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A FOCUS ON THE LANDSCAPE MOSAICS: VEGETATION MAP OF "SERRA ROCCA CHIARANO – MONTE GRECO" S.C.I (ABRUZZO, CENTRAL APENNINES)

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Abstract: Aim of this paper is to produce a GIS vegetation map of a high mountain area in Central Apennines applying the landscape ecological approach. The study area is Greco Mountain and Rocca Chiarano mountain ridge (Abruzzo, Central Italy), a calcareous system with very high biodiversity, designated as a Site of Community Importance in the frame of the Directive 92/43/EEC. 120 phytosociological relevés, sampled in 2005-2009 from May to October, were subjected to Cluster Analysis and 18 vegetation types, at the association level, have been distinguished. Ten of these associations are not represented in the vegetation map, due to their small-scale extent. Two alternative methods for vegetation mapping of the area, i.e. the standard synphytosociological and the landscape mosaic approach are briefly discussed. The former cannot be applied to the study area due to recent very intensive disturbance and ongoing rapid dynamics. The mosaic types represented in the map have been individuated on the basis of the occurrence of dominant species. Two mosaic categories have been identified: morphological and dynamic mosaic resulting from the different importance of natural factors *vs.* anthropogenic disturbance. Advantages and usefulness of the mapping approach adopted here are discussed as tools to detect, describe and represent complexity of ecosystem relationships.

Keywords: Landscape mosaics, GIS, Vegetation map, Disturbance, Monitoring

Introduction

The Mediterranean grasslands have been intensively subjected to grazing. Therefore, the study of community change over time in relation to herbivory is of great importance in order to conserve, monitor and manage the habitats. The aim of this study is the redaction of a GIS vegetation map that will be a useful tool for the management and conservation of a high mountain area in Central Apennines (Greco Mountain and Rocca Chiarano mountain ridge). When mapping the vegetation of this area, synphytosociological attempts failed, since the vegetation is rapidly changing: change is a consequence of ongoing relaxation from a long history of anthropogenic impacts, in particular sheep grazing, leading to a mosaic of patches represented by fragmentary vegetation types and even by extensive mono-specific stands. It was therefore necessary to rely on a landscape ecological approach to represent rapid vegetation dynamics. In landscape ecology, mosaics represent a pattern with its own structure and spatio-temporal dynamics (Ingegnoli, 2001; Battisti, 2004; Fanelli et al., 2007). The study of mosaics can be carried out following two approaches: a) the synphytosociological approach (Pignatti, 1980; Rivas-Martinez, 1976; Tüxen, 1973) gives emphasis to the floristic composition and the phytosociological classification of the mosaic patches; b) the landscape ecological approach (Forman & Godron, 1981; Forman, 1995; Haber, 1990), focuses on patch structure and shape.
There is a long history in vegetation cartography in Italy, following the synphytosociological approach (Béguin et al.,

1979; Biondi & Baldoni, 1991; Blasi et al., 1998; Stanisci et al., 2005).
In this investigation the landscape ecological approach was applied, considering that mosaics are easily described on the basis of the shape of patches, and easily interpreted even by people lacking a specific background in plant ecology.
To our knowledge, this paper is the first case of a map of vegetation mosaics that follows the landscape ecological approach, which is reversely routinely applied when exploring the relationships between animal communities and ecological processes (Battisti, 2004; Opdam et al., 1994).

Study area

The study area is Greco Mountain and Rocca Chiarano mountain ridge (Abruzzo, central Italy), a calcareous system with very high biodiversity, designated as a SCI (Site of Community Importance) under the European Directive 92/43/EC. The calcareous massif belongs to the phytogeographic Province of Central-Apennines, with a large number of endemics and with strong affinities with Balkan flora.
The mean altitude of the study area is 1880 m. a.s.l. and covers a surface of 2960 ha, ranging from the mountain- to the subalpine vegetation belt (Fig. 1). From the geological point of view, the area belongs to the carbonatic shelf of Latium–Abruzzo. Geomorphology shows a system mainly composed of large flat valleys at different altitudes (Piano Polverino, Piano le Gravare, Antone Rotondo, Valle di Chiarano etc.), separated by three mountain ridges (Serra Rocca Chiarano, Serra le Gravare, Serra Santa Maria).

