Fitosociologia vol. 48 (2) suppl. 1: 119-125, 2011

Two Mediterranean landscape types and their interface as a case study for "landscape red-listing".

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Abstract
Landscapes can be viewed as one of the levels in which biodiversity is hierarchically arranged; hence, it may prove important to develop lists of endangered landscape types. Among the landscape systems (sensu Blasi *et al*., 2000) of NW Lazio (C-Italy), two are particularly distinctive and biodiversity rich: the clayey-carbonate turbidite system ("Flysch della Tolfa") and the pyroclastic-flow system ("Tufo Rosso"). The turbidite system, due to pedological features unfavorable to agriculture, and because of public property of land, shows a characteristic low density of human settlements (to an extent usually found in Italy only at much higher altitudes), and is therefore composed of ecosystems featuring many endangered and protected species. The pyroclastic system is characterized by unique land forms: flat plateaux divided by deep gorges with vertical slopes and flat bottoms. These features led to a typical and rich combination of plant communities: within a single gorge, we often found a toposequence ranging from *Fagus sylvatica* extrazonal stands to evergreen "macchia". Until c. 1951, human settlements in the pyroclastic system were confined to the cliff tops, and the plateaux were almost deserted and exploited as sheep-grazing land. The two landscape types are in touch with each other through a long, geologically-driven boundary, which is very distinctive of NW Lazio. Such an interface influenced the shape and location of urban settlements, and originated a belt particularly rich in plant biodiversity. For centuries, traditional land-use practices have enhanced the differences in the assemblage of land-cover types between the two sides, hence increasing both visual distinctiveness and biodiversity across the interface. Structural patterns of both landscapes are nowadays endangered, due to land-use changes and urban sprawl: as a result, present-day development is blurring fast the difference between the two areas – the landscape interface as well should be viewed as a feature worth to be protected at landscape level. Based on the analysis of this case study, we provide some theoretical and methodological reflections on the problem of "landscape red-listing", with some preliminary suggestions concerning the methods for landscape classification and for their "threat assessment".

Keywords: flysch, hierarchical land classification, Italy, landscape boundaries, landscape protection, land-use changes, pyroclastic flow, urban sprawl.

Riassunto
Il paesaggio può essere considerato uno dei livelli di organizzazione della biodiversità; potrebbe pertanto essere utile sviluppare metodiche per la stesura di liste rosse di paesaggi minacciati. Il Lazio nord-occidentale comprende due sistemi di paesaggio (*sensu* Blasi *et al*., 2000) particolarmente caratteristici e ricchi di diversità: il sistema delle torbiditi del "Flysch della Tolfa" e quello delle piroclastiti ("Tufo Rosso"). Il sistema torbiditico, a causa di fattori edafici poco favorevoli all'agricoltura, e della proprietà collettiva delle terre ("Università Agrarie"), presenta una ridottissima densità dell'urbanizzazione, nonostante le bassissime quote, che ha permesso la sopravvivenza di comunità e specie protette. Il sistema piroclastico è caratterizzato da morfotipi esclusivi: tavolati sub-pianeggianti bruscamente interrotti da canyon con pareti verticali e fondivalle pianeggianti. Su questa peculiare topografia si imposta una toposequenza altamente diversificata (da lembi extrazonali di faggeta fino a popolamenti di macchia sclerofillica). Fino agli anni '50, gli insediamenti abitativi del paesaggio piroclastico erano esclusivamente ubicati sulle "penisole" rupestri alla confluenza fra due canyon, e i pianori tufacei, privi di case sparse, erano sfruttati prevalentemente per il pascolo ovino. I due tipi di paesaggio sono separati da una linea di contatto litologica lunga e convoluta, molto caratteristica, anche dal punto di vista percettivo, del territorio del Lazio settentrionale. Per secoli, le utilizzazioni tradizionali del suolo, fortemente controllate dalle proprietà fisiche dell'ambiente, hanno ulteriormente rinforzato le differenze fra i due paesaggi. Attualmente, però, i cambiamenti nell'agricoltura e l'urbanizzazione diffusa stanno significativamente perturbando i pattern dei due paesaggi, con modalità (svincolate dall'ambiente fisico e controllate da fattori economici) simili su entrambi i lati dell'interfaccia; di conseguenza, sta avvenendo un processo di omogeneizzazione reciproca e perdita dell'identità, anche visuale, dei due settori. Partendo da questo caso di studio, proponiamo alcune riflessioni teoriche e metodologiche in materia di "liste rosse di paesaggi", sviluppando anche alcune considerazioni in merito al processo classificatorio più opportuno e alla valutazione dello stato di rischio.

