for N-CE. The Weibull model b and c coefficients were quite similar between fire size classes, with overlapping 95% confidence intervals. Consequently, extreme fire weather does not change the fuel-age dependency of burn probability in Portugal. Note also that fuel age dependency is higher in the drier CW-S sub-division.

Table 2 displays additional information regarding the size of the burnt patches for the entire data set (n=10197). Size variability and maximum size are higher for burnt patches belonging to larger size classes. Again, this points to a fuel age buffering effect against extreme fire weather.
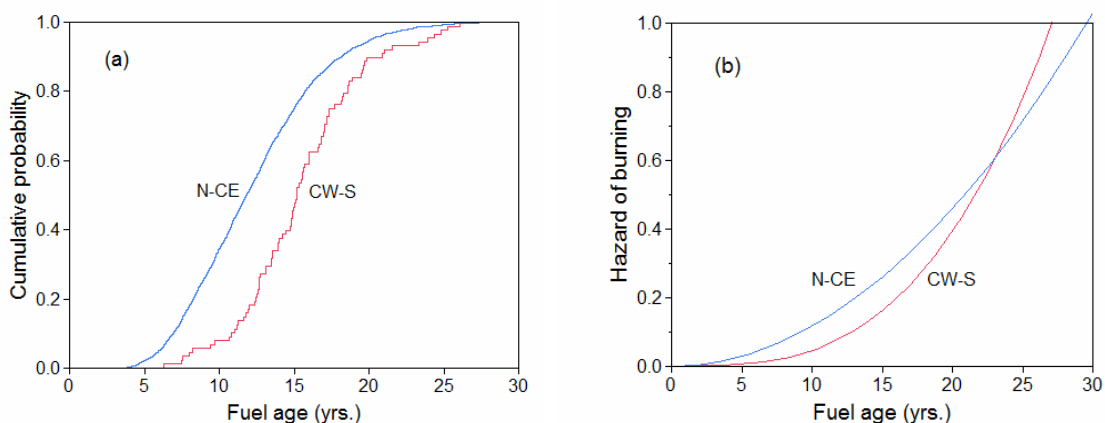
Figure 1: Empirical probability of fire occurrence (a) and fitted Weibull hazard of burning (b) for the N-CE and CW-S sub-divisions of Portugal.

4. Discussion

Considering the fire return intervals involved, this study reflects primarily the fire regime of shrubland and regenerating forest. The results are coherent with the fuel dynamics described for shrubland in northern (Fernandes and Rego 1998) and central Portugal (Fernandes et al. 2000) which indicate increased flammability with time since fire; depending on shrubland type, fine fuel loads in these systems are at near-equilibrium 9 to 26 years after fire.

While the typical fire return interval is shorter in N-CW, age-dependency is more apparent in CE-S Portugal. The differences can be explained by distinct fire environments in terms of physiography, vegetation and land use, as well as by differences in climate and ignition density. Topography is rougher and vegetation types − namely atlantic and sub-atlantic shrubland types (*Ulex*, *Erica*, *Pterospartum*, *Cytisus*) and *Pinus pinaster* and *Eucalyptus globulus* forest − are more flammable in N-CE than in CW-S Portugal. Also, because of drier climate, growth rates and fuel accumulation are expected to be slower over much of CW-S in comparison with N-CE. Mediterranean shrubland types prevail in CW-S (limestone maquis and garrigue, *Cistus*), and because their canopy is poor in dead fuels, exhibit fire behaviour patterns in relation to weather that are distinct from atlantic and sub-atlantic shrublands and that may increase the age-dependency of fire hazard. Density of fire ignitions is also substantially higher in N-CE, where traditional fire use at short-return intervals for pastoral purposes is common in the mountains. Higher fire recurrence may promote a fuel complex with a significant grass component that will burn more readily, hence facilitating more frequent fire.

Table 1: Weibull model parameters (and 95% confidence intervals) and median fire-free interval (MEI) for the fire frequency analysis. Fire size class data respect to the N-CE sub-division.

Data set	n	MEI	b	c
N-CE	2862	12.1	13.7 (13.5-13.9)	3.0 (2.9-3.1)
CW-S	88	15.5	17.0 (16.1-17.9)	4.1 (3.5-4.7)
Fire size class				
10-99 ha	2131	12.3	13.9 (13.7-14.1)	3.0 (2.9-3.1)
100-499 ha	594	11.7	13.2 (12.8-13.6)	3.0 (2.8-3.1)
500-999 ha	88	11.2	12.6 (11.7-13.5)	3.1 (2.6-3.6)
$\geq$ 1000 ha	49	12.2	13.7 (12.4-15.1)	3.2 (2.6-3.8)

Table 2: Burnt patch size statistics by fuel age class.

Fuel age class (yrs.)	n	Median (ha)	CV (%)	Max. (ha)
3-4	26	50.2	117.7	379
5-6	197	43.4	146.1	1100
7-8	418	48.3	190.4	2196
9-12	1043	44.0	222.9	5487
13-19	1681	41.8	351.1	13119
$\geq$20	6832	27.3	876.6	66071

In comparison with other Mediterranean regions, the fire-free interval is shorter in Portugal than in southern California chaparral (Moritz 2003; Moritz et al. 2004) and in southwestern Australia shrubland (O'Donnell et al. 2008), and is comparable with South Africa fynbos (Van Wilgen et al. 2010). In contrast to our findings, shrubland systems in other Mediterranean regions are generally characterized by weak (Moritz 2003; Moritz et al. 2004; Van Wilgen et al. 2010) to moderate (O'Donnell et al. 2008) age-dependency. While several factors other than vegetation type and fuel hazard can affect fuel age dependency − fire suppression, landform, landscape fragmentation, frequency and severity of extreme weather events – and be involved in the results, this study shows that not all crown fire regimes are independent of fuel age. The usual expectation is that extreme weather conditions will prevail over, or will cancel the effect of fuel on landscape fire spread (Fernandes and Botelho 2003; Moritz 2003; Keeley and Zedler 2009), but such pattern did not emerge in the analysis. The results imply that the fuel age effect on burn probability is weather-independent, which is highly relevant for fire management, as it increases the expectations of effective fuel treatment performance under unfavourable weather scenarios. Consequently, this study supports a policy where landscape-level, strategically-placed prescribed burning treatments are an integral component of fire management.

Acknowledgments

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Interfaces and interactions between forest and agriculture in rural landscapes

When forests are managed by farmers:
Implications of farm practices on forest management

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Abstract

Farm forests, *i.e.* forests managed by farmers, are important components of French landscapes. Farmers, who do not have knowledge in sylviculture in general, harvest them for firewood and timberwood, but also for hunting, mushroom harvesting or grazing. The social and ecological functions of these woods call for a better understanding of their management. These private woods are mainly small (< 25 ha) and thus are not submitted to French management regulations. We present the conclusions of three multidisciplinary long term studies, in south west of France, based on historical, social and technical analyses of the particularities of these woodlots. Results showed that the traditional social system ("house-centered system") is still influencing forest management, despite its loosing of importance. Woodlots are parts of the agricultural systems but some cultural features limit the implementation modern forestry practices. The roles of farm forests have to be considered on a larger landscape scale perspective.

Keywords: Rural forest, private forest, management pratices, SIG, ethnology

1. Introduction

In France, 28 % of the territory is forested and around 75% of this forested area (i.e. 10 millions of ha) belongs to a multitude of private owners (around 3.5 millions). A large part of these private woods are farm forests that are forested areas managed and used by farmers, whatever are the legal system and the structure of the stands (Normandin 1996). They represent 17% of French private forest and up to 50% in several departements in South-West (Cinotti and Normandin 2002). Despite their important cultural and ecological functions in agricultural landscapes (Balent et al. 1996, Sourdril 2008) and their potential role in the sustainable development of rural areas, management modalities of farm forests are still poorly known. Moreover, their surface area is decreasing because of their conversion into common private forest, due to sales and inheritance to non-farmers (Cinotti and Normandin 2002): farming and forestry are thus more and more disconnected (Larrère and Nougarède 1990; Cardon 1999).

A characteristic of French private forest is the small size of the properties: half of them have an area of less than 25 ha. Yet regularly obligations do not impose particular forest management in these small properties, unlike in larger ones for which a management schedule (Plan Simple de Gestion, regulatory document that is both a guide for forest management and a traceability document) approved by the Centre Régional de la Propriété Forestière (public institution supporting private sylviculturists to manage their forests) is compulsory. As a consequence, management in small private woods is not described in any document or inventory that hampers the study of practices and the build up of forest management history.

The objective of this paper is to present an original combination of retrospective mapping from aerial photographs of farm forest management for 60 years with anthropological analysis of the drivers of forest management and forestry practices. We thus have to analyze forestry practices thanks to aerial photographs and to interviews analysis. Interviews were also used to assess forest representational systems that are linked to practices (Lemonnier 1994), and the relationships among stakeholders concerned by farming and forestry (social networks).

2. Methodology

2.1 Study sites

Studied woods are located in the Long Term Ecological and Sociological Research platform « Vallées et Coteaux de Gascogne » in southwestern France, at ~ 60 km south-west of Toulouse, in 5 rural parish territories (43° 16' N, 48° 43' E, 200 - 400 m a.s.l.). This hilly region is characterized by a temperate climate with oceanic and slight Mediterranean influences. Two types of soil occur in the study site: superficial calcareous soils (superficial terrefort) and non-calcareous acid molasse (brown acid and brown washed soils) (CRAMP 1995). The region is not densely populated and is still largely agricultural. The dominant tree species of the woods are sessile oak (*Quercus petraea* Lieblein) and pedunculate oak (*Q. robur* L.), mixed with hornbeam (*Carpinus betulus* L.) (Cabanettes and Guyon 1994). Wood management system is traditionally coppice (with or without standard trees) each 30 years by clear cutting mostly to produce fire wood and some standard trees can be cut to be sold or used as timber wood.

2.2 History of forest logging

We selected a set of woods (total surface area ~ 100 Ha) with a common history, *i.e.* they were all included in a whole larger wood two centuries ago that has been fragmented. Aerial photographs are the most appropriate data that allow reconstructing logging history at a fine scale. We chose 7 missions conducted by the French National Geographical Institute and by the French National Forest Inventory (1942, 1953, 1962, 1977, 1984, 1996, 2006) in order to obtain a regular temporal sequence. The photographs were analyzed using optical stereoscopy in order to detect and date cuttings. We circumscribed polygons defined by their cover classes, based on tree height (Bakis and Bonin 2000, Muraz *et al.* 1999): cuttings (C), young coppice (R) and mature stands (M) (see De Warnaffe et al. 2006). These cover classes were digitalized on aerial photographs georeferenced with ArcGis®. We adapted the most frequently used photo-interpretation method (regressive photo-interpretation method, which consists in digitizing from the most recent to the older photograph (Muraz et al. 1999): indeed, at the fine scale of our study, superimposed digitalized maps do not fit perfectly because of inherent imprecision of georeferencing process, which induces artefactual edge changes (see Andrieu et al. 2008). Resulting maps were crossed in a SIG to obtain a synthesis map summarizing logging history.