Fig.1. Study Area: "Serra Rocca Chiarano – Monte Greco" SCI (Abruzzo, central Apennines).

The signs of the Quaternary glaciations are evident, as well as the karstic phenomena. Accumulations of rock fragments represent important refuges for several species of high ecological and nature conservation importance. Up to few decades ago, Monte Greco Massif hosted thousands of sheep that grazed intensively the grasslands with severe impact on the vegetation. Nowadays, after a substantial decrease of grazing impacts, new pressures and potential threats might affect the territory, such as the possible construction of skiing tracks. The conservation management of this area is entrusted to the Forest Service, which has established collaboration with the Department of Plant Biology - La Sapienza, University, Rome – aiming at the documentation and monitoring of the various diversity issues within the considered SCI.

Methods

Vegetation Survey, Statistical Elaboration and Mosaics Classification

120 phytosociological relevés were carried out in 2005-2009, from May to October, following the standard procedures of the Zurich-Montpellier School (Mueller-Dombois & Ellenberg, 1974; Braun-Blanquet and Jenny, 1926).
The relevés were analyzed through the procedure of Cluster Analysis, using Euclidean Distance as algorithm, to classify the plant associations. The software used was Biodiversity Pro (McAleece, 1997). It was not possible to adopt the standard synphytosociological method to represent the entire territory, because the vegetation, due to the recovery dynamics after the relaxation of grazing a few decades ago, often presents chaotic spatial patterns, preventing the identification of the elementary association stands. It was necessary, therefore, to identify cartographic vegetation units on the basis of the occurrence and frequency of *fragments* of associations recognizable by *dominant* species; for instance, the mosaic named "*Potentillo rigoanae-Brachypodietum genuensis*/*Sesleria tenuifolia"* represents a fragmentary stand dominated by *Brachypodium genuense*, with abundant ingression of *Sesleria tenuifolia,* a species belonging to a different altitudinal belt. In Table 1 a list of the fragments of associations whose combination identifies the cartographic units is reported.
Grids of different sizes have been used to identify mosaics at micro (10x10 cm^2), meso (2x2 m^2) and macro (10x10 m^2) scales (Noss, 1992); grids have been located at random in the field within the vegetation types distinguishable, even not classifiable. These mosaics, even if it not possible to be

attributed to the phytosociological scheme concerning the natural Mediterranean grasslands of the central Apennines (Di Pietro et al., 2005; Biondi et al., 1992), represent units related to environmental factors, such as the traditional associations.

Table 1. List of the association fragments whose combination identifies the carthographic units. The extension of fragments ranges from 1 m^2 to 10 m^2.

1. *Taraxaco apennini-Trifolietum thalii*
2. *Galio magellensis-Festucetum dimorphae*
3. *Potentillo rigoanae-Brachypodietum genuensis*
4. *Poo violaceae-Nardetum strictae*
5. *Poo alpinae-Festucetum circummediterraneae*
6. *Seslerietum apenninae*
7. *Phyteumo orbicularis-Juniperetum alpinae*
8. *Daphno oleoidis-Juniperetum alpinae*
9. *Trigonello monspeliacae-Sideritetum siriacae*
10. *Helianthemo grandiflori-Juniperetum alpinae*
11. *Sesleria tenuifolia*
12. *Brachypodium genuense*
13. *Festuca paniculata*
14. *Nardus stricta*
15. *Bromus erectus*
16. *Carduus carlinaefolius*
17. *Poa violacea*
18. *Carduus carlinaefolius*
19. *Festuca dimorpha*
20. *Juniperus alpina*
21. *Festuca robustifolia*
22. *Juniperus nana*
23. *Taraxacum apenninum*
24. *Anthoxanthum alpinum*

Mosaics have been described on the basis of (Forman, 1995; Ingegnoli, 2001):

- Structure: spatial distribution of species and communities and their dominance ratio;
- Function: interactions with natural and anthropogenic factors;
- Change: alteration and evolution of mosaic structure and function over time.

