AGRO-FOREST LANDSCAPE DYNAMICS DURING THE LAST 50 YEARS

THE CASE STUDY OF TWO NORTH-WESTERN ITALIAN PARKS

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Abstract

We studied the consequences of land management on two regional Parks in the north east Piedmont (north west Italy) high plan (280 – 320 m a.s.l). The study sites are the “Riserva Naturale Orientata delle Baragge” and the “Lagoni di Mercurago” Park.
We analyzed historical aerial photographs (1954-2000) and we produced 4 land use maps (2 sites, 2 years). We studied the landscape structure changes computing landscape metrics for each map. After 50 years at the “Baragge” site the newly forested area covered 44% of the total surface of the Reserve; while at “Lagoni” Park only 7% of the total area is interested by natural afforestation. The study shows how different social-economic environment can influence the dynamics of an agro-forest landscape and underlines the problems of a passive conservation approach on a landscape point of view.

Keywords: Landscape changes, Agro-forest landscape, Forest management, Landscape metrics, Regional Parks.

1. Introduction

Landscapes are the expression of the dynamic interaction between natural and anthropogenic forces in the environment (Antrop 2005) and land-use changes are a critical link between anthropic activities and natural changes (Brown et al. 2005). Due to the changes in the economy in the last decades, traditional agricultural and silvicultural land use are no longer viable in many places. In particular the abandonment of marginal lands has become a strong trend in land-use change in many parts of Italy and others industrialized country (MacDonald et al. 2000, Poyatos et al. 2003). The agro-forest landscape is a dynamic system in which forested and agricultural patches are patterned in a complex mosaic that is strongly conditioned by human actions (Löfman and Kouki 2003). The forest component of this landscape, due to the marginal land abandonment (agricultural abandonment of grassland and crops), can be considered as the most active changing actor (Höchtl et al. 2005).
A protected area can be a good sample of the land-use changes of the neighbour region; on the other hand the establishment of a protected area can be itself a cause of landscape transformation. The main objects of this study was to analyse the land-use spatio-temporal dynamics in two Natural Parks during the last 50 years and to evaluate the impact of the protection status (land management) on the landscape dynamics.

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2. Methodology

2.1 Study area

The consequences of land-use management has been assessed on two regional Parks in the north east Piedmont (north west Italy).
The first study site is the "Riserva Naturale Orientata delle Baragge" (BA), established on 1992 in order to safeguard the arboreal moorlands and the grasslands as typic landscapes of these large plateaus. "Baraggia" is an open forest of oaks and birches with an understory of heather and tall moor grass and it is a non-productive land in which a poor agro-pastoral activity was abandoned some years ago.
The second protected area is the "Lagoni di Mercurago" Park (LM), established on 1980 to contrast with the urban sprawl of the Maggiore Lake tourist area. This is an hilly area (280-320 m a.s.l.) in which forests (classified mostly as *Querco-carpinetum*) cover almost three quarter of the whole Park area.

2.2 Materials and methods

We selected an agro-forest area of ca. 800 ha at BA and 500 ha at LM was selected, in order to compare the two study areas. Following rectification and pre-processing, historical aerial photographs (1954, 2000) were analysed. Photointerpretation of B&W aerial photographs (mean nominal scale ca. 1:60.000 and RMS between 11-13 m) dating from 1954 (GAI flying program) and of 5 coloured aerial photographs (Alluvione 2000 flying program) at a mean nominal scale of ca. 1:15.000 (RMS between 4-5 m) , made it possible to assess land-use changes between 1954 and 2000 in each study site. From the digital photos 4 land-use maps (2 sites, 2 periods) have been derived in a GIS environment and the forest structure in some ground control points has been studied. GIS tools are widely used for analysing changes in landscape patterns (e.g. Johnson, 1990, Axelsson, 2000) and landscape metrics are usually involved in landscape structure description.
Several land cover categories (8 at BA and 11 at LM) were identified and, after converting the data from vector to raster (grain of 2,65 m), transition matrices were assessed, as to point out the dominant landscape processes (Rhemtulla et al. 2002).
By using the software FRAGSTATS 3.3 (McGarigal et al., 1995) landscape metrics have been computed so as to analyse the composition and spatial configuration (landscape structure and changes) of the 4 land-use maps. Only landscape level metrics were used in the study in order to make a comparison between the two different sites; moreover the indices referred to a per unit area basis were preferred to that ones who were affected by scale and grain variations (Turner et al. 1989; Wu et al. 2002; Rocchini 2005).

