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The map of the vegetation series of Italy

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Abstract
We present the methodology developed for mapping the vegetation series of Italy (at scale 1:250,000) in the frame of the project "*Completion of Basic Naturalistic Knowledge*", funded by the Italian Ministry of the Environment. A hierarchical land classification is combined with expert knowledge of vegetation dynamics and phytosociological field data. The Map of the Vegetation Series is an essential tool for ecological planning and land management.

Keywords: vegetation series, potential natural vegetation, hierarchical land classification.

Riassunto
Viene presentata la metodologia sviluppata per cartografare le serie di vegetazione del territorio italiano nell'ambito del progetto "*Completamento delle conoscenze naturalistiche di base*", finanziato dal Ministero dell'Ambiente. Un procedimento di classificazione gerarchica del territorio ha consentito di cartografare unità omogenee per ambiente abiotico, alle quali sono state attribuite la vegetazione potenziale e le tappe seriali sulla base delle conoscenze fitosociologiche e sindinamiche. La Carta delle Serie di Vegetazione, realizzata in scala 1:250.000 per l'intero territorio nazionale, rappresenta uno strumento fondamentale per la pianificazione territoriale e la progettazione ambientale.

Parole chiave: classificazione gerarchica del territorio, serie di vegetazione, vegetazione naturale potenziale.

Introduction

In the last decade a great deal of ecological work was dedicated to the European Network Natura2000, but in the next future research should be largely inspired by the Convention on Biological Diversity (CBD) and its Programmes of Work (Blasi *et al.*, 2003a).

The main objective of this convention is the conservation of biological diversity at species, community and landscape level through a complex procedure, which includes the Global Taxonomy Initiative and the Ecosystem Approach. The Global Taxonomy Initiative addresses the knowledge gaps in taxonomic information and the shortage of expertise available in many parts of the world. The Ecosystem Approach is a strategy for the integrated management of terrestrial and aquatic environments and living resources that promotes conservation and sustainable use in an equitable way.

The Convention introduces an integrated methodology based on the relationships between socio-economic and ecological processes. Its strategy promotes not only conservation measures but also sustainable development and equitable sharing of resources between developed and developing countries.

The CBD states the main causes responsible for the gradual decline of biodiversity (land use change, climatic change, alien species, greenhouse effect), and the most vulnerable environmental systems. At present, the focus is on protected areas and forest ecosystems. Implementing the sustainable management of these systems implies an outstanding contribution to biodiversity conservation at world scale.

Furthermore, in many cases the participant countries are urged to consult the scientific academic world. Surveys and ecosystem studies are required, in order to define the state of the environment at species, community and landscape level. In this regard, plant sociologists can play a crucial role, due to their sound knowledge of plant indicators and the capability to interpret their dynamical meaning in space and over time. Thus, the CBD represents a crucial chance for promoting the application of plant sociology to the conservation and management of natural and semi-natural ecosystems.

Within this context, this paper presents the methods underlying the "*Map of the vegetation series of Italy*" and the possible applications of this type of maps to the evaluation of the state of conservation of a territory.

The Map of the Vegetation Series of Italy

The "*Completion of Basic Naturalistic Knowledge*" project, funded by the Italian Ministry of the Environment, is a huge programme aimed at acquiring full knowledge of the flora, vegetation, fauna, wet habitats, land cover, phytoclimate and landscapes of Italy.

The project started in 1998 and its outputs include the map of phytoclimate, the CORINE Land Cover map

and the map of the vegetation series of Italy, all at a scale of 1:250,000.

The Phytoclimate Map of Italy is based on the classification of monthly temperature (minimum and maximum) and rainfall data for the thirty year period 1950-1980, collected from 400 stations evenly distributed throughout the country.

The CORINE Land Cover map was produced by upgrading the former 1:100,000 CORINE Land Cover map and by integrating this map with data from satellite images, existing vegetation maps and the Digital Elevation Model. The Land Cover legend was redefined so to achieve a greater detail in mapping natural and semi-natural habitats.

The Map of the Vegetation Series is based on a hierarchical classification approach (Blasi *et al.*, 2000a; 2000b; 2003b), which identifies land units that are homogeneous in their bioclimatic and lithomorphological characteristics. This approach is based on the premise that the various ecosystems are identifiable as a function of their homogeneity, which, in turn, depends on the scale of observation. In a hierarchical land classification, the landscape is categorised into similar ecosystems at progressively smaller scale (e.g. Klijn & Udo de Haes, 1994; Klijn, 1994).

Thus, the main factors structuring the landscape at progressively finer spatial (and temporal) scales are used to identify land units according to the following scheme:

- Land regions, based on macroclimate;
- Land systems, based on lithology;
- Land facets, defined on a geomorphological basis;
- Environmental units, based on the bioclimate at a finer scale.