These three points are particularly important for the maintenance and management of priority habitats and animal and plant communities (Battisti, 2004; Opdam et al., 1994). The priority habitats found in the study area are the following:
Poo violaceae-Nardetum strictae Pedrotti 1981.
Koelerio splendentis-Brometum erecti Biondi et al.1995.
Poo alpinae-Festucetum circummediterraneae Biondi et al. 1992.

Cartographic elaboration

A GIS map has been produced on the basis of the relevés utilizing the software Esri ArcGis-ArcView 9.1, on a topographical base in scale 1:25000 (Fig. 2). In total, 38 units have been mapped with the following partition: 8 plant associations, 24 mosaics, 5 other landscape units (Table 2). The territory has been surveyed by direct observation, with the support of landscape photographs in different seasons and aerial photographs. Polygons representing the mapped units have been identified in the field, through geo-referenced points drawn on the topographic map, during the phase of data collecting. The photo-interpretation allowed the definition of the landscape units and, in a second phase, all data available for the identification of vegetation types and their geometric definition have been used.

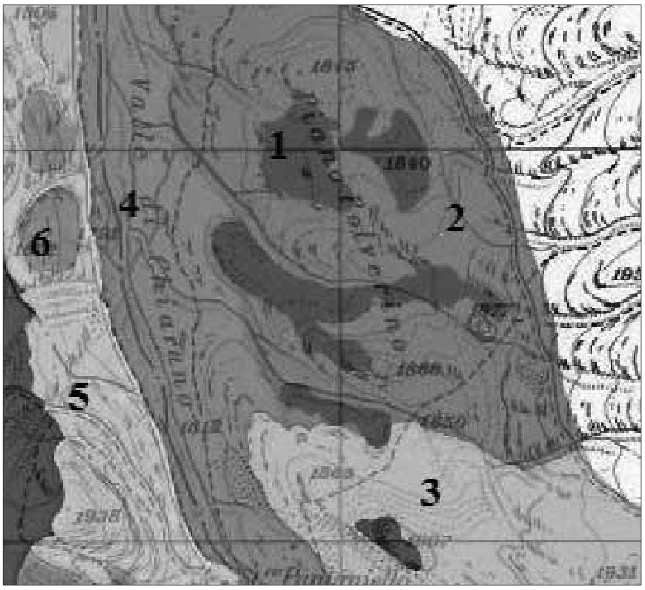

Fig. 2. An excerpt of the map. 1 – *Poo violaceo-Nardetum strictae*; 2 – Mosaic with *Poa violacea, Nardus stricta, Brachypodium genuense, Bromus erectus;* 3 – Mosaic with *Sesleria tenuifolia, Festuca robustifolia, Brachypodium genuense, Poa violacea*; 4 – Mosaic with *Brachypodium genuense, Bromus erectus, Carduus carlinaefolius*; 5 – Mosaic with *Sesleria tenuifolia, Brachypodium genuense, Festuca robustifolia, Festuca paniculata*; 6 – *Potentillo rigoanae-Brachypodietum genuensis*.

Table 2. Vegetation units represented in the map. The units are distinguished in: 8 plant associations, 24 mosaic types and 5 other vegetation units.