Between 1942 and 2006, we assessed temporal changes (Mann-Kendall test for monotonic trends) in cutting system : cutting number, cutting total surface area per year, cutting mean surface area, ratio of areas coppiced with *vs.* without standards, cutting shapes complexity (Area Weighted Mean Shape Index, and Area Weighted Mean Patch Fractal Dimension). Matches between the shapes of cuttings and cadastral parcels were estimated visually. To test whether both ecological factors and forest accessibility can influence the number of cutting between 1942 and 2006 (elevation, slope and aspect, distance for streams, forest edge and ways, geology and soil type), we built log-linear regression model (log link function) on a random sample of 2000 points generated in the study area. Significance of effects was assessed by comparing deviance reduction of nested models with χ^2 tests (anova function, stats package, R)

and contrasts tests were used to compare regression coefficient estimates among levels. We analyzed wood maturation through changes in the proportion of surface area of cuttings, mature and immature stands. To assess spatio-temporal stability of mature stand habitat, we built cores of mature stand areas with potential edge effect of 10 m to 50 m for each period: maps were pooled in order to detect areas that were continuously mature since 1942.

2.3 Analysis of forest management practices

In order to analyze forest management practices we selected 7 woods with different surface areas (0.7 – 11.2 ha) on which we had rebuild the history of logging. They belong to 11 private owners: 4 active farmers, 7 retired farmers and 7 non-farmers. We used semi-directive interviews to analyze practices, know-how and ethnobotanical knowledge of private owners, and to define social networks. Both interviews and visits in the woods allowed rebuilding « mental-maps » of cuttings realized by the owners or their family. At home, we asked the owner to draw on an empty map the shape of the cutting procedure as far as he could remember. In the wood, the owner completed the information obtained (seeing logging signs helped the owner remind) and modify the previous map drawn. These "as told" practices (mental maps) where crossed with "observed" practices (from aerial pictures) in a GIS. During the interviews, the owner was also asked to describe the nature of the cutting procedure, cuttings people involved, season and equipment used, standards maintained, and what use was made of the wood that was cut since 1938. From these descriptions, two hypotheses have been tested. First, retired farmers are traditionally the managers of the woodlots after the transfer of the farm ownership and management to their son (Nougarède 1999). We tested thus the hypothesis of such a separation between knowledge and / or practices of forestry and farming which can be led by this transfer (Nougarède 1999; Cardon 1999). Second, the inheritance of woodlots to non-farmers could lead to a separation of forestry practices between farmers and non-farmers, each having their own knowledge and social networks. We tested thus whether the management of woodlots by non-farmers is disconnected or not from agriculture.

3. Results and Discussion

Whereas they constitute a large part of forested area in France, modalities and history of management of small private woods remained widely misunderstood because of the difficulty to collect and analyze historical information. Based on the analysis of historical documents and of semi-directive interviews, our studies show clearly how complex in space and time forest management by private owners can be.

3.1 Comparing mental maps and photo-interpreted aerial photography: benefits from the comparison between "as told" and "observed" practices

First, there was a good agreement between the "as told" and "observed" practices. Three types of disagreement were detected: (1) cutting operation is reported at the time of the interview without being identified on the aerial photograph, generally due to an high density of the standards; (2) cutting operation is detected by the aerial photograph but not reported at the time of the interview, due to an incomplete memory; and (3) rarely a great difference in the cutting areas for a given date or cutting date very different for a given area which can point out the difficulty of the informant to legend the "mental map". Since it is not possible to verify the memory of the owners, we should place greater faith in the aerial photographs to detect the cutting places; however cutting places choices and cutting procedures cannot be understood

without the memory of the owners. The combination of the two methods is therefore required to understand forest management through space and time.

Second, photo-interpretation showed some evolutions of management practices between 1942 and 2006. In our study site, the management consisted in numerous small cuttings (< 1 ha), mainly coppiced with standard (65% of the cuttings). The type of management (coppice with or without standards), the shape of the cuts, and their spatial localization (*i.e.* their aggregation) remained stable through time. However, even if the number of cutting remained stable, their mean size decrease since around 1980 (0.43-0.63 ha - depending on the year - before 1980, 0.16-0.20 ha after), which caused a decrease of total cut surface area (3.8 to 1.4 ha). This pattern associated to general information collected on rural life changes in the interviews indicate that the origin of the decrease of total cut surface area is not rural depopulation and the subsequent abandonment of forested parcels. It is very likely to be either the energetic transition to fossil fuel that decreased the needs in firewood (which is the main use of wood in our study site), or the lack of time available for forest management activities (and more widely the management of semi-natural habitats) in a context of change of farmer activities during the last decades. An important ecological consequence of the reduction of wood harvest is the maturation of the stands. In our study site, stand age structure changed drastically and we are now assisting to a homogenization of stand maturity toward mature trees: in 1942, 6 % of wood surface area was mature and 88% immature whereas in 2006 59 % was mature and 39% immature. Such changes of age structure can lead to a change of biodiversity patterns, like the replacement of assemblages dominated by early successional species by assemblages dominated by late successional species.

Photo-interpretation showed that the main part of the woods has been submitted to a moderate harvest intensity and has been cut once (27 % of surface area), twice (38 %) or three times (16 %) (Fig. 1). In appearance, around 15% of the wood surface area has never been cut since 1942. However these areas tally mainly with ancient abandoned fields or parts which have been already cut just before 1942. When these areas are excluded, only 3% of wood surface areas that were mature in 1942 have never been cut between 1942 and 2006. These preserved areas are scarce and small, particularly when a small edge effect of 10 m is attributed to them (9 isolated patches, surface area <0.3 ha). Species assemblage linked with old stands, characterized by the presence of dead wood and natural cavities, could thus be rare or missing in these farm forests. Another important result of our study is that the number of consecutive cuttings was not related to ecological or accessibility variables. This means that the choice of cutting localization was done on the basis of other criterion like land register (cuttings follow the shape of cadastral parcels, even if besides the cuts becoming smaller, their boundaries matched lesser in 2006 than in 1942). In addition, the choice depends on the conception of the owners - but not also of neighbors of the forest or of others managers - of how their woods have to be managed, because of particular events or agricultural needs (*e.g.* need for timberwood for the construction of a barn, needs for stakes for the pastures). These ideas led us to try to understand in a more precisely and through anthropological investigations the local management of the forest and the different people involved in it.

3.2 Who is doing what in the forest? From the classification owner and manager to the classification owner, decision-maker and performer

Following our interviews and direct investigations with the people involved in the forest management, we realized that the classical typology of the relationships between stakeholders and the woods (owner/ non-owner and manager / non-manager) - leading to the idea that forest were progressively managed without any influence of the farm practices on the forest land - did not fit our studied situation because : (1) some stakeholders can be decision-makers (*i.e.* makes the strategic decisions about the general management of the forest and who takes technical decisions during field activities) without being the owner of the woodlot (*i.e.* legally holds the

land); (2) some stakeholders can manage forests without being owner or decision-maker. We thus have to consider together property, decision and action: our typology is then owner / non-owner, decision-maker / non-decision-maker and action performer / action non-performer. These characteristics are non exclusive, for example a performer can occasionally make decisions or an owner decision-maker can occasionally carry out some forest activities. The term of « manager » is then meaningless in our study context. Therefore, even if the owner is not a farmer - anymore or at all - farmers can be involved in the forest practices at some point.

Following the idea that forest can be hold by retired father, while the son deal with the farm, we try to understand with our new typology the different roles shared by fathers and sons in forest management. Four father / son couples have been interviewed. All fathers were retired farmer, owners and decision makers, two were performers (the two other were occasional performers). No son (active farmers) was owner but all were decision-makers together with their fathers, three were the main performers and one was occasional performer. Retired farmer always helps their son in the farm. When the woods belong to the father, a strong relationship between agricultural and forestry practices remains, due to the implication of both father and son on both agricultural and forest lands. Even if they sometimes disagree about the way forests have to be managed, the management of the forests belonging to retired farmers is not dissociated from agricultural practices. Moreover most retirees keep considering and are considered to be as farmer as active farmers themselves. In the process of transmission of the property, if the forest can be separated from the farm for a while because being kept by the father while the farm is given to the son, this process is never definitive and the forest will automatically be transmitted to the son at the death of his father; it is finally never detached from the farm except on the paper.

What happens when non farmers are owners of forest land? Five non-farmers were owners and two were non-owner but were performers or decision-makers. Whereas non-farmers have no professional link with farming activities, we found that their forestry practices were strongly influenced by farming activities because (A) they can have relatives who are farmers and they integrate their practices, know-how and representations of the forest; (B) forests are embedded in an agricultural matrix so logging can be dependent of agricultural practices (for example, a farmer can ask his neighbors to manage the forest edge adjacent to his field); (C) techniques can percolate through social networks (neighbors, friends).

To conclude, these multidisciplinary studies illustrate that the specificity of rural forest management, particularly the high spatio-temporal variability of cuttings, the strong links between forestry and farm practices even when owners are "non-farmers", and the organization of activities within farming families.

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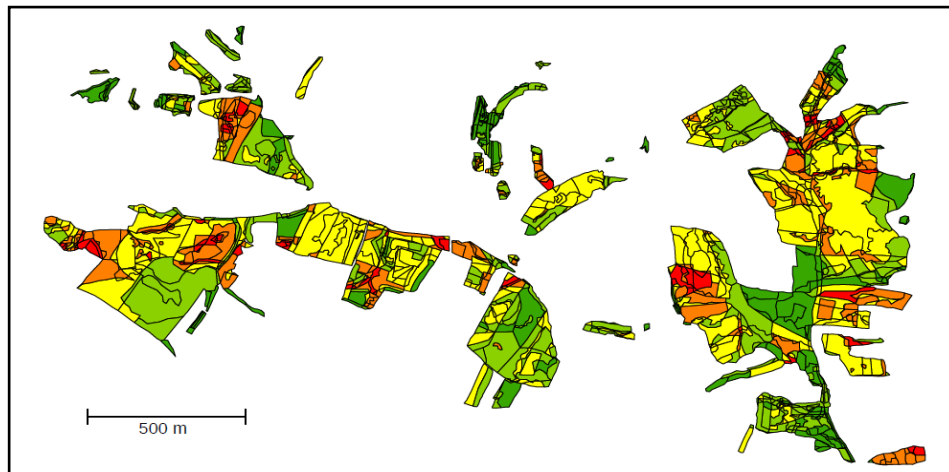

Figure 1: Synthesis map of cutting number between 1942 and 2006 (dark green = 0, light green = 1, yellow = 2, orange = 3, red = 4 and more, black lines = delimitation of different cutting events).