Parole chiave: cambiamenti di uso del suolo, classificazione del paesaggio, conservazione del paesaggio, flysch, piroclastiti, urbanizzazione diffusa.

Introduction

From the point of view of ecology, a landscape can be defined as a system of ecosystems, or as any extent of land characterized by a particular combination of ecosystems or land-cover types (Turner *et al.,* 2001). Landscapes can therefore be viewed as one of the levels in which biodiversity is hierarchically arranged, the other levels being populations, species and ecosystems. Due to the emerging properties principle, landscapes are not just the sum of their ecosystems: features and patterns of landscapes and their "diversity" can be disrupted by different factors from those affecting communities or populations, as disturbance is a scale-dependent property (cfr. e.g. Turner *et al.,* 2001). Furthermore, landscapes often have a high cultural and spiritual value, both for local people and for tourists (cfr. e.g. Antrop, 2006). This value often dwells in a landscape's "identity" – i.e. in the structural properties of the whole landscape, such as the spatial pattern of land-cover types.

Nowadays, many landscapes of cultural value become fragmented and disappear gradually while new ones emerge. The ever faster changes to landscapes

are experienced by an increasing number of people as a threat – as they may have difficulty adapting to a continuously changing landscape (Antrop, 2006). The concern about the vanishing traditional cultural landscapes and new emerging landscapes has become a recurring topic (e.g. Vos & Stortelder, 1992).

Hence, it may prove useful to develop a theoretical framework for conserving landscapes as organic entities constituting an aspect of biodiversity. In particular, it could be interesting to develop methods for a "red-listing" of landscapes, i.e. to obtain lists and definitions of endangered landscape types – somehow analogous to Natura2000 habitat-types lists. This exercise could help popularizing the issue of landscape conservation to the general public and identifying priorities to be addressed in the communicating process between ecologists and policy-makers (Naveh, 1993).

This approach should not be confused with the need of considering species- and habitat-conservation issues in a landscape ecology framework (and through landscape ecology methods). The latter is a nowadays recognized paradigm in conservation biology, while the idea of "landscape red-listing" is not well developed in literature yet: after the first proposals in the early 90's for "Red Books for Threatened Landscapes" (Naveh, 1993) and "Green Books for Landscape Conservation" (Naveh, 1995; 1998), practical and theoretical development apparently did not go forward, with the exception of a few local studies (usually at the scale of single counties/districts within European countries) (cfr. Bastian *et al.*, 2006, and references therein); while the recent, preliminary study on a "National register of historical rural landscapes" in Italy (Agnoletti, 2010), is focused on strictly "agricultural" landscapes only, and these are recognized at a much narrower spatial scale than considered here.

In the present paper, we present some reflections on these points and a preliminary proposal to be developed for Italian landscapes, based on a case-study in NW-Lazio (*c.* 80-100 km NW of Rome: fig. 1), an area we have been studying for many years under the point of view of floristic and vegetation classification (see e.g. Scoppola, 1995; Scoppola & Caporali, 1998; Magrini *et al.*, 2006; Scoppola & Filibeck, 2008a, 2008b; and references therein), and where we are now addressing landscape history issues (Scoppola *et al.*, 2010) .