3. Results

The biggest land-use change over the last 50 years was the increase in forested areas observed at BA where there was a transition of many land-use classes, especially the arbormoorland and field classes (tab. 1), to forest class. In contrast with it at LM only 7% of the total area was interested by natural afforestation and the greatest shift observed was constituted by a new Eastern white pine (*Pinus strobus* L.) plantation (tab. 2).
The metrics described in table 3 indicated that the landscape structure in 1954 at BA was more complex than the LM's one. The *Patch Density* was greater at BA as well the shape complexity (*Edge Density*, *Shape Index Distribution Mean*) and the aggregation level showed by many indexes like *Landscape Shape Index* and *Area Mean*.
About the alteration in the ecological pattern over time, the results showed that the BA landscape was more dynamic than the LM because of the natural afforestation process described.

An evidence of this process was a remarkable decrease of the *Contrast-Weighted Edge Density* (from 92,3 to 65 m/ha) at BA and a slight decrease at LM. In addition, some metrics as *Area Mean* and *Patch Density* showed an increasing in patch aggregation (stronger at BA than at LM) that was the main cause of a general landscape structure simplification.

4. Discussions

It's commonly accepted that the establishment of a protected area should concern an active conservation action toward a certain ecosystem or environment. However, this protection is often applied in a passive way. The two study sites shows two different effects caused by a passive land management. At LM the establishment of a Regional Park has contributed to limit the exurban growth and the land-use change. On the contrary the lack of management actions at BA has caused the lost of ca. 50% of the arbormoorland class that was the cultural landscape to be protected with the establishment of the reserve.

Land-use dynamics in study sites during the period analysed can be summarized in terms of several main processes: natural afforestation of arbormoorland (BA), fields and meadows (both sites), and increasing tree density in the forests (both sites).

The main effects caused by these processes are the increasing dimension of patches (above all at BA) and a decreasing of shape complexity and dissimilarity between patch types; but one of the strongest effects on the landscape was a general homogenisation of the landscape pattern. This structural simplification must be taken into account because the landscape, in absence of human action, under homogenous conditions tends naturally toward a homogeneous structure.

As several situation in Europe, the natural afforestation of areas with sparse trees and scrub vegetation, as observed may be due to an abrupt decline in the cows and sheep pasture (Poyatos et al. 2003).

To understand land-use dynamics can help ecologists better contribute to policy debates about land management (Brown et al. 2005, Dale et al. 2000). A landscape analysis must provide scientific information to decision makers to help anticipate possible unintended ecological effects of land-use changes (Theobald 2005).

The loss of diversity and the vanishing of the traditional cultural landscape must be limited with active management, at least in some area or if some rare habitats are endangered. When these particular habitats or cultural landscape have declined due to recent land-use changes, they could be maintained by using techniques that resemble the traditional agricultural practices (Eberhardt et al. 2003).

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References

Antrop, M., 2004. Landscape change and the urbanization process in Europe. *Landscape and Urban Planning*, 67: 9-26.

Axelsson, A.-L., 2000. Temporal and spatial changes in a boreal forest landscape: GIS applications. In: M. Agnoletti and S. Anderson (Eds.). *Methods and approaches in forest history*. Wallingford, UK: CABI Publishing: 157-163.

Brown, D.G., Johnson, K.M., Loveland, T.R. and Theobald, D.M., 2005. Rural land-use trends in the conterminous United States, 1950-2000. *Ecological applications*, 15(6): 1851-1863.

Dale, V.H., Brown, S., Haeuber, R.A., Hobbs, N.T., Huntly, N., Naiman, R.J., Riebsame, W.E., Turner, M.G. and Valone, T.J., 2000. Ecological principles and guidelines for managing the use of land: a report from the Ecological Society of America. *Ecological Applications*, 10: 639-670.

Eberhardt, R.W., Foster, D.R., Motzkin, G. and Hall, B., 2003. Conservation of changing landscape: land-use history of Cape Cod National Seashore. *Ecological applications*, 13(1): 68-84.

Höchtl, F., Lehringer, S. and Konold, W., 2005. "Wilderness": what it means when it becomes a reality-a case study from the southwestern Alps. *Landscape and Urban Planning,* 70: 85-95.

Löfman, S. and Kouki, J., 2003. Scale and dynamics of a trasforming forest landscape. *Forest Ecology and Management*, 175: 247-252.

MacDonald, D., Crabtree, J.R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Gutierrez Lazpita, J. and Gibon, A., 2000. Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. *Journal of Environmental Management*, 59, 47-69.

McGarigal, K. and Marks, B.J., 1995. *FRAGSTATS: spatial pattern analysis program for quantifying landscape structure*. USDA For. Serv. Gen. Tech. Rep. PNW-351, Portland, OR, 122 p.

Johnson, L.B., 1990. Analyzing spatial and temporal phenomena using geographical information system. *Landscape Ecology*, 4: 31-43.

Poyatos, R., Latron, J. and Llorens, P., 2003. Land use and land cover change after agricultural abandonment. The case of a mediterranean mountain area (Catalan Pre-Pyrenees). *Mountain research and development*, 23(4): 362-368.