	PLANT ASSOCIATIONS
1	Polysticho aculeati-Fagetum sylvaticae
2	Phyteumo orbicularis-Juniperetum alpinae
3	Poo violaceae-Nardetum strictae
4	Koelerio splendentis-Brometum erecti
5	Potentillo rigoanae-Brachypodietum genuensis
6	Seslerietum apenninae
7	Taraxaco apennini-Trifolietum thalii
8	Polygalo majoris-Seslerietum nitidae

	MOSAICS
9	Carduus carlinaefolius community / Taraxaco apennini-Trifolietum thalii
10	Galio magellensis-Festucetum dimorphae / Potentillo rigoanae-Brachypodietum genuensis
11	Poo violaceae-Nardetum strictae / Carduus carlinaefolius community / Taraxaco apennini-Trifolietum thalii
11A	Poo violaceae-Nardetum strictae / Carduus carlinaefolius community / Taraxaco apennini-Trifolietum thalii / Sesleria tenuifolia
12	Poo violaceae-Nardetum strictae / Potentillo rigoanae-Brachypodietum genuensis
13	Potentillo rigoanae-Brachypodietum genuensis / Poo alpinae-Festucetum circummediterraneae
14	Seslerietum apenninae / Phyteumo orbicularis-Juniperetum alpinae
15	Daphno oleoidis-Juniperetum alpinae / Koelerio splendentis-Brometum erecti
16	Seslerietum apenninae / Koelerio splendentis-Brometum erecti / Helianthemo grandiflori-Juniperetum alpinae
17	Brachypodium genuense / Festuca paniculata / Nardus stricta / Bromus erectus / Carduus carlinaefolius comunity
18	Brachypodium genuense / Poa violacea / Bromus erectus / Carduus carlinaefolius community
19	Festuca dimorpha / Brachypodium genuense / Sesleria tenuifolia / Juniperus alpina community
20	Festuca paniculata / Potentillo rigoanae-Brachypodietum genuensis community
21	Festuca robustifolia / Bromus erectus / Brachypodium genuense / Nardus stricta / Sesleria tenuifolia community

	MOSAICS
22	Juniperus nana / Brachypodium genuense / Sesleria tenuifolia community
23	Nardus stricta / Carduus carlinaefolius / Taraxacum apenninum / Bromus erectus / Anthoxanthum alpinum / Brachypodium genuense communities
24	Nardus stricta / Carduus carlinaefolius / Trifolium thalii / Taraxacum apenninum / Festuca robustifolia community
25	Nardus stricta / Poa violacea / Brachypodium genuense / Carduus carlinaefolius / Sesleria tenuifolia
26	Poa violacea / Brachypodium genuense / Nardus stricta / Bromus erectus / Carduus carlinaefolius
27	Poa violacea / Bromus erectus / Brachypodium genuense community
28	Sesleria tenuifolia / Brachypodium genuense / Bromus erectus / Festuca robustifolia / Festuca paniculata community
29	Sesleria tenuifolia / Bromus erectus / Festuca robustifolia community
30	Sesleria tenuifolia / Bromus erectus / Festuca robustifolia / Brachypodium genuense community
31	Sesleria tenuifolia / Carduus carlinaefolius / Trifolium thalii community

	OTHER MAPPED UNITS
33	Synanthropic vegetation
34	Vegetation series of Pantaniello lake
35	Folds vegetation
36	Screes vegetation
37	Chasmophitic vegetation of calcareous rocky slopes

Results

Phytosociological classification

Cluster analysis (see dendrogram in Fig. 3), identifies 18 clusters corresponding to the associations reported in the synoptic table in Appendix. (The species nomenclature follows Pignatti, 1982; Conti, 1998). Only 8 associations phytosociologically identified have been represented in the vegetation map (see Table 2), whereas the others were too small in extent and could not be represented in the map.

Overall, the associations are defined only partly by the characteristic species composition, and are mainly identified by their dominant species combination. For instance, *Sesleria tenuifolia* occurs in more than a cluster, but is dominant only in the cluster of *Selerietum apenninae*. This is probably a consequence of strong disturbance throughout the study area.