This approach overcomes the difficulties met by integrated phytosociology (based on phytosociological surveys of spatially contiguous plant communities dynamically related) when not only the typology of vegetation series, but also their mapping is required. Inductive aggregation of existing data is valid only if exhaustive typological and cartographic information on plant associations is available, which is not the case for Italy, where a phytosociological map at national scale does not exist. On the other hand, the concept of potential natural vegetation (and hence the identification of mature stages of vegetation) implies the knowledge of the climatic, lithological and geomorphological features of an area.

Combining the overlay of phytoclimatic, lithological and geomorphological information with basic knowledge of vegetation at regional level enables to first delimit environmentally homogeneous units and then describe them in terms of vegetation series (Fig. 1). The work of expert plant sociologists is crucial for characterising the units derived from the hierarchical classification, for defining the syntaxonomical scheme and joining or splitting the land units derived from the map overlay.

In other words, the Vegetation Series Map of Italy is the result of the integration of two processes:

- Land units are obtained through a hierarchical land classification;
- Their vegetation series are defined using phytosociological field data and the expert knowledge of the relationships between presentl vegetation communities, environmental factors and vegetation dynamics.

Therefore, the land units map helps to define the spatial distribution of potential vegetation types, whereas their phytosociological characteristics and their seral stages are defined through field data.

Obviously the scale of observation influences the degree of environmental homogeneity achievable. At the small scale of the Map of the Vegetation Series of Italy (1:250,000), *land systems* are delimited, that are homogeneous in terms of climate and lithomorphology and are characterised by a dominant vegetation series. However, subordinate series may be present as well. Furthermore, in cases where ecological and morphological gradients change drastically within very limited surface areas, vegetation mosaics or *geosigmeta* are mapped instead of vegetation series. This is the case of the coastal dunes and terraced alluvial plains, and of the orotemperate and criotemperate belts.

The Map of the Vegetation Series of Italy will be completed by the end of 2004, and will be accompanied by a monograph describing in the details the vegetation series present in each Italian administrative region.

The list of the vegetation series which occur in Italy shows interesting biogeographical and syntaxonomical information, which confirms earlier data (e.g.: Blasi *et al.*, 2001; 2002a; 2002b; Poldini *et al.*, 2002; Blasi *et al.*, 2004; Di Pietro *et al.*, in press). For example, in Central Italy *Quercus cerris* woods and *Fagus sylvatica* forests clearly prevail. In particular, the *Q. cerris* woods belong mainly to the *Carpinion orientalis*, whereas the beech forests mainly belong to the *Erythronio-Fagion sylvaticae* and locally to the *Geranio versicoloris-Fagion*.

The *Ostrya carpinifolia* woods and the *Quercus pubescens* woods are mainly assigned to the *Carpinion orientalis*. As for the *Quercion ilicis*, different aspects of *Q. ilex* forests prevail.

The woods of *Q. cerris* and *Q. frainetto,* and the few strips of *Quercus petraea* and *Quercus robur* woodlands of the *Carpinion* alliance are rare but very interesting.

Applications of the Map of the Vegetation Series

Traditionally, ecological networks have been defined on a species-specific basis, taking into account the biology of the species for which the role of the network in terms of dispersal is investigated. However, the concept of ecological network has recently taken on a wider significance, becoming relevant not only for ecologists but also for town and land-use planning. In this regard, the Italian Ministry of the Environment defined the National Ecological Network as "a natural and environmental infrastructure aimed at interrelating and connecting areas with a high degree of naturalness" (Ministero dell'Ambiente-Direzione Conservazione della Natura, Delibera C.I.P.E. 22.12.98).

The core of this ecological network, at national level, is clearly represented by the ensemble of existing Protected Areas. However, the spatial distribution of parks and nature reserves in Italy is rarely consistent with the environmental heterogeneity occurring in this country. For instance, montane systems are over-represented within the existing protected areas, whereas the coastal and alluvial systems are extremely under-represented. The Natura2000 network improved this situation, in that the spatial arrangement of the Sites of Community Importance and the Zones of Special Protection is undoubtedly more representative of the landscape diversity of Italy. However, they still do not exhaust the potential environmental heterogeneity of the Italian territory.

Knowledge of present heterogeneity alone is not sufficient to guarantee a good reference model, because human activities contribute with different levels of intensity to the existing heterogeneity and thus the same degree of heterogeneity (generally measured by diversity indices) can represent extremely anthropised areas as well as natural landscapes. To distinguish between these two cases, a neutral reference model is needed (Ricotta *et al*., 2000; 2002; Carranza *et al*., 2003). At landscape scale, this model is basically a map of the potential natural vegetation, that is the vegetation which is likely to develop taking present bioclimatic and soil conditions as a starting point (Tüxen, 1956; Westhoff & van der Maarel, 1973).