A framework for characterizing convergence and discrepancy in rural forest management in tropical and temperate environments

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Abstract

Rural forests are forests that are more or less formally appropriated, managed, shaped or rebuilt by rural communities, who have developed refined local knowledge and practices related to their use and perpetuation. Based on detailed monographs, we compared eleven situations of rural forests both from developing and developed countries, localized within a high diversity of ecological environments (humid tropics, dry forests, temperate forests) as well as regarding socio-economical and public policies characteristics. Data were pooled within a common analysis chart and processed by means of multivariate analyses. Results show that some variables are characteristic of all rural forests, such as multiple-use, tree species diversity, ecosystem stability, or patrimonial functions. Other results point out some specificities of particular rural forests, depending on the main use of single out of several tree species, importance of NTFPs, land ownership and management, and the magnitude of public action. This framework aims at better characterizing these particular forests in order to think about alternative forest management policies.

Keywords: rural forests, local practices, local knowledge, multivariate analyses,

1. Introduction

Forests in various parts of the world are not only places for wood production or environmental services (Myers, 1988; Ros-Tonen et al., 2005). They also play several roles for local people and are deeply integrated within diversified livelihood systems (Pretzsch, 2005; Agrawal, 2007). Rural forests are all forests more or less formally managed, shaped, transformed or rebuilt by rural communities, integrated within farming systems which structure landscapes and rural territories. These forests have not only contributed to sustain local livelihoods but are an entire part of local patrimony and identity. They are indeed based on trans generational knowledge and know-how that have contributed to social reproduction. However, particularities of these rural forests are not well defined since they encompass highly diversified situations and have not been of interest for classical forest science. Very few authors have explored the intrinsic characteristics of rural forests. Balent (1995) talked about peasant forest with examples from the French situation. Michon et al. (2007) coined a new paradigm for integrating local communities' forestry into tropical forest science with the notion of domestic forests. These authors argued and illustrated that domestic forest is "a forest for living, a forest that integrates

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production and conservation with social, political, and spiritual dimensions" at local level, and constitutes an entity which has to be dissociated from the more classical forests.

There is a real need for a better characterization of these rural forests. Which indicators can be addressed to understand the specific relationships that have evolved between rural people and the forests they have shaped? Are there general features found both in northern and southern countries? As complex socio-ecological systems, how do social and ecological factors jointly determine their nature? Can the concept of rural forest be an empirical model to put sustainable development in practice?

The research program POPULAR "Public policies and farmers' local management of trees and forests: sustainable alliance or dupery?" (www2.toulouse.inra.fr/popular/), supported by the French National Research Agency, aims at exploring the links between public policies and local uses and management of small-scale forests by rural people, at sharing experiences both from North and South, and at going further in the characterization of this almost orphan research object that constitutes rural forest. As part of this project, we report here on a comparative study that attempted to show the general characteristics and particularities of rural forests from examples taken both from North (five sites in France) and South (Cameroon, India, Indonesia and two sites in Morocco).

2. Material and Methods

The eleven sites were chosen in order to cover a large array of situations both ecologically (humid tropical forest, dry forests, temperate forests) and concerning human population pressure, socio-economic conditions and public policies related to forest management.

In France, different cases were developed within a context of centralized forest management and both agricultural modernization and decline : 1) common small-scale forests privately managed by traditional farmers from south-west part of France (Gascogne) (Deconchat et al., 2007): 2 and 3) the domestic chestnut forests in Corsica and Cevennes (South of France) which experienced several phases of abandonment and renovation and where confrontations between local dynamics and sustainable development policies are recurrent (Michon & Sorba, 2010); 4) An example of a multifunctional management of a tree out of forest in the Pyrenees (south-western France) which coevolved with changing agricultural systems and land use management : The ash tree (Mottet et al., 2007); and 5) the Languedoc Garrigues, a case of agriculture abandonment where local initiatives emerge to control parts of the territory, such as truffle forestry (Therville, 2009).

In Morocco, two situations representative of semi arid environment were analyzed : a secular endogenous community-based forest management named agdal in the High Atlas mountains (Cordier & Genin, 2008); the argan forest, located in the South West of the Country, with a unique a semi-arid climate (annual rainfall around 350 mm). Argan tree (*Argania spinosa*) is an endemic tree which provides highly valued oil for alimentary and cosmetic uses, and where there is large historic trajectory of forest management both from local populations and forestry services (Simenel et al. 2009).

In Southern Cameroon, even if forest ownership is public, management of forest is usually performed by local communities who partly depend upon the extraction of forest resources for their livelihood (Lescuyer, 2007).

In the Western Ghâts of India, different situations coexist such as commercial agroforests, sacred forests both managed by local people, and reserved forests managed by forestry services but where collective land use rights still continue. Two situations were analyzed in this paper: agroforests and reserved forests (Hinnewinkel et al., 2008).

In Indonesia, there is a large experience on indigenous communities' utilisation of forest resources. Since the 1970s, the relevance of local management systems for forest science, conservation and development have become well-recognized facts.

In each forest case, an interdisciplinary attempt was made in order to provide a detailed description of the rural forest, taking into account stakeholders, resources, practices involved, and ecological aspects and dynamics. A common analysis grid was previously built in order to produce a corpus of comparable data. The general aim was to characterize the socio-ecological systems by putting emphasis on interactions between ecological structures and functioning, use rules and intensity of uses of natural resources both in time and space. We encompassed five main themes: 1) physical and ecological characterization; 2) Actors and use rules; 3) Uses and functions of forests and forest resources; 4) Naturalist, technical, organisational, spiritual and political knowledge linked with the uses of trees and forests; 5) Main dynamics and challenges related to forested areas.

In a first step, monographs were analyzed and similarities or differences were pointed out by a qualitative analysis of the results within themes above mentioned. On the basis of this material and team researchers' expertise, a comparative data base was built, composed of 58 variables. We rated the outcomes for each variable on a five-point scale: inexistent or very low (1), low or poorly important (2), neutral or average (3), high or important (4), very high or very important (5). Assessments were done by a reduced researchers' group, and codification result discussed with the all team members of the POPULAR project. This process was effective for stimulating discussions, facilitating consistent and comparable information, and scoring of the variables. All variables were treated as having uniform weight, and were analysed together through Multiple Correspondence Analysis (MCA, see Benzecri, 1973). MCA was performed in two stages: first by fitting a cloud of points in a multidimensional vector subspace, and second, by setting a metric structure on this space. This analysis provided a non-parametric description of the relationships between modalities of variables and an indication of their importance rather than a measure of significance. It allowed the possibility of treating together both qualitative and quantitative data. We performed a Hierarchical Cluster Analysis of both variables and case studies using their scores along the main MCA axes, Euclidian distance and Ward linkage function. The Pearson correlation test was used in order to evaluate similarities between sites, and between variables. Data treatments were carried out using the STATBOX software.

3. Results and discussion

The main difficulty in studying rural forests is to deal with the complexity and interrelationships of uses, practices, functions and representations associated with forest resources and wooded landscapes. In this sense, a global descriptive approach of this complexity can constitute a first step in order to filter the main aspects governing the functioning of these systems. The set of case studies we undertook here, though far from being exhaustive, gives an interesting overview of this diversity in terms of ecosystem types and forest resources, forms of organization and operation of local communities, role of public authorities in forest management, and functions devoted to forest areas.

MCA reduction of the initial table in a few number of dimensions led to a synthetic representation of both forest case and influential variables that made possible a comparison of the similarities and dissimilarities between the forest cases. The first four MCA axes covered more than 50% of the overall observed variance, which is a relatively high score for a qualitative data set.

The first axis made it possible to discriminate the tropical forests (Cameroon, Indian reserved forests and to a lesser extent Indonesia significantly correlated to little to average domestication of trees, very strong rate of tree cover associated with a very strong tree species diversity, uses related to timbering and the non timber forest products (NTFP), and a strong control of the rules at the collective level) from the Corsican and Cevennes chestnut groves and truffle growing significantly correlated to highly transformed ecosystem, little fragmentation of the landscape, private landownership associated with little influence of collective institutions, strong use for

firewood, very strong technical know-how, and control of the trees and strong transformations of the social systems .

The second axis allows discriminating the small private forest of Gascogne, the ash tree case and the Indian Reserved forest from the Argan forest and Indonesian agroforests. The first group of forests is correlated to private landownership except for the Indian reserved forest, strong compliance with the collective rules (often because they do not exist!), poor commercial economic functions associated with poor economic issues, little economic valorisation of the products extracted from the forest, and a weak forest/agriculture integration. The second one to strong domestication of the trees, little fragmentation of the landscape, mixed landownership status associating private, collective and public ones, strong set of rules established at collective level and associated with a rather strong control of the rules by the State, and common use of non woody forest products.

The third axis allows to discriminate truffles and small private forests of Gascogne, characterized by a domestication at the tree stand rather than at the individual tree level, few new actors intervening who claim or not of being partisans of sustainable development, little transformation of the forest products, a weak home consumption of forest products and a very little transformation of the social systems, from Corsican and Cevennes chestnut cases characterized by the importance of the use of the forest for animal husbandry, a strong dynamic of the practices associated with strong transformation of the social systems, a high transformation of the products resulting from the forest and the importance of new actors intervening in the use of the forest.

On the fourth axis, cases with a high significance were found the A*gdals* of the High Atlas and Indian agro-forests. For the first case, outstanding variable modalities were those related to the collective landownership status, the influence of the collective rules for access, uses and management of forests; modalities such as the strong use of foliage as fodder, the function of the rural forest as reserve/safety in cases of climatic hazards, a high home consumption associated with a very weak commercial activity with the forest products were also significant. For the Indian agro forests, associated modalities of variables were a very strong forest/agriculture integration, associated with an agricultural use of the forest and the use of NTFP, a landownership mainly private, but a very strong political know-how suggesting a structured local organization; also an increase of surperficie.

The Hierarchical Cluster analysis on the forest cases provided a classification of the studied rural forests in five groups: High Atlas (group 1); Cameroun, Indonesia, Indian Reserved Forests (group 2); Indian agro forests (group 3); Corsica, Cevennes, Argan forest (group 4) Gascogne, truffles, ash tree (group 5).