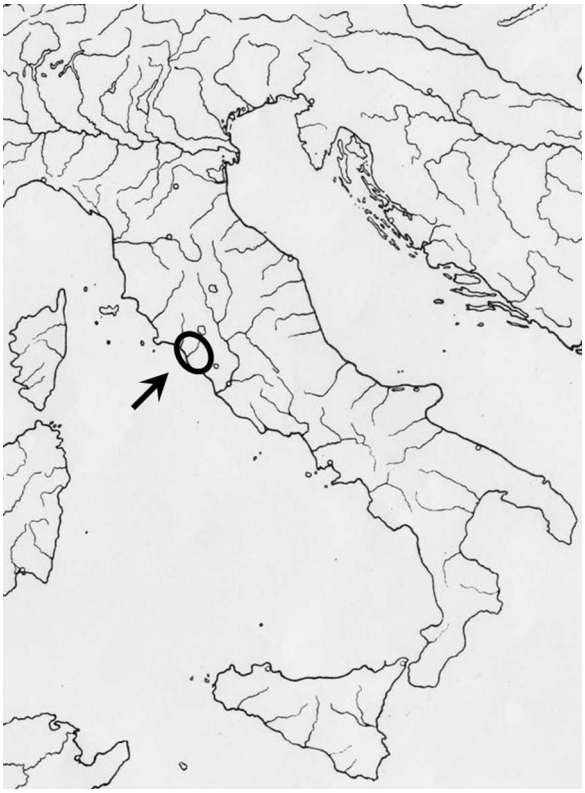

Fig. 1- Study area.

Landscape classification problems

If landscape types have to be identified and their status has to be assessed, they need to be classified and delimited on objective basis, e.g. through models of hierarchical classification of the biosphere based on the causes of spatial heterogeneity, such as the methods proposed by Klijn & Udo de Haes (1994) or Blasi *et al.* (2000; 2004) (see also the references therein).

The factors that cause the spatial patterns of systems of ecosystems show a hierarchical relationship, as the first ones set the constraints within which the others can operate. The hierarchical sequence can be summarized in the following way (cfr. O'Neill *et al.,* 1989; Blasi *et al.,* 2000):

- climate
- lithological types
- landforms
- historical (biogeographical) factors
- disturbance.

It is to be underlined that the existence of a "hierarchical relationship" refers only to the fact that each type of causes set the constraints for the following ones – it doesn't necessarily mean that the first ones are responsible for a larger proportion of the observed pattern. In fact, in many landscapes (including most European ones) human disturbance accounts for the largest proportion of the pattern, although it can

act only within certain "directions" set by abiotic variability and biogeography (cfr. e.g. Scoppola & Filibeck, 2008b; Scoppola *et al.*, 2010).

This hierarchy makes it possible to divide the biosphere in progressively smaller systems of ecosystems (or of vegetation types or land-cover types): Blasi *et al.* (2000; 2004) proposed to name the ranks as "land regions" (large, macroclimate-driven landscape types), "land systems" (geologically-driven types within the same climate region), "land facets" (landform-controlled types within the same bedrock type) and "land units" (meso-climate units within each land facet).

Unfortunately, this approach can not take into account the variety of cultural heritages, however a "physical" classification of landscapes has the advantage of providing an objective, repeatable and consistent landscape taxonomy. Classification methods that try to take into account both physical and cultural attributes of the landscape (e.g. Bastian *et al.*, 2006; cfr. also Brabyn, 2009) seem to have a large subjective component in delimitation of units and to be scarcely repeatable – although further research is probably needed.

However, for the reasons we briefly mentioned above (i.e. the existence of a hierarchy among pattern-causing factors, where human influence takes the lower place, regardless of the amount of variability explained by it), even the identity and distinctiveness of the "cultural landscapes", or the "semiotic" layer of a landscape [i.e. the perceivable, scenic landscape and its cognitive meaning (cfr. Antrop, 2006); see also the definition by the European Landscape convention: "Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe, 2000)], is strongly dependent and controlled, although not completely explained, by ecological and biogeographical factors. For instance, traditional types of crops and land-use, as well as the size of the farmers' properties and the density and pattern of settlements used to be largely controlled by climatic, geomorphological and pedological factors (e.g. Ingegnoli, 1993). Even the architectural features of traditional houses, too, although an expression of human cultural patterns, had to develop within the constraints set by climate (influencing e.g. the "adaptive" shape of roofs and windows), geology (as different bedrock types will provide more or less useful building materials) and biogeography (for instance, traditional houses in the Alps are made up of spruce, while those of the Apennines are made up of stones, because for biogeographical reasons there are no significant extensions of conifer forests in the Apennines, hence there is a lack of appropriate timber).