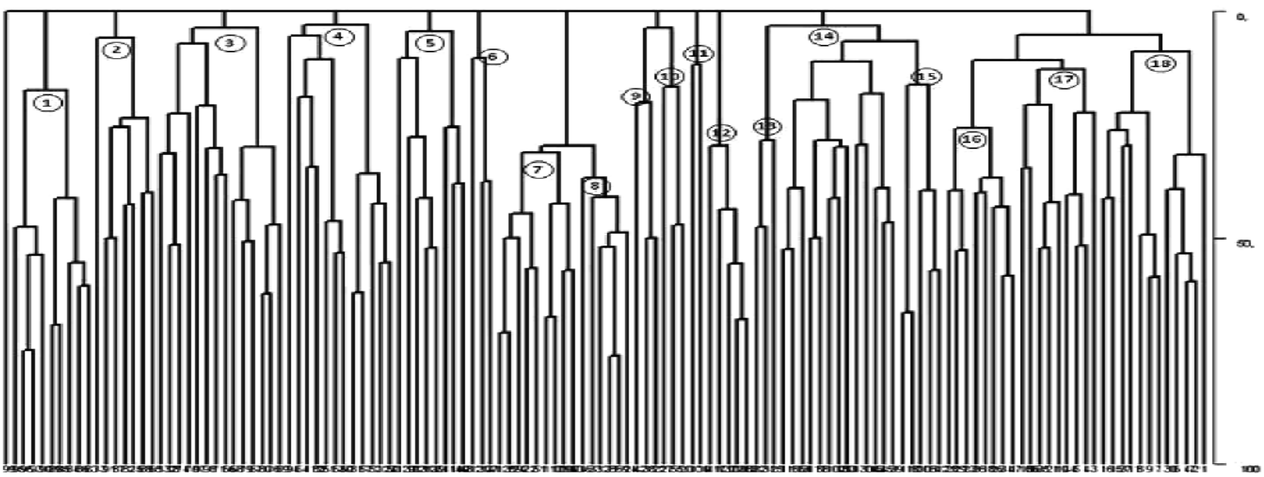

Fig. 3. Dendrogram from Cluster Analysis. 18 clusters are recognized and identified by progressive numbers.

Identification and classification of the mosaics

24 different types of mosaics have been defined and reported in Table 2. Mosaics in the map are often represented by almost monospecific stands of species with high productivity e.g. *Festuca paniculata, Bromus erectus, Brachypodium genuense*. Such fragments have been named after the derived association method (Kopecky & Hejny, 1978), indicating the dominant species and its class affiliation.
Two classes have been identified (Ingegnoli, 2001):
a) morphological mosaics (Figs. 4 and 5)
b) dynamic mosaics (Figs. 6 and 7)

Morphological mosaics are related to convexities and depressions (usually only a few meters). These depressions are correlated with variations in: soil moisture (caused by accumulation of water and snow), soil development (soil accumulates in the depressions and is eroded in the convexities), soil acidity (increases where soil is more developed), soil nutrients that accumulate in the depressions. Striking examples are observed in the dolines, widespread in particular near Antone Rotondo (Fig. 4); these mosaics represent a complex typical of snowbeds. For instance, near Antone Rotondo, we recognized three different belts: a) an outer belt with *Carduus calinaefolius*, b) an inner belt with *Trifolium thalii* and c) an intermediate belt with *Nardus stricta*. The limits among the different belts show conspicuous variations from year to year as a consequence of the climatic variations; for instance, in 2007, *Trifolium thalii* association almost disappeared due to scarce snowfall. Another example is Piano le Gravare, a gently undulated plateau, where we analyzed (Fig. 5) a geomorphological system composed of moister depressions and drier convexities. In the depressions, *Festuca paniculata* prevails; in the intermediate sector, *Brachypodium genuense* is dominant and on the top of the convexities, dry Mediterranean-high-mountain *Sesleria tenuifolia* grassland predominates.