It pointed out similarities found in tropical forests, globally (group 2), the ones found where a single tree species represents the main characteristic and uses of the forest (chestnut groves, argan forest) (group 4), and the ones with a traditional forest and tree management found in France mainly characterized by almost completely private decisions and practices, with very weak external interventions. Two situations remained individualized: *Agdals* in the High Atlas where strong traditional collective rules and uses conform the overall forest management, and Indian agro forests where there is a mix between individual, collective and state interventions, and a high diversity within the transect between natural to highly transformed forest.

The Hierarchical Cluster analysis on the variables data set provided a partition within seven classes:

Class 4 represents the overall common characteristics of the rural forests (multi-use, home consumption, importance of use of wood (firewood and timber), tree species diversity, stability of ecosystem, important patrimonial functions as well as their stakes in the construction of the territories). All the studied forests present important scores for these variables (> 3.5 on average).

Classes 1 and 3 are characteristics of group 4 (Corsica, the Cevennes, Argan forest). They correspond to rural forests based on the use of a single tree species (chestnut or Argan) for which the knowledge related to control and the domestication of the individuals are important, as well as the practices of transformation and product valorization.

Class 2 represents the reactive variables with the group 5 (Gascogne, truffle, ash tree) which represents the French small-scale forests integrated to traditional farming systems, very weakly influenced by the forest public policies and managed at the family level to meet various needs and amenities (timber and firewood, mushrooms, hunting places, etc).

Class 5 gathers the major variables characterizing tropical rural forests (groups 2 and 3), it said the importance of timbering, an important biodiversity, the use of various non woody forest products (resins, fruits, medicinal plants, etc).

Class 7 reflects the variables for which the State is very present, at the same time in the management of the forests and its relations with the local populations (High Atlas and India reserved forest).

Class 6 gathers the significant variables linked with the traditional rural forests found in developing Countries (groups 1, 2 and 3) where the influence of diversified collective institutions (being customary or more or less legally formalized) is critical in the management of forest areas and where these areas have important functions reserve/safety for the livelihood systems.

Conclusion

In this first attempt to put evidence of what could be the specificities of rural forests, we can advance that they are, in essence, multi functional areas, of long term usefulness both for extracting goods, accommodating livelihoods to local environment, taking control of landscapes and territories, and building a representation's world intimately linked to local culture and knowledge. Diversity logically characterizes rural forests which are an on-going result of this multifaceted shaping; it has then to be undertaken in the light of the functioning of rural societies. As Michon et al. (2007) argued, rural forests present two universal features that could characterise them. The first one concerns the local managers who are usually farmers. Management practices are closely related to agriculture (sensus lato) and range from local interventions in the forest ecosystem, to more intensive types of forest cultivation, and ultimately to permanent forest plantation showing high similitude with classical agricultural practices. The second one concerns the continuum of planted forests with the natural forest, in matters of vegetation's structure and composition, as well as economical traits and ecosystems services. Arnold (1977) claimed that uses-oriented forest management by local people and tree planting can be explained as being one or more of four categories of response to dynamics of rural change: to maintain supplies of tree products as production from off-farm tree stocks decline; to meet growing demand for tree products; to help maintain agricultural productivity in face of declining soil quality; and to contribute to risk management and securization of the overall functioning of farming systems. We would like to add: an early perception by local people of specific forest resources' potentialities to enhance their livelihoods, the demand for a local land control both for extraction and long term management, and a fundamental structural element of the way local societies perceive their surrounding world and their humanity. Hence, rural forests constitute also a critical element of the biocultural sphere of local societies which determine in a significant part, both structure of ecosystems and the ways rural societies evolve. Far from being strictly geographically determined, they usually are the result of a deep shaping of the natural forest, and enter in complex domestication processes in order to satisfy changing rural livelihood requirements. In this sense, a better understanding of their characteristics and functions is required for developing renewed integrated strategies for sustainable development of rural and forest management systems.

References are available upon request to didier.genin@univ-provence.fr

Figure 1: *Representation of the 11 case studies of rural forests and some significant modalities of variables on the F1xF2 plan of the Multiple Correspondences Analysis (MCA).*

Figure 2: Cluster Analysis of the eleven case studies of rural forests

Do wooded elements in agricultural landscape contribute to biological control in crops?

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Abstract

Wooded landscape elements are supposed to enhance biological control of pest thanks to natural enemies by provided with alternative preys, nectar and pollen resources, and refuges against unfavourable weather conditions. On the basis of two research studies in south western France we identified key features in woody elements contributing to biological control. The first study monitored in 14 winter wheat fields during 5 years aphids and aphidophagous hoverflies abundance in two landscapes differing in woodlot density. Landscape with the higher (27%) wood cover sheltered higher hoverfly abundance during the early spring period (beginning of aphid pullulation), thus providing them with higher potential regulation capabilities. Afterwards, the difference decreased during the season. The second study dealt with ground beetles overwintering in woods. Taking advantage of emergence traps, we showed that many carabid species, including species controlling pest, overwinter in woodlots before colonizing fields. Within woodlot, distance from edge influenced abundance of overwintering carabids.

Keywords: landscape, hoverfly, carabid, woodlot, pest regulation

1. Introduction

Because most of the natural enemies of crop pests feed in fields but usually carry out other life cycle steps, like overwintering, in semi-natural habitats of farmland (Groeger, 1993), many studies focus on the important role of the latter, such as hedges, field margins, "beetle banks" and fallows, in increasing their populations and in improving their efficiency as control agents (Russel, 1989; Landis *et al.*, 2000; Gurr *et al.*, 2004). This is most probably because these semi-natural habitats have a more buffered micro-climate, are less subject to agricultural disturbance than fields themselves and provide complementary or alternative food resources for larvae and adults.

A lot of studies have focused on overwintering of beneficial arthropods in field margins (Thomas et al., 1992). Fewer studies looked at woodlots as potential overwintering sites. Nevertheless, in temperate rural landscapes, forest cover can be as high as 30% with a high proportion of small woodlots. In such situations, woodlots, which are in close contact with agriculture, are likely to play an important role as a refuge for overwintering beneficial arthropods (e.g. Sarthou et al., 2005).

The two studies presented in this paper tested the role of woodlots in controlling the population densities of beneficial insects at two different spatial scales. In the first study, we tested if there are more hoverflies and potential aphid control in wheat parcels surrounded by woodlots. In the second study, we estimated the overwintering density of ground beetles in different parts of a woodlot, from the edge to its core.

2. Methodology

The study region lies between the Garonne and Gers rivers, in south-western France (c. lat: 43°, long: 1°). This region is hilly (200-400m. alt.), dissected by south-north valleys, within a sub-Atlantic climate zone subject to both Mediterranean and montane influences. Forest covers 15% of the area and is composed of multiple small, private forest fragments (Balent & Courtiade, 1992). Landscapes include a mix of cropland (winter cereals, sunflower, rape, and maize or soya in irrigated lowland), pastures, and small coppice woodlots. Semi-natural habitats are hedges, field margins, woodlots, fallow lands and stream plus ditch edges.

Spring abundance of hoverflies was studied in wheat fields in two landscapes differing by wood density: 27% versus 15%. Wood density was determined using a land cover classification based on four satellite images (Multiband mode, April 2001, July 2001, October 2001 and January 2002). Aphidophagous hoverfly (larvae and eggs) and aphid abundances were recorded in twelve wheat fields (6 in each landscape) in spring 2003 (April, May, June), then 14 were monitored from spring 2004 to spring 2007.

We selected a woodlot that was representative of the site with respect to area (11 ha), vegetation composition (dominated by *Quercus robur* and *Q. pubescens*) and management (coppices with standing trees), and for which we had data on previous logging events. We set up 45 emergence traps in the woodlot, according to the distance from the boundary. The boundary of the woodlot was defined as the line joining the bases of the first trees (diameter at 1.3 m > 10 cm) belonging to the woodlot. We selected three separated zones of the woodlot according to the distance from its boundary: the edge zone (0 m to 3 m from the boundary, 12 traps), the center (75 m to 100 m, 17 traps) and an intermediate zone (25 m to 50 m, 16 traps). To trap ground beetles, we chose the method of emergence traps because it makes it possible to estimate true densities of insects in very limited areas without the disadvantage of catching larvae as with soil and litter sampling, larvae being more difficult to identify. The traps were enclosed areas of 1.8 m² and were made of 0.5 mm mesh, looking like tents which sides were buried into the soil (5 cm depth). Each emergence trap included two recipients for insects: an upper recipient half-filled with 70% ethanol at the top of the trap to catch flying and climbing insects and a lower recipient level with the soil surface with 50% propylene-glycol (i.e. a pitfall trap inside the tent) to catch epigeous arthropods. The recipients were collected once a month from early March to late October 2008. Ground beetles were identified to species level (Jeannel, 1942). Then, species were pooled in three groups according to their habitat preference reported in other studies (Jeannel, 1942; Thiele, 1977; Thomas *et al.*, 2002; Luff, 2002): forest species, which adults are caught mainly in wooded habitats with pitfall traps, open habitat species. and generalist species, found in both types of habitat. Variables used in the analysis were thus total densities of ground beetles per trap, species richness and densities of individuals in each of the three groups listed above, per trap.

3. Result

Spring abundance of hoverflies and aphids in wheat fields
Overall, there were more aphids and hoverflies in the wooded landscape than in the non wooded landscape. When summing all the records in a spring, there is no significant difference in

hoverfly abundance (eggs+larvae) in wheat fields between the wooded and non wooded landscapes. Compared with poorly wooded landscapes, landscapes with 27% of wood land-cover seemed to shelter higher hoverfly abundance during one of the key-periods for the aphid population dynamics (early spring), thus providing them with higher potential regulation capabilities. Afterwards, the difference between hoverfly population abundances decreased during the season (Figure 1).

Density of overwintering ground beetles in a woodlot

We collected a total of 2014 ground beetles during the whole trapping period, belonging to 48 species. The total density of emerging ground beetles was four to five times higherin edges than in the inner areas of the woodlot and the mean number of species per trap was three times higher in edges than in the inner areas. Open habitats species overwintered only in the edges and not in the inner areas while the two other groups of species overwintered in all the woodlot but with a marked preference for the edges (Figure 2).