Case study and results

NW-Lazio belongs to the Mediterranean climate region of C-Italy (Blasi, 1994), and is a hilly area between sea level and *c.* 600 m a.s.l., featuring a high heterogeneity of bedrock types (Accordi *et al*., 1988). Among the many land systems (*sensu* Blasi *et al.*, 2004) of this area, two are particularly distinctive and biodiversity-rich: the clayey-carbonate turbidite system ("Flysch della Tolfa", in the Italian geological literature) and the pyroclastic-flow system ("Tufo rosso Vicano" of Italian authors). The two landscape types are in touch with each other through a long and convoluted, geologically-driven sharp boundary.

The turbidite system shows peculiar pedological features unfavorable to agriculture: the bedrock features a complex alternance of thin layers of clay, marls and marly limestones (e.g. Civitelli & Corda, 1993) – the resulting soil being scarcely productive (Potenza, 2005). Therefore, large extents of land have been left by local people for centuries as woodlands or extensive grazing (mostly exploited by the free-ranging Maremman Cow). Indeed, until the 60's, some crop fields (mainly wheat) did occur (cfr. Zongoli, 2005) – but they used to be limited to the less stony sites and to soils neither too rich in calcium carbonate nor too clayey (F.A. Biondi, pers. comm.). These wheat fields are nowadays almost completely disappeared from the Flysch della Tolfa, following the generalized changes in the social and economic structure of Italian agriculture. Further, it is to be taken into account that most of the land was – and still is – a public property of the local municipalities, managed by the so called "Università Agrarie", a kind of organization found only in Lazio region (cfr. e.g. Bargiacchi, 2005; see also Scoppola *et al.*, 2010, and references therein). Because of the shared property of the land, the fields to be planted with wheat were assigned only temporarily – hence, the peasants had no interest in building farmhouses or other permanent structures. On the other hand, pastures were left at their natural floristic composition and exploited only through extensive grazing of free-ranging cows and horses – as the shared property (and the Mediterranean climate) made not feasible to sow grasslands for intensive exploitation. As a result, the landscape shows nowadays a surprisingly low density of human

settlements, to an extent usually found in Italy only at much higher altitudes (Almagià, 1966; Scoppola & Filibeck, 2008b): villages are almost non-existent on this geological substrate, while scattered farmhouses are (or used to be) very rare. Hence, the landscape has a distinctive pattern of land-cover types (Spada, 1977; Lucchese & Pignatti, 1990; Scoppola & Filibeck, 2008a, 2008b; Scoppola *et al.,* 2010): large areas of deciduous *Quercus cerris/Q. pubescens*[1] coppice woods with a lower layer dominated by *Fraxinus ornus, Acer campestre* and *A. monspessulanum;* even larger extensions of high-diversity dry grasslands (with e.g. *Brachypodium distachyum, Dasypyrum villosum, Hedysarum coronarium, Malope malacoides, Cynara cardunculus, Asphodelus microcarpus,* etc.), typically featuring a scattered, savanna-like cover of xerophilous deciduous trees (*Pyrus amygdaliformis* and *Acer monspessulanum*), used for extensive grazing of free-ranging cows; secondary thorny shrublands (colonizing the less exploited pastures and the abandoned wheat fields), dominated by *Crataegus monogyna* and *Rosa sempervirens* or by *Paliurus spina-christi;* a network of seasonal streams, looking dry for most of the year (with *Fraxinus oxycarpa, Tamarix africana, Laurus nobilis,* etc.). Such a landscape preserves animal and plant species bound to scarcely urbanized areas (including many Red List and Habitat Directive taxa, the most noteworthy one being probably the wolf, *Canis lupus,* featuring here a very viable population) (Contoli, 1977; Spada, 1977, 1996; Battisti & Gippoliti, 2004; Forniz, 2005; Calvario *et al.*, 2008; Scoppola & Filibeck, 2008b).