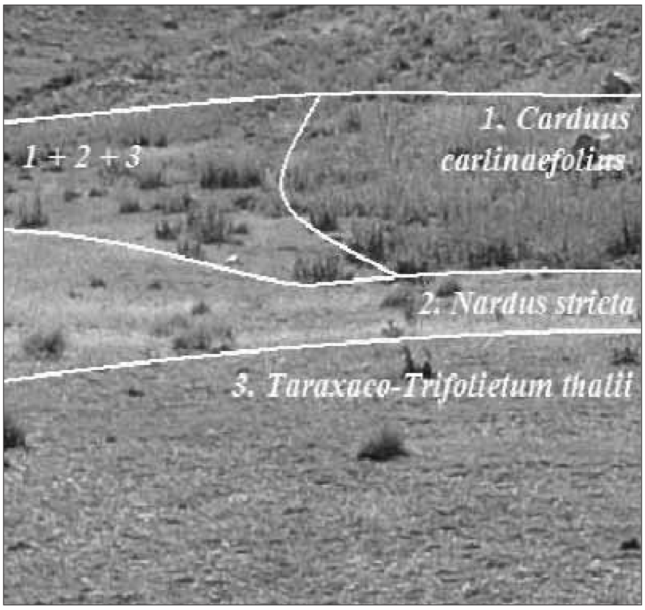

Fig. 4. Morphological mosaic in the snowbeds of Antone Rotondo (in summer).

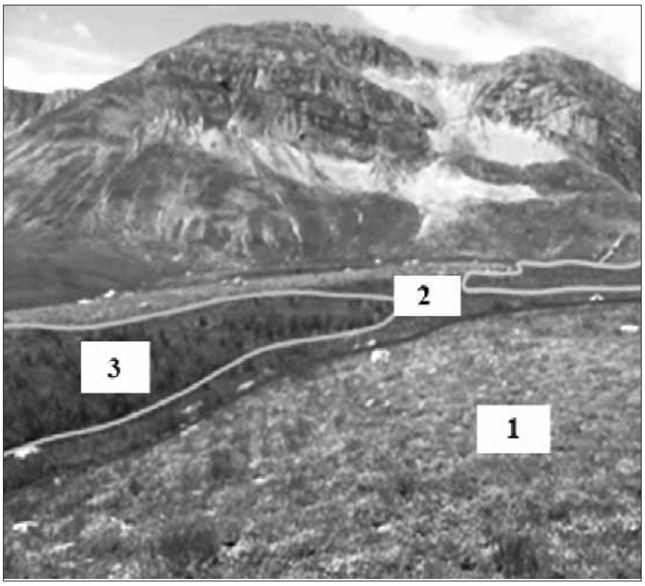

Fig. 5. Morphological mosaic in Piano Le Gravare (in summer): 1 - *Seslerietum apenninae,* 2 - *Brachypodium genuense,* 3 - *Festuca paniculata.*

Dynamic mosaics are related to the reduction of grazing, very heavy until a few decades ago. Two sub-types can be recognized:

1) The plateaus historically subjected to heavy grazing by sheep exhibits a very disarranged vegetation pattern, resulting from the mixture of different successional stages. This mosaic type is composed not only by fragments of associations but also by groupings of few species (*Festuca paniculata, Brachypodium genuense, Bromus erectus, Nardus stricta*) that cannot be classified as phytosociological units. For instance, in Fig. 6, it is possible to observe a patch of *Brachypodium genuense* and *Festuca paniculata*, surrounded by a matrix of fragmentary *Seslerietum apenninae*. *Brachypodium* and *Festuca* have a higher growth rate than species of *Seslerietum*, and therefore in this patch succession has taken place more rapidly than in the surrounding matrix. This patch more over is expanding in the surrounding matrix, given that *Brachypodium* and *Festuca* are more competitive than species of the matrix;
2) The convexities show a more simple pattern of succession, where nuclei of later successional species

develop and spread in the pre-existing matrix. For instance, in Fig. 7 individuals of the shrub *Juniperus nana* expand in the matrix of *Seslerietum* grassland and finally coalesce in a shrubland substituting almost entirely the original matrix.