4. Discussion

Our results show that woodlot edges are favourable for insect biodiversity in agricultural landscapes, by (i) favouring abundances of aphidophagous hoverflies in early spring in fields, and (ii) sheltering both high species richness and abundances of ground beetles. Positive influence of woodlot edges on these insect populations seems to occur mainly during the winter period, probably by offering local environmental conditions favourable to their overwintering. Identifying such landscape elements which favour overwintering of beneficial insects is of a particularly interest from the agronomic point of view of biological control of pests, for which early arrival of a natural enemy is required in spring (Honek, 1983; Tenhumberg & Poehling, 1995; Corbett *in* Pickett & Bugg, 1998). Aphidophagous hoverflies distribution and abundance prove to be dependent both on landscape parameters (Molthan, 1990), peculiar to forests and crop mosaic respectively, which act at different periods through the year and sometimes with a lasting effect. Indeed south forest edges proved to be important landscape elements for the overwintering of adult females of the beneficial aphidophagous hoverfly *Episyrphus balteatus*, particularly when spatially coupled with grasslands and fallows rich in floral resources (Arrignon et al., 2007). As for north forest edges, they also proved to enhance populations of adult *E. balteatus* emerging in spring since they are preferential overwintering sites for the larvae, probably because of higher density of aphid populations in the fall (Sarthou et al., 2005). For ground beetles, forest edges appeared as a major reservoir of specific diversity (numerous species and their individuals) potentially able to control some pest species in the nearby crop fields, even the forest species, which are the biggest ones and are reported to prey on slugs (Kromp, 1999; Symondson *et al.*, 2002). Moreover, woodlot edges sheltered ground beetles species whose adults live and exert beneficial influence in crops but are not usually found in wooded habitats. The impacts of edge management on these populations and their ability to move from forest to crop have to be investigated in the future. These results offer new insights for pest regulation through landscape management, particularly by pointing the forest edges as other important landscape elements to add to well-known set-asides and hedges in the design of semi-natural element network in agricultural landscapes (Russel, 1989; Landis *et al.*, 2000; Gurr *et al.*, 2004). Undoubtedly, this 'landscaping' management of agroecosystems will benefit from a better ecological services-based knowledge of other landscape elements (natural grasslands, fallows, ditch edges…) at different spatial scales, and a better integration of this knowledge in crop management.

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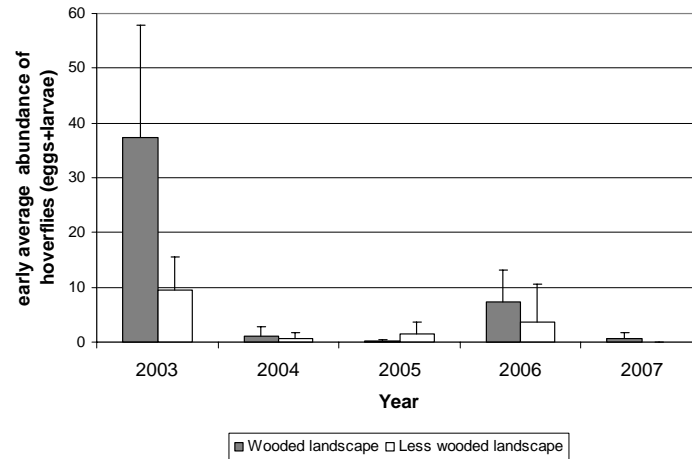
Figure 1: Early average abundance (the first four records) of hoverflies in wheat fields in wooded and less wooded landscapes during the five years.
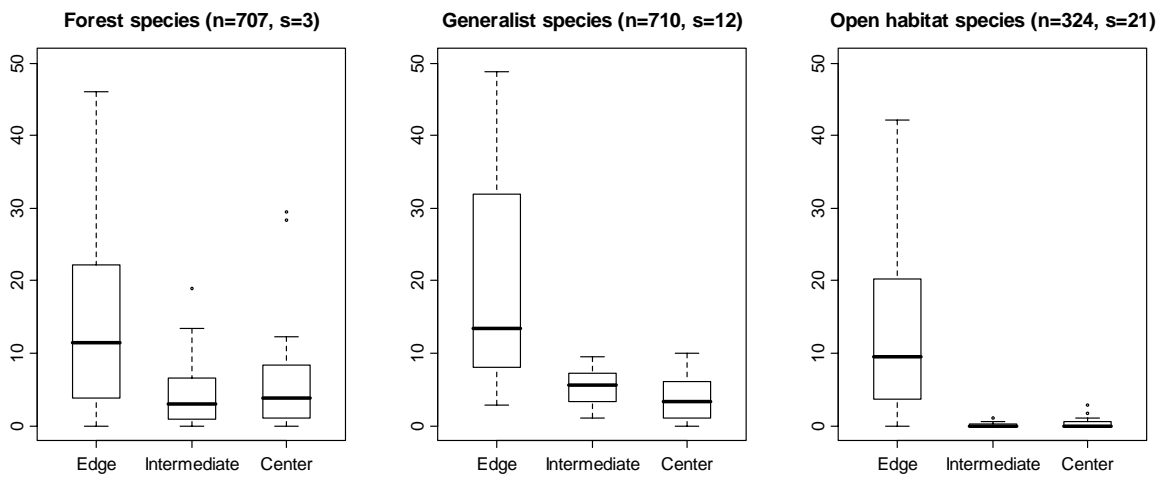
Figure 2 : Density of overwintering ground beetles (number of individuals per square meter) in the edge, intermediate area and center of a woodlot, according to habitat preference of the adults. The extent of the boxes represents the first and third quantiles, the bold trait is the median.

From abandoned farmland to self-sustaining forests: challenges and solution

Harmonized measurements of spatial pattern and connectivity: application to forest habitats in the EBONE European Project

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Abstract

Within the EBONE European project ("European Biodiversity Observation NEtwork"), fine-grained maps of harmonized "General Habitat Categories" are available for sixty 1 km^2 samples located in Austria, Sweden and France. Three methods were proposed to map and assess automatically the spatial pattern and connectivity of habitats. They were demonstrated for forest phanerophytes habitats. Forest spatial pattern maps were obtained from mathematical morphology (GUIDOS freeware applying a 25 m edge size) to discriminate core forest, their boundaries, connectors between core areas and islets as small non-core elements. Landscape pattern mosaic maps were generated with a Landscape Mosaic Index to characterize the forest surroundings in a disk of 25 m radius. The two pattern maps were overlaid. A "Similarity" index was proposed to assess the pre-dominance of natural habitats (thus a similar/permeable forest – non forest interface) and of anthropogenic habitats (possibly fragmentation due to cultivated or artificial land use) in the context of the forest boundaries, connectors and islets. Forest interior areas were delineated with edge sizes depending on the similarity with their adjacent habitats. Finally, two forest connectivity indices (one with CONEFOR freeware) were computed for species with 500m dispersal capabilities on the basis of habitat availability, matrix permeability and inter-patch least-cost distances. The two indices were compared.

Keywords: spatial pattern, connectivity, forest habitat, European reporting

1. Introduction

The European EBONE project (**E**uropean **B**iodiversity **O**bservation **Ne**twork, http://www.ebone.wur.nl/UK) aims at European-wide habitat mapping, the delivery of habitat area estimates and the characterization of landscape level habitat pattern, fragmentation and connectivity as it is requested in the SEBI 2010 process (Streamlining European 2010 Biodiversity Indicators). Methodologies should be standardized and easily repeatable across scales, using existing capabilities from national/regional habitat monitoring programmes. Reporting is expected using the thirteen environmental zones from the European Environmental Stratification (Metzger *et al.*, 2005) based on climatic and topographic data at a 1 km^2 resolution. The EBONE in-situ database offers harmonized habitat field based maps (seamless vector layer with 400 m^2 Minimum Mapping Unit) over several 1km^2 samples thanks to the currently on-going conversion of national data into the common BioHab General Habitat Categories (GHCs, Bunce *et al.*, 2005 - figure 1). GHCs are organized in 5 super-categories *i.e.* whether the land surface element is 'Urban', 'Cultivated', 'Sparsely Vegetated' (vegetation cover below 30%),

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'Herbaceous', 'Trees or Shrubs'. Each element is described according to 16 life forms based on plant structural characteristics like plant height and leaf retention division. For example, phanerophytes are classified as forest when above 5 m height.

For this study, available samples including forest phanerophytes were 16 in Sweden (NILS: National Inventory of Landscapes http://nils.slu.se), 39 in Austria (SINUS: Spatial INdices for land-Use Sustainability), and 11 in the French Provence Cote d'Azur (PACA) region (Figure1).

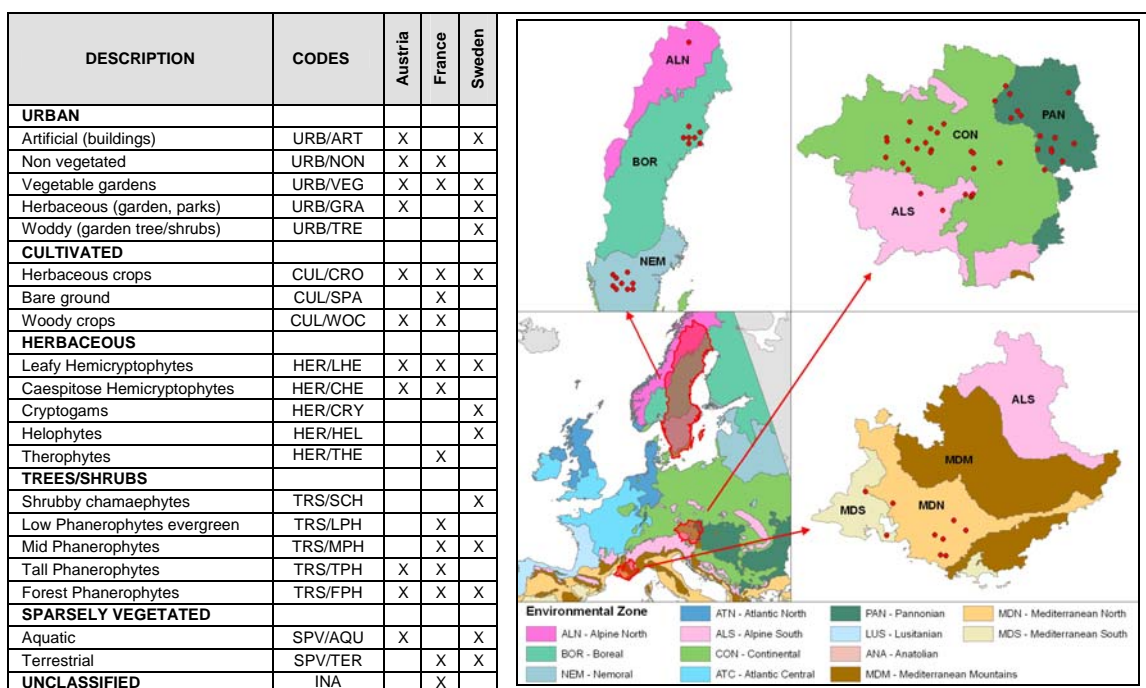| DESCRIPTION	CODES	Austria	France	Sweden
URBAN				
Artificial (buildings)	URB/ART	X		X
Non vegetated	URB/NON	X	X	
Vegetable gardens	URB/VEG	X	X	X
Herbaceous (garden, parks)	URB/GRA	X		X
Woddy (garden tree/shrubs)	URB/TRE			X
CULTIVATED				
Herbaceous crops	CUL/CRO	X	X	X
Bare ground	CUL/SPA		X	
Woody crops	CUL/WOC	X	X	
HERBACEOUS				
Leafy Hemicryptophytes	HER/LHE	X	X	X
Caespitose Hemicryptophytes	HER/CHE	X	X	
Cryptogams	HER/CRY			X
Helophytes	HER/HEL			X
Therophytes	HER/THE		X	
TREES/SHRUBS				
Shrubby chamaephytes	TRS/SCH			X
Low Phanerophytes evergreen	TRS/LPH		X	
Mid Phanerophytes	TRS/MPH		X	X
Tall Phanerophytes	TRS/TPH	X	X	
Forest Phanerophytes	TRS/FPH	X	X	X
SPARSELY VEGETATED				
Aquatic	SPV/AQU	X		X
Terrestrial	SPV/TER		X	X
UNCLASSIFIED	INA		X	