Rhemtulla, J.M., Hall, R.J., Higgs, E.S. and Macdonald, S.E., 2002. Eighty years of change: vegetation in the montane ecoregion of Jasper National Park, Alberta, Canada. *Canadian Journal of Forest Research*, 32: 2010-2021.

Rocchini, D., 2005. Resolution problems in calculating landscape metrics. *Spatial science*, 50(2): 25-35.

Theobald, D.M., Spies, T., Kline, J., Maxwell, B., Hobbs, N.T. and Dale, V.H., 2005. Ecological support for rural land-use planning. *Ecological applications*, 15(6): 1906-1914.

Turner, M.G., O'Neill, R.V., Gardner, R.H. and Milne, B.T., 1989. Effects of changing spatial scale on the analysis of landscape patterns. *Landscape ecology*, 3: 153-162.

Wu, J., Shen, W., Sun, W. and Tueller, P.T., 2002. Empirical patterns of the effects of changing scale on landscape metrics. *Landscape ecology*, 17: 761-782.

Table 1: Landscape metrics computed for the two sites at two period examinated (4 land-use maps).

METRICS		Units	LM 1954	LM 2000	BA 1954	BA 2000
TA	Total Area	ha	473.1	473.1	770.2	770.2
PD	Patch density	n/100 ha	13.1	13.5	18.2	13.0
LPI	Largest Patch Index	%	62.3	77.2	12.5	25.6
ED	Edge density	m/ha	88.3	78.5	146.0	118.8
LSI	Lanscape Shape Index	-	6.5	6.0	12.3	10.4
AREA_MN	Area Mean	ha	7.6	7.4	5.5	7.7
SHAPE_MN	Shape Index Distribution Mean	-	1.8	1.8	1.9	1.8
PAFRAC	Perimeter-Area Fractal Dimension	-	1.3	1.3	1.4	1.4
DCAD	Disjunct Core Area density	n/100 ha	15.2	16.5	20.5	14.4
CAI_MN	Core Area Index Distribution Mean	%	70.7	66.0	81.1	82.5
ENN_MN	Euclidean Nearest Neighbor Distance Distribution Mean	m	199.7	242.0	86.4	185.0
CWED	Contrast-Weighted Edge Density	m/ha	65.0	62.8	92.3	65.0
CONTAG	Contagion	%	75.3	78.3	60.7	67.3
PRD	Patch Richness Density	n/100 ha	1.7	2.1	0.8	1.0
SIDI	Simpson's Diversity Index	-	0.4	0.4	0.7	0.7

Table 2: Transition matrix showing land-use changes from 1954 to 2000 at Lagoni di Mercurago Park.

	2000											
1954	Forest	Open forest	Shrub	Arbormoorland	Meadow	Afforestation	Arborfield	Field	Wetland	Water	Anthropogenic	Total area (ha)
Forest	317.0	0.0	0.0	2.4	3.9	24.9	0.9	1.2	2.3	0.0	2.0	354.5
Open forest	14.3	0.0	0.0	0.4	0.0	0.6	0.8	0.0	0.0	0.0	0.0	16.0
Shrub	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	3.4
Arbormoorland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meadow	13.0	0.0	0.0	1.3	4.0	0.6	0.2	3.6	0.1	0.0	0.2	22.9
Afforestation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arborfield	0.3	0.0	0.0	0.0	0.0	0.0	29.1	0.0	0.0	0.0	0.5	29.9
Field	17.2	1.1	0.0	0.0	7.2	5.4	4.2	5.2	0.5	0.0	0.1	41.0
Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	3.6	0.0	4.8
Anthropogenic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
Total area (ha)	365.0	1.1	0.0	4.1	15.0	31.5	35.3	10.0	4.2	3.6	3.4	473.1

Table 3: Transition matrix showing land-use changes from 1954 to 2000 at Baragge Park.

	2000								
1954	Forest	Open forest	Arbormoorland	Meadow	Afforestation	Field	Water	Anthropogenic	Total area (ha)
Forest	121.3	33.3	25.8	1.3	0.0	1.0	0.2	0.1	183.1
Open forest	21.6	11.0	6.2	0.4	0.0	0.6	0.0	0.0	39.9
Arbormoorland	133.7	82.8	138.3	0.6	4.8	4.6	0.0	0.0	364.7
Meadow	14.9	4.5	6.7	0.7	0.1	0.2	0.1	0.0	27.1
Afforestation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Field	82.6	25.3	7.4	1.9	2.3	35.0	0.0	0.9	155.4
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anthropogenic	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1
Total area (ha)	374.1	157.0	184.4	4.9	7.2	41.4	0.3	1.1	770.2