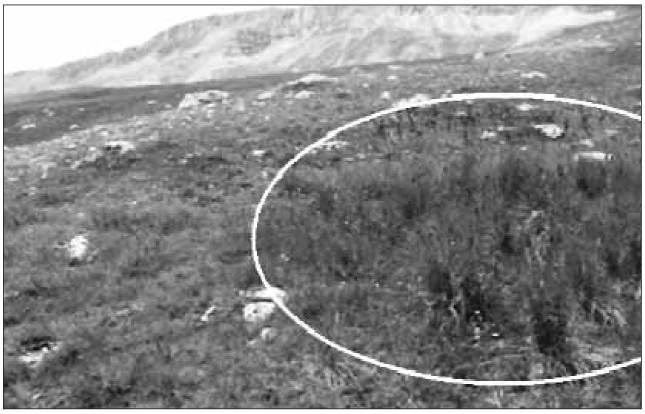

Fig. 6. Dynamic mosaic in Piano Le Gravare: patches of *Festuca paniculata* and *Brachypodium genuense* (in the circle) in a matrix of impoverished *Seslerietum apenninae.*

Fig. 7. Dynamic mosaic: recolonization of *Seslerietum apenninae* by *Juniperus nana.*

Discussion

In the study area we recognized 18 associations. This figure can be misleading since only few associations cover almost the whole area. In particular, *Potentillo rigoane-Brachypodietum genuensis* and *Drypido-Festucetum dimorphae* are the most widespread in the montane belt, and *Seslerietum apenninae* in the subalpine belt, with patches of *Helianthemo grandiflori-Juniperetum.* In other words, β-diversity is not very high. Clusters retrieved in the analysis of relevés, although well characterized, are differentiated mainly by dominant species. Even when a cluster of relevés can be referred to a named association, its floristic composition is strongly untypical. Unsaturated communities represent the most widespread vegetation types; for this reason it is difficult to recognize "true" phytosociological associations in the study area and a traditional phytosociological or synphytosociological map was therefore impossible. These difficulties led us to develop a different approach, following landscape-ecological ideas and emphasizing *mosaics* of vegetation instead of associations (Forman, 1995; Haber, 1990). The history of anthropical pressure in the study area represents the main factor underlying shape and distribution of mosaics in the landscape. Dominance among patches of mosaics are subjected to rapid changes. The decrease of grazing pressure drives plant communities evolution through transitory phases characterised by high fragmentation and great variations in extent -dominance and composition of the plant communities. Some communities are expanded at the expense of the others, generating a high spatial heterogeneity (Davies et al., 2001).

Natural patchiness (Wiens, 1976; Farina, 1991) and anthropogenic gradients lead us to outline two classes of mosaics (morphological and dynamic) resulting from the different importance of natural factors vs. anthropogenic disturbance (Fanelli & Testi, 2008; White et al., 2000). In the morphological mosaics, natural factors (snow, climatic variability, etc.) are the main responsible drivers of the landscape structure; in the dynamic mosaics, anthropogenic disturbance plays the major role. Anyway, in all mosaics both anthropogenic and natural factors are important in shaping the vegetation.

Among the natural factors, a major role is played by morphology (Reinhardt et al., 2010), where it is possible to distinguish lower zones of accumulation (of snow, soil, nutrients) and higher zones of erosion. In the lower zones, nutrients are more abundant. Moreover, grazing interacts with morphology, since grazing is usually stronger in areas with higher nutrient availability (lower zones). For instance, the snowbeds are mainly shaped by the micro-morphology, but the morphological pattern is in a few cases complicated by an overlapping dynamic pattern arising from moderate grazing (Fig. 4).

Grazing has been accompanied by cutting of forests that are nowadays not-existent (apart