Figure 1: General Habitat Categories from the available 1km^2 samples per country (left) and localization of the samples (red dots) per environmental zones (right)

Available definitions of habitat pattern are first based on landscape structure and further refined by considering organisms' behavioral responses to the landscape:

1. The landscape level spatial pattern of a habitat simply refers to the spatial arrangement or configuration of this habitat across the landscape.
2. Fragmentation refers to the entire process of habitat loss and isolation. Isolation means lack of connectivity and is more complicated than simple distance.
3. Connectivity refers to the "degree to which the landscape facilitates or impedes movement of organisms among resource patches". It depends on habitat availability and spatial distribution, species' dispersal abilities and response to the nature of the matrix.

From literature on forest fragmentation, interior forest habitats are remnant minus an edge of a certain width. They retain similar abiotic and biotic conditions to pre-fragmented conditions and do not experience strong influences from neighboring patches of other land cover categories. The width of recently exposed edges, measured by two tree heights, could range from 20 m to 160 m. Adjacent land cover types possibly influence the development of the forest edge communities and interior habitat. Depending on their similarity to the forest habitats, interfaces are more or less permeable. In temperate regions, shift in land uses at forest edges may be more important than direct forest loss. Forests fragmented by anthropogenic sources are intuitively more vulnerable to further fragmentation than forest fragmented by natural causes.

2. Methodology

Three available methods are tested to characterize spatial pattern and functional connectivity for a focal habitat class and demonstrated for the focal forest phanerophytes (FPH) habitat class.

2.1 Morphological Spatial Pattern Analysis (MSPA)

The spatial pattern of a focal habitat class can be automatically characterized and mapped at pixel level thanks to mathematical morphology using the freeware called GUIDOS (Soille and Vogt, 2009). Seven mutually exclusive pattern classes are obtained by segmenting a binary raster map (1: foreground/focal class and 0: background):
1. 'Core': foreground pixels beyond a distance of a given size s to the background; s is the only entry parameter of the method; the input map is eroded with a Euclidian disk of radius equal to s.
2. 'Islet': foreground pixels that do not contain any core.
3. Boundary 'Edge of core': outer boundary pixels of a cluster of core pixels.
4. Boundary 'Edge of perforation': inner boundary pixels of a cluster of core pixels when perforated by background pixels (like 'holes' inside a foreground region)
5. Boundary 'Branch': foreground pixels with no core that is connected at one end only to a connector, an edge of core or an edge of perforation.
6,7. 'Connector': foreground pixels with no core that connects at least two different core units (bridge) or connects to the same core unit (loop).

2.2 Landscape mosaic index

The landscape context of a focal habitat class can be characterized in a Geographic Information System by applying a landscape mosaic index (Riitters *et al.*, 2009) on a 3-dimensional raster input map (for example, natural, agricultural and urban). Landscape pattern types are defined by placing a "window" on each pixel of the input map, calculating the proportion of the three classes within the window, and putting the result on a new map at the same location. This new map has fifteen landscape pattern categories (see Figure 2) and the landscape mosaic pattern map of the focal class is obtained by masking all non-focal classes. The "window" will be a Euclidian disk of radius s, like in the MSPA method, to further overlay the two pattern maps.
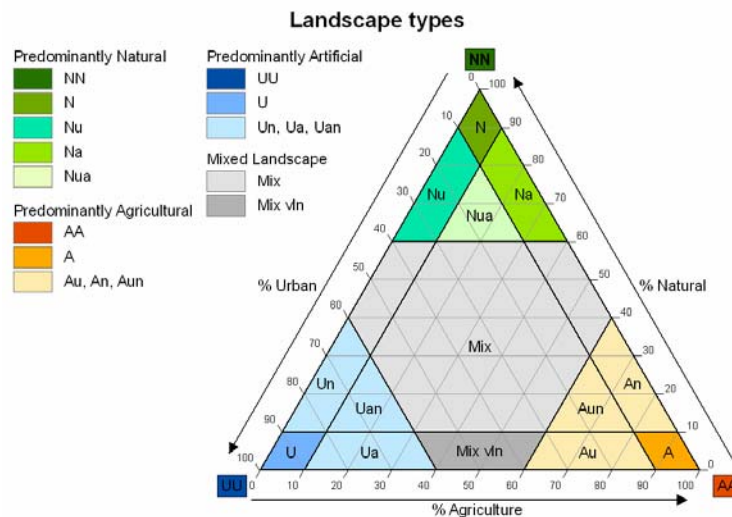

Figure 2: the fifteen landscape pattern types derived with the landscape mosaic index

The MSPA and the landscape mosaic pattern maps will then be overlaid to provide the landscape context composition in terms of mosaic pattern types for each non-core MSPA class (boundary, connector, and islet). A new "similarity" index (SI) is proposed to translate the anthropogenic or natural dominance in the surroundings. When the mosaic pattern is NN and the focal class forest, the context is similarly 100% natural, possibly permeable and most

probably due to natural fragmentation causes. Anthropogenic fragmentation causes in predominant natural context are pointed at by using patterns N or (Nu, Nua, Na) in the formula.

$$SI(MosaicPattern)_{MSPAClass} = \frac{(MosaicPattern)_{MSPAClass}}{MSPAClass} \qquad (1)$$

"Interior" areas are delineated as core areas plus the NN part of the MSPA boundary edge.

2.3 Connectivity assessment

The Probability of Connectivity (PC) index for a focal class, calculated with the software Conefor Sensinode (Saura and Torne, 2009 at http://www.conefor.org), is based on topology (inter-patch distances), patch attributes like area and species specific dispersal ability. PC will be processed with the probability of dispersal, being a decreasing exponential function of the effective distance, matching to a 50% probability for a specific average dispersal distance. The effective distance is a value of movement cost through different habitats that is obtained through least-cost path algorithms, thus considering the landscape permeability between the focal patches. PC has a bounded range of variation from 0 to 1. The cost distance matching the 50% probability ($p = 0.5$, $cost_{d50\%}$) corresponds to the average dispersal distance ($d_{50\%}$) multiplied by the average friction per distance unit (avg_f). The average friction is set at half a logarithmic scale of frictions, being from 1 to 10,000 (avg_f = 100). PC is made comparable to the available habitat in the total landscape area, by computing its square root (RPC).

$$PC = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} a_i \cdot a_j \cdot p_{ij}}{A_L^2} \qquad (2)$$

$$RPC = \sqrt{PC} \qquad (2bis)$$

with:
$a_i\ a_j$ = area of patches
A_L = total landscape area
$p_{ij} = e^{\,k \cdot cost_{ij}}$

$$k = \frac{\ln(0.5)}{cost_{d50\%}}$$

$$cost_{d50\%} = avg\_f \cdot d_{50\%}$$

Another index, adapted from Hanski (1994), called Isolation Sensitive Index (IsoSi) is proposed. It is similar to PC but accounts for solely the arrival patch area size for each pair of patches. The landscape area (A_L) and the number of links (node to node) are used for normalization purposes.

$$IsoS_i = \frac{\sum_{i \neq j, i=1}^{n} a_i \cdot p_{ij}}{A_L \cdot (n-1)} \qquad (3)$$

with:
n = number of patches (nodes)

3. Result and discussion

3.1 Pattern characterization based on MSPA and landscape mosaic index

First, the GHCs vector maps of all available samples (figure 1) were rasterised at 1 m spatial resolution, re-classified into forest phanerophytes (FPH)-non forest and processed with GUIDOS using a narrow forest edge width (*s* equal to 25 m). The local morphology of the FPH habitat cover was mapped according to 4 main pattern classes (upper figure 3) and their forest area share (figure 4 left) was calculated: core, boundary (edges of core, perforation and branch), connector (bridge and loop) and islet.
Second, the GHCs 1 m raster maps were re-classified into natural (TRS, HER, SPV), cultivated (CUL) and urban (URB) habitat types (figure 1). The fifteen landscape pattern types were mapped by applying the mosaic index using a 25 m radius disk. The non-FPH classes were masked. The landscape context map of FPH habitats enables to visualize and characterize FPH interface zones (NN discriminated from Nu for example) (figure 3 bottom), and compute forest proportion of the 4 main landscape FPH pattern types for each available sample (figure 4, right):