A map of this kind provides a tool to analyse the natural or potential heterogeneity of a given area, which depends only upon climatic, lithological and morphological factors. It can thus be compared with a land cover map of the same study area to assess the relationship between potential and present heterogeneity. If these two match, the maximum biological and physical potential possible for that given area is achieved. If they do not, the distance between them corresponds to the level of change caused by the human impact acting on that area.

The potential heterogeneity in vegetation terms can thus be identified with the "Land Ecological network", that is to say the ensemble of areas which maintain their structural and functional heterogeneity regardless of human activity or, in other words, that are "naturally" heterogeneous (e.g. Blasi *et al*., 2002c; see also Acosta *et al*., 2003). The map of the vegetation series is essential to detect these sites with maximum potential heterogeneity and to identify the different degrees of disturbance due to human activities which affects areas away from their maximum potential - this is particularly useful for restoration and requalification projects.

Comparing the land cover map and a map of the vegetation series of a territory gives already some information on its state of conservation. However, the maps of the vegetation series can prove even more useful for assessing the state of conservation, when pattern analysis on the vegetation patches belonging to the same vegetation series is performed.

In the past the state of conservation was defined as "naturalness" and different values of naturalness were assigned to the plant communities of a phytosociological map on the basis of their floristic and structural features. However, this typological evaluation ignores the spatial arrangement of vegetation patches. In particular, the analysis of the spatial pattern of patches belonging to the same environmental unit, that is to the same unit of potential natural vegetation, gives important results.

In a pilot study concerning two vegetation series occurring in the Molise region, the *Roso sempervirentis-Querceto pubescenti sigmetum* and the *Anemono-Fageto sigmetum*, a range of landscape indexes were applied to the individual patches of vegetation and classified by multivariate analysis.

Results showed that some of the inland patches of the *Roso-Quercetum* are in a state of conservation as good as that of the patches of the *Anemono-Fagetum*; the *Roso-Quercetum* patches along the coastline are, instead, heavily anthropised. Whereas an analysis based on the types of vegetation would assign a general better state of conservation to the *Anemono-Fagetum*, the spatial analysis on the individual patches of a same

vegetation series enables to recognise different situations within the same type of vegetation and to identify groups of patches with the same degree of naturalness, regardless of the vegetation type (Fig. 2).

Conclusions

Present technologies enable an incredibly fine integration of data from different disciplines. Within this context, plant sociology represents the core of environmental and landscape analysis, because of its crucial role for understanding vegetation dynamics and defining reference models. Mapping vegetation series and *geosigmeta* is the starting point for assessing present and potential environmental heterogeneity, and thus to reconstruct the potential heterogeneity of a given area, which represents the reference model for assessing the ecological functionality and the state of conservation of a territory. The availability of maps representing such information can be an important tool for ecological planning, environmental design and requalification projects, as well as for evaluating representativeness, connectivity and coherence of the national network of protected areas.

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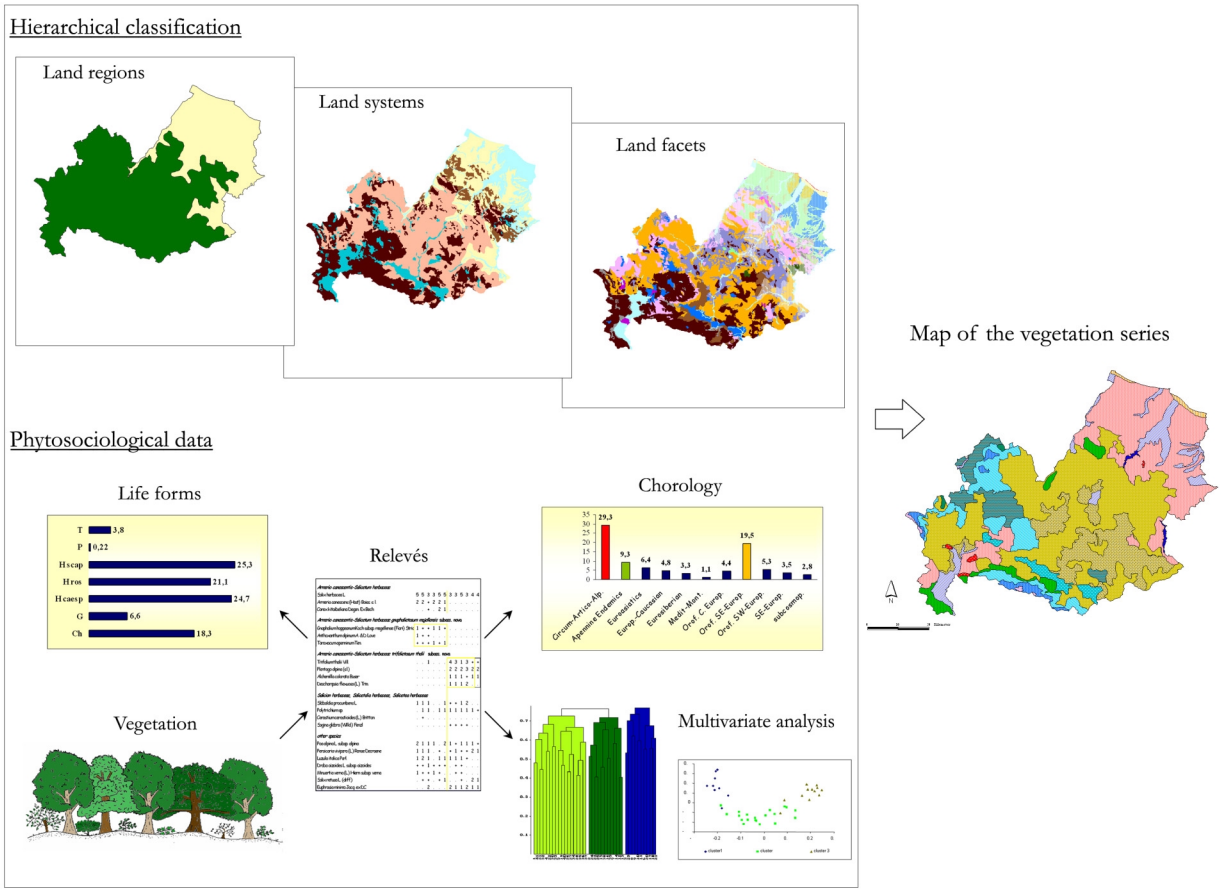