The system of the pyroclastic-flow ("Tufo Rosso": see e.g. Di Filippo, 1993) is characterized by unique landforms, due to the peculiar mechanical properties of the bedrock: river erosion gives rise to flat plateaux divided by canyons with vertical slopes and flat bottoms. These landforms – along with a transitional bioclimate between the Mediterranean and Temperate region – led to a typical and rich combination of plant communities (due to steep meso- and micro-climate gradients), ranging even in a few hectares from extrazonal stands of C-European mesophytic vegetation dominated by *Fagus sylvatica,* to Mediterranean xerophilous "macchia" dominated by *Phillyrea latifolia, Erica arborea* and *Quercus ilex* (Scoppola & Caporali, 1998; Scoppola & Filibeck, 2008b, and references therein). Highly fertile soil types resulting from the volcanic bedrock, and the easily defensible steep slopes of the canyons (an essential resource in troubled historical times) led to a high number of villages. Water is a much more plentiful and stable resource than in the flysch system – with permanent streams and even waterfalls in the bottom of gorges, that look lush and rich in ferns (*Polystichum setiferum, Phyllitis scolopendrium,* etc.) and other mesophytic plants (*Carpinus betulus, Corylus avellana,* etc.). The flat tops of the plateaux, originally covered with deciduous *Q.cerris* forests, were mostly converted into pastures: oak woods typically survive on the slopes and in the bottoms of the gorges, leading to a peculiar network of "linear" forests. However, for many centuries and until World War II, most of the land was owned by feudal large estates – for this reason, even large areas of the flat plateaux, although very fertile and easily accessible, were exploited only as extensive, seasonal sheep pasture, remaining devoid of settlements and even of roads and of any permanent human dwelling (the lonely landscape resulting was well known to the travelers of the Romantic period, and quoted as the "Roman desert") (Sestini, 1963; Almagià, 1966). Villages were invariably set – since pre-historical times – exclusively on the edge of the steep, easily defensible cliffs at the junction of two gorges. However, in the 50's of the XX century, the government forced the owners of the large estates to sell the land to the Ente Maremma – a governmental agency for land reclamation which operated through the whole C-Thyrrenian area of Italy. The Ente Maremma divided the former feudal estates into thousands of small properties of c. 10-12 hectares each, built a farmhouse in each lot, connected them with a network of roads and assigned the properties to families of local peasants who had no other significant income; permanent crops, such as olive groves and vineyards, were also massively introduced and encouraged by the government (Ente Maremma, 1955; Finodi, 2005; Scoppola *et al.,* 2010). This process led to the disruption of the characteristic landscape pattern, originally featuring settlements confined to the cliffs between gorges and plateaux left to sheep grazing.

Discussion and conclusions

Which criteria should be followed in order to establish a national (or broader) red list for landscape types?

First, the method for classifying and delimiting landscape types should be defined a priori as the operational method for the list and used consistently.

[1] Nomenclature follows Pignatti (1982).

We would recommend a divisive hierarchical classification, based on the factors that cause landscape patterns, for the reasons specified above.

As landscape classification systems are hierarchical and scale-dependent, a red-listing program should define a priori the "taxonomic level" of interest (e.g. land system or land-facet in the model adopted here). Second, a method of "threat assessment" should be developed. This is probably the most critical part, due to the inherent complexity of landscapes. However, the method should take into account the danger of disappearance of the typical land-cover pattern of a given physical landscape type and/or the "range" of each landscape type. Some of the criteria defined by the EU Habitat Directive to define the "habitats of Community Interest" could be applied to landscapes – namely, we could consider for red-listing those landscapes (i) whose typical patterns are in danger of disappearance; or (ii) have a small range by reason of their intrinsically restricted area.

More theoretical work and practical testing is needed on this issue. However, as a first test, we can consider the present case study.

The thick pyroclastic flow of "Tufo Rosso", capable of generating the peculiar landform system of gorges and plateaux, is in Italy virtually exclusive of NW-Lazio and a small area of S-Tuscany. The total area covered is approx. 700 sq. km . It can be considered a "narrow endemic" landscape type.