- Two natural forest landscape patterns where FPH habitats have no (NN) or not significant (N) edge shared with cultivated and/or artificial habitats, interface zones are possibly permeable.
- Mixed natural forest landscape pattern (Nu, Nua, Na) where FPH habitats have possibly less permeable interfaces as being adjacent with cultivated and urban types of habitats
- "Some natural" forest landscape (all others) where FPH habitats are pre-dominantly embedded in non-natural context of cultivated and urban types of habitats.
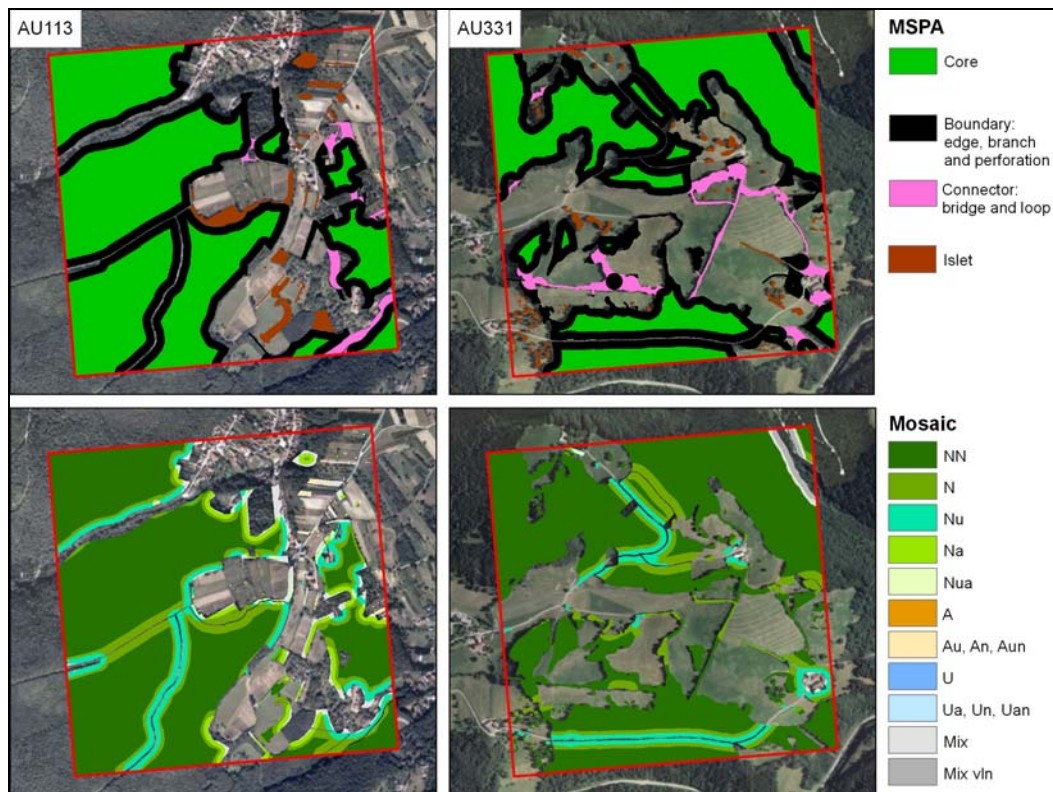
Figure 3: Example of two samples in Austria: Forest MSPA (upper) and landscape mosaic (bottom) maps
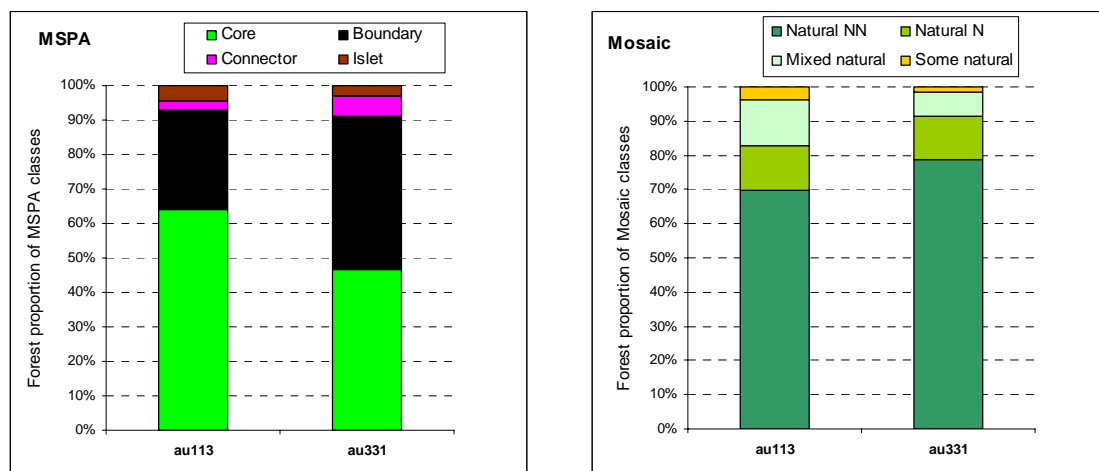
Figure 4: MSPA and landscape mosaic class proportion for the same two samples in Austria

The MSPA and the mosaic pattern maps were overlaid to compute the Similarity Index for non-core MSPA classes, and delineate "interior" forest areas which edge width depends on adjacent habitats. Forest proportion of "interior" and core areas can be compared in table 1 for two samples with different permeable boundary contexts as illustrated by the proportion of NN in

the boundary MSPA class (SI (NN) $_{Boundary}$). Also, boundaries are more exposed to anthropogenic fragmentation in pre-dominant natural context (SI(NuaNaNu)$_{Boundary}$) in the less permeable Au113.

Table 1: Forest (FPH) proportion of "interior" and Core area, and the Similarity Index applied to boundaries in two samples in Austria (Continental zone).

Samples Id	Core FPH	Interior FPH	SI (NN) $_{Boundary}$	SI (NuaNaNu)$_{Boundary}$	SI (some nat.) $_{Boundary}$
Au113	40.1%	43.5%	18.6%	36.7%	6.4%
Au331	26.5%	41.3%	58.9%	13.7%	3.6%

3.2 Connectivity

Connectivity indices PC, RPC and IsoSi were calculated for species dispersing at 500 m average dispersal distance. Costs of movement (friction) were assigned to every habitat types using a logarithmic increment values from FPH (lowest friction 1) to urban habitats (highest friction 10.000). The parameter cost$_{d50\%}$ was 50.000. RPC and IsoSi behaved differently (see Table 2 with the sample Au113 with fewer nodes and a less permeable context than the sample Au331).

Table 2: Connectivity indices in two different spatial configurations and permeability contexts

Samples Id	FPH area %	Nodes number	PC	RPC	IsoSi
Au113	63 %	33	35 %	59 %	50%
Au331	57 %	85	31 %	56 %	55%

IsoSi is more sensitive to the inter-patch landscape matrix permeability, possible barrier effects and is thus more focused on the probability of species movement. This was expected since the weight for areas (intra-patch) is the same than p$_{ij}$ while it is double in the PC (and RPC) index. In contrast, PC (and RPC) reacts better to habitat availability (its intra and inter-connectivity). Are the two indices necessary to correctly describe landscape connectivity and its permeability? How sensitive a connectivity index should be to the matrix permeability? More research needed.

4. Conclusions

For all sample, harmonized pattern and connectivity maps and tabular data were organized per environmental zone. They will be incorporated into the EBONE data management structure prototype to be ready at the end of the project (2012). The methods here proposed are currently repeated over the available Earth Observation based land cover maps to prepare the integration of EO based and *in situ* habitat pattern assessment in the view of extending the geographical extent of habitat pattern/connectivity information available for biodiversity assessment (Estreguil and Mouton 2009).

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Restoration of biodiversity and ecosystem services in cropland.
Further research is needed but action is desperately needed

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Abstract

Farmland currently extends on more than 40% of the land's surface. Secondary succession on abandoned agricultural land is often slow owing to biotic and abiotic limitations as it occurs in e.g. Mediterranean environments. Tree plantations can be expensive if large areas are to be restored and they are often controversial because they negatively impact on species of conservation concern. We suggest "woodland islets" as an alternative approach to designing ecological restoration in extensive agricultural landscapes. This approach allows conciliate farmland production, conservation of values linked to cultural landscapes, enhancement of biodiversity and provision of a range of ecosystem services. If "*further research is needed*", "*action is desperately needed*". The *International Foundation for Ecosystem Restoration* is developing the "Islets and coasts in agricultural seas" Initiative to implement demonstration projects of conciliation of farmland production and enhancement of biodiversity and ecosystem services. The implemented restoration actions intended to "renaturalize" agricultural landscapes are accompanied by a variety of social and educational values including citizen science.

Keywords: conciliation, ecological and societal benefits, secondary succession, tree plantations, woodland islets

1. Introduction

Human cultural evolution has left an unprecedented ecological footprint on Earth, so as to affect currently about 80% of the planet's surface. This implies large losses of biodiversity and of the variety, amount and quality of ecosystem services, which compromises the sustainability of eco-sociological systems (Ostrom 2009). Unfortunately, predictions suggest that the ecological human footprint will expand in the future (Hockley et al. 2008). A large part of global environmental degradation is due to the expansion of the agricultural and livestock boundary in most parts of the world together with agricultural intensification. Currently, agricultural lands and pasturelands make up over 40% of the terrestrial surface, in detriment of natural vegetation cover (Foley et al. 2005). On the contrary, large extents of agricultural land and pastures have been abandoned over the last few decades for economic reasons. Any event that spurs an either "positive" or "negative" effect in these systems can have a relevant ecological and socio-economic impact.

Ecological restoration aims to recover, at least partially, the characteristics of an ecosystem, such as its biodiversity and function, before degradation or destruction occurred, generally as a result of human activities (Rey Benayas et al. 2009). Restoration ecology actions have been increasingly implemented, supported by agreements by global politicians such as the

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Convention for Biological Diversity and the sustained global biodiversity crisis (Sutherland et al. 2009). The scientific community must search for ecological restoration protocols and models that allow a synergy between the exploitation of ecosystems and nature conservation, which will in turn improve the sustainability of systems for the exploitation of natural resources.

2. The agriculture and conservation paradox

Few human activities are as paradoxical as agriculture in terms of their role for nature conservation. On one side, agricultural activities are the main cause of deforestation worldwide, which has occurred at an estimated global rate of 130,000 km^2 per year over the last five years (FAO 2006). Traditional agriculture allowed remnants of natural vegetation to remain on steep hillsides, valleys, rocky outcrops, shallow soils, saline and infertile areas, property boundaries and track edges. In recent history farming practices in many areas have become intensified, and increasing amounts of water, fuel, fertilizers, pesticides, and herbicides are used worldwide to increase food and fiber production. E.g., global area equipped for irrigation expanded by 0.3% to 280 million ha between 2004 and 2005, and at present irrigated area accounts for ca. 20% of cultivated land. Intensification of land use has brought remnant areas of natural vegetation into mainstream agriculture and many such areas have been lost or severely degraded. The conversion of natural ecosystems to human land-uses seems to have ensured our food supplies at a global scale. However, food security has damaged the regulation function of ecosystems. Whereas the provision of environmental services such as crops and livestock production have increased, hydrological and climate regulation, soil retention, and greenhouse gas mitigation have decreased as a consequence of overall degradation of ecosystem services by 60% in the last 50 years (Millenium Ecosystem Assessment 2005).