Fig. 1 - The Vegetation Series Map of Italy is the result of the integration of two processes (deductive and inductive): land units are obtained through a hierarchical land classification; their vegetation series are defined using phytosociological field data and expert knowledge

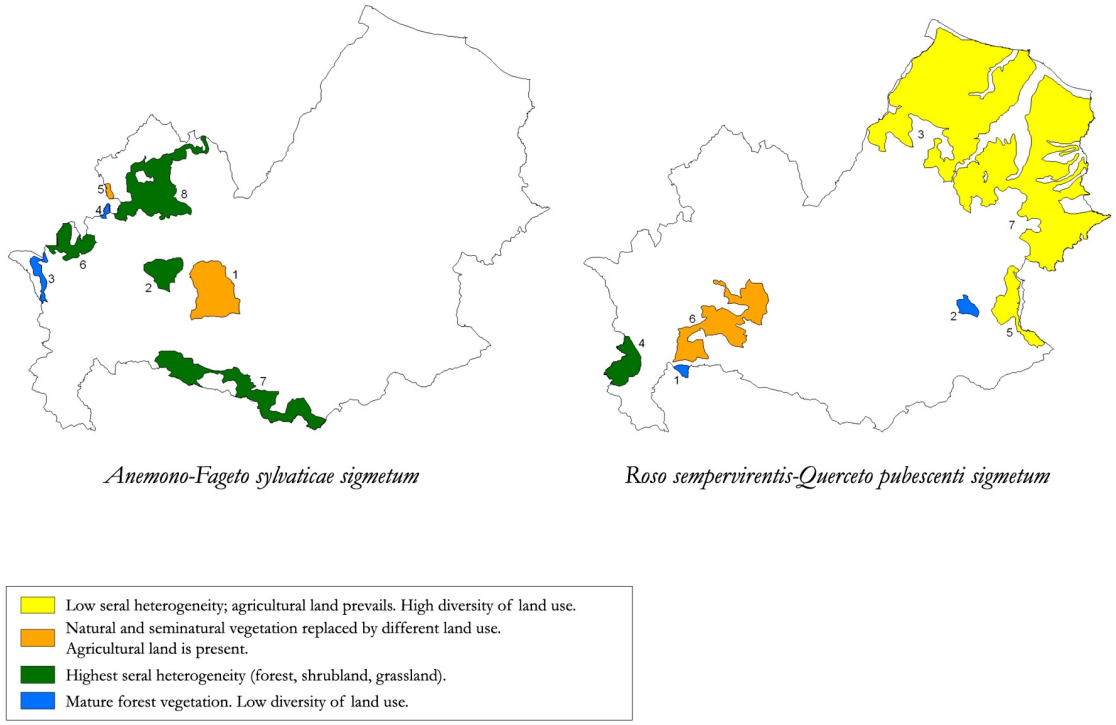

Fig. 2 - A pilot study concerning environmental quality of two vegetation series occurring in the Molise region: a range of landscape indexes were applied to the individual patches of vegetation and classified by multivariate analysis