The "Flysch della Tolfa" turbidite formation is even more restricted to a specific geographical subregion, extending for *c.* 300 sq. km: the other turbidite types found in Italy are of different nature (sandy-clayey, while the Tolfa formation is marly-clayey) and/or they belong to the Temperate region (while the Tolfa flysch is in the Mediterranean biome).

Structural patterns of both landscapes are nowadays seriously endangered, due to causes rooted in social changes and lack of urban planning.

The turbidite system was until the 70's of the XX century almost completely devoid of settlements and buildings, with the exception of a negligible number of scattered farmhouses built in the 50's by the Ente Maremma: contrary to what happened to the volcanic district, here the land reclamation process promoted by the government after World War II did not lead to a significant disruption of the landscape patterns, probably because of both the difficulties encountered in ameliorating the soil on Flysch bedrock, and the large extents of common pastures. In the last few decades, however, this landscape is being subjected to urban sprawl, due to its proximity to some highways and railways available for commuters – in this way loosing, above all, its distinctive "emptiness". Moreover, new agricultural techniques and new trends in the market (e.g. the high demand for meat from organic farming) are allowing the conversion into crop fields of some areas of the landscape, previously mostly left to coppice-woods and dry pasture.

In the pyroclastic system, instead, the first heavy transformation process, as discussed above, begun in 1951, when the end of the large estates was imposed by law and the typical landscape pattern of "deserted" plateaux begun to be heavily disrupted by the network of regularly scattered farmhouses built by the government for the new settlers – accompanied by the introduction of olive groves, vineyards, etc. on large areas previously covered by coppice woods or pastures (Ente Maremma, 1955; Almagià, 1966; Finodi, 2005). However, even this land-use change was quite light, if compared to the very aggressive urban sprawl that in the last 30 years has been attacking the flat, easily accessible land of the volcanic plateaux – especially along some preferential directions, bound to the occurrence of important highways and railroads. In addition, recent changes in agriculture market (including the EU policy of olive-oil subsides) are promoting a further retreat in sheep-grazing land, which is often being replaced by olive groves.

For these reasons, the two land systems of the study area appear to be ideal candidates for more rigorous testing (through the development of formalized criteria and ad-hoc metrics) of the practicability of a "landscape red-list": the next step within this research project will be the development of objective measures of the exact amount of the landscape-pattern changes in the two landscapes, applying diachronic, quantitative analysis on historical aerial photographs (thanks to the existence of air photogrammetric surveys taken in 1940, i.e. well before the 1951 land reclamation) (Filibeck *et al*., in prep.).

A final, noteworthy point that emerged from our preliminary analysis concerns the interesting properties of the boundary between the two landscape types. As this is a geologically-driven border and not a climatic one, it is very sharp and convoluted. This long, abrupt line is visually very distinctive of NW-Lazio. It influenced through centuries the shape and location of towns and villages, while the contact between two different landscape-types further enhanced beta-diversity, originating a belt particularly rich in plant species: during a floristic survey in a small protected area (1,000 hectares) placed right across the boundary, nearly 1,000 species were found, including many taxa

included in Red Lists and/or previously thought to be extinct in Lazio (Scoppola & Filibeck, 2008b).

For centuries, traditional land use practices have been enhancing the differences in land-cover types combination on the two sides, hence increasing both visual distinctiveness and biodiversity across the interface. However, we suggest the hypothesis that present-day development is blurring fast this diversity, as both modern agriculture and modern settlements are not strictly controlled any more by the physical properties of the environment. In particular, urban sprawl seems to have very similar patterns on the two sides – being controlled more by the pattern of highways and railroads than by the physical features of the environment. Future researches in the study area will include specific studies on the properties of the landscape interface, concerning both biodiversity evaluation at landscape scale and diachronic quantitative analysis of the "blurring" of the landscape pattern distinctiveness across the boundary. Somehow, this landscape interface as well constitutes a land feature worth to be protected for the future generations.

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