However, deforested habitats as a result of agricultural activities have been often granted a relevant role in nature conservation (Kleijn et al. 2006). Thus, of the seven main categories of terrestrial habitats in the EU Habitats Directive, four include agricultural and livestock land uses (pastures, scrub, "dehesas" and "montados", etc.). Several species, some of them endangered, especially birds, depend on agrarian systems (http://www.birdlife.org/). Agricultural intensification can have a negative impact on these values, but so can agricultural abandonment and, particularly, afforestation of former cropland. It seems that agriculture, woodland, and biological conservation are in a permanent and irreconcilable conflict, *the agriculture and conservation paradox*. This creates a dilemma in woodland restoration projects, which can only be resolved by considering the relative values associated with woodland vs. agricultural ecosystems. Can we solve this dilemma?

3. Contrasting approaches for vegetation restoration in abandoned cropland

Abandoned agricultural land, i.e. cropland and pastures where extensive livestock farming has been removed, can be subject of secondary succession or passive vegetation restoration. Worldwide, land abandonment and passive restoration have revegetated a greater surface area and at a smaller cost than active restoration (45,000 Km^2/year vs. 28,000 Km^2/year, respectively, in 2000-2005; in Europe, agricultural land area have declined by ca. 13% between 1961 and 2000). Passive restoration is cheap and genuine since all ecological filters are at play, It is generally fast in productive environments, but usually slow in low productivity environments such as the Mediterranean. This is because woody vegetation establishment is limited, since conditions in bare areas are different to those of places where trees and shrubs regenerate naturally (Rey Benayas et al. 2005). A key bottle-neck that hinders revegetation is lack of propagules due to absence of mother trees and shrubs due to complete destruction of the original vegetation.

Active restoration basically consists in planting trees and shrubs. It is needed when abandoned land suffers continuos degradation, local vegetation cover cannot be recovered and secondary succession should be accelerated, among others. The European Union has paid farmers for afforestation since 1990, offering grants to turn farmland back into forest and payments for the management of such forest. Between 1993 and 1997, EU afforestation policies made possible the afforestation of over 5,000 Km^2 of land. A second program, running between 2000 and 2006, afforested in excess of ca. 1,000 Km^2 of land. A third such program began in 2007. Much of the forthcoming afforested land will occur in former vineyards that occupied ca. 3.4 million hectares in the EU-25 by 2006. In Spain, during the first five years of the 2000 decade, the recovery of forests has reached 152,400 ha/year, of which 16% are plantations (FAO 2006). On top of this, 700,000 ha were reforested during 1993-2006 thanks to the incentives of the Common Agricultural Policy of the European Union. This amount of reforested agricultural land will increase as removal of vineyards is intended to be 175,000 ha in the 2008-2011 period, 44,090 of which have already been extirpated in 2008-2009.

Most afforestations of former cropland in Mediterranean Europe has based on coniferous species, though other species such as eucalyptus and oaks have been used. There is debate about the ecological benefits of these afforestations, some of which are controversial. The trade-off among different types of ecosystem services and biodiversity values is at the core of such debate. For instance, the fast-growing plantations are better for carbon sequestration per time unit than secondary succession of shrubland and woodland, and they may provide timber in the future. However, they may cause damage to open habitat species, especially birds which are of conservation concern in Europe, by substracting amount of high quality habitat and increasing risk of predation. Further, these plantations have been shown to be suitable habitats just for generalist forest birds but not for specialist forest birds (Rey Benayas et al. 2010a).

4. Innovating vegetation restoration in agricultural landscapes

The reconstruction of vegetation in a landscape ("where and when to revegetate?") is an issue that deserves to become a research priority (Munro et al. 2009). The problems with existing methods to restore woodlands in agricultural landscapes should not give rise to pessimism, but instead inspire researchers to devise new creative solutions. A realistic view of conservation must acknowledge the conservation value of the agricultural matrix in forest landscapes. A focus on the matrix is required if we are serious about solving the biodiversity crisis, and that matrix is usually an agro-ecosystem of some sort (Vandermeer and Perfecto 2007). Thus, agro-successional restoration schemes are proposed, which include agroecological and agroforestry techniques as a step prior to forest restoration (Vieira et al. 2009).

We suggest a different concept for designing restoration of forest ecosystems on agricultural land, which uses small-scale active restoration as a driver for passive restoration over much larger areas. This could increase the economic feasibility of large-scale restoration projects and facilitate the involvement of local human communities in the restoration process. Establishment of "woodland islets" is an approach to designing restoration of woodlands in extensive agricultural landscapes where no remnants of native natural vegetation exist (Rey Benayas et al. 2008). Whereas passive restoration leaves reforestation to chance and active restoration usually requires a large input of resources, the woodland islets approach provides an intermediate degree of intervention. It allows direction of secondary succession by establishing small colonisation *foci*, while using a fraction of the resources required for large-scale reforestation. In addition it maintains flexibility of land use, which is critical in agricultural landscapes where land use is subject to a number of fluctuating policy and economic drivers. The approach involves planting a number of small (some tens or a few hundreds of m^2), densely-planted (e.g.

one introduced seedling per 2 m^2), and sparse (some tens or hundreds of m apart) blocks of native trees within agricultural land that together occupy a tiny fraction of the area of target land to be restored, e.g. <1% of a field. It provides a means of reconciling competing land for agriculture, conservation and woodland restoration at the landscape scale.

The planting of woodland islets could enhance a range of processes relating to biodiversity restoration, ecosystem services, agriculture, and rural societies and economies. Critically, while individual processes, such as carbon sequestration, may be achieved more efficiently by other approaches, islets could provide an integrated set of ecological, social and economic services. We detail the various benefits below.

- Reduced cost. Management interventions to overcome abiotic limitations can include fertilizing, irrigation, and artificial shading, while weed eradication and protection from herbivores can mitigate biotic limitations. Costs of managing planted trees can be high, but because the area planted is small, intensive management can be more concentrated compared with extensive reforestation programs, and so total costs are greatly reduced.
- Provision of woodland habitat. The islets would provide habitat for a range of woodland species including microbes, fungi, plants, invertebrates and vertebrates. Colonization of woodland patches is enhanced by directed dispersal of relevant species: animals directly seek out such patches in a hostile landscape and seeds may be deposited by animal dispersers or trapped while being blown by wind. Furthermore, the high density of planting may lead to facilitation of the establishment of woodland plants in otherwise exposed conditions. The islets can also function as habitat at a landscape scale by sustaining metapopulations or providing local resources such as food and shelter for relatively mobile species.
- Provision of ecosystem services. Small areas of trees and shrubs in agricultural landscapes can provide valuable services to the farmer. These include sources of natural enemies of pests, pollinators of crop plants, shelter from wind for crops and livestock, and fodder for livestock. More broadly, woodlands can enhance certain ecosystem services compared to croplands and agricultural grasslands. These include carbon sequestration, soil fertility, protection from erosion, and water retention.
- Acceleration of secondary succession. Woodland patches provide sources of seed and dispersing animals that can colonize adjacent habitats. If the surrounding land is abandoned, colonists from the islets could accelerate woodland development because dispersal of many woodland organisms will continue over many years.
- Income generation and social benefits. A critical aspect of woodland islets is that they allow human communities to maintain flexibility with respect to the use of the majority non-planted land. If the land is not abandoned, and so does not undergo succession, the land surrounding the islets can be farmed or devoted to other activities that generate income. This approach can contribute to comprehensive management schemes that lead to improved productivity and an increase in farmers' income. The area planted with trees has social value by providing labor and as an educational resource. The woodland blocks could be created by local young people to gain technical training and education about conservation (e.g. training placements). The social benefits will vary depending on the economic status and land use traditions of countries and local communities.

The proposed woodland islets approach reconciles agriculture and ecological restoration. The woodland islets idea has similarities to other approaches involving planting small areas of trees on farms, such as woodlots, hedges or shelterbelts and agro-forestry systems. These practices provide ecological benefits as well as supporting farm production. A critical difference of the wooded islets approach is that it is designed spatially to provide additional ecological benefits as well as socio-economic flexibility. While the small areas of planted trees on farms also confer

other benefits than production, such benefits are the primary objective of the woodland islets approach. A key distinction is the landscape emphasis on a planned planting of islets to maximise benefits to biodiversity, and the potential of allowing the islets to form *foci* for larger-scale reforestation of intervening land. Furthermore, if the surrounding land is to be farmed, its management can be designed to make use of the ecosystem services provided by the islets.

5. Action is desperately needed

We have been running research on the woodland islets approach since 1993. As researchers, we have produced a number of publications that illustrate observations, patterns, processes, hypotheses, etc. for particular case studies. In most of our publications, as it usually occurs in the scientific literature, we mention that "further research is needed" to tight up popping up issues. It is certainly our responsibility as academia professionals to research further but, in my view, we must transfer as well the created knowledge to projects in the real world.

To target this aim, the *International Foundation for Ecosystem Restoration* (www.fundacionfire.org) is developing the "Islets and coasts in agricultural seas" Initiative to implement demonstration projects of conciliation of farmland production and enhancement of biodiversity and ecosystem services. Restoration actions in these projects include the following.

- Introduction of woodland islets of native plant species as explained above.
- Revegetation of field boundaries and way sides ("coasts" in the agricultural "seas").
- Rehabilitation and construction of water spots (ponds, springs, drinking troughs), which are of critical importance for wildlife, especially for amphibians.
- Installation of nest boxes for birds, particularly those that are useful to farmers (insectivorous birds, raptors). The young pine plantations on afforested former cropland are suitable habitats for this action.
- Installation of perches for birds in abandoned cropland to enhance seed rain on them.
- Rehabilitation and construction of stone mounds and walls, as well as constructions of rural architecture.
- Propagation and plantation of singular fruit trees, i.e. old and healthy fruit trees of local varieties that are rapidly going extinct. We use the propagated trees for their plantation in restored cropland and for creating a genetic reserve.
- Plantation of olive groves for CO_2 emission compensation, where we implement the actions above.

The implemented restoration actions intended to "renaturalize" agricultural landscapes are accompanied by a variety of social and educational benefits. Most work in the field is developed by volunteers as we pursue environmental education and sensibility. These volunteers derive from environmentalist and conservationist groups, schools, and companies (corporative volunteers). We are developing a program of citizen science consisting in the monitoring of introduced plants and nest boxes. Our restoration projects are visited by students from schools, universities and specialized training courses (Rey Benayas et al. 2010b). The nest boxes are built by handicapped local people under the supervision of professional carpenters. The propagation of singular fruit trees is done by horticulture schools as well as by professional nurseries. Some restoration actions and their maintenance are contracted to local farmers. Overall, these projects are producing income and opportunities to local communities.

Importantly, land owners must be explicitly rewarded for the restoration actions occurring in their properties. Beyond the subsidies from agri-environmental schemes, other approaches such as payment for environmental services and tax deduction must be rapid and generously

implemented in a time when society demands from agricultural land and farmers much more than food and fiber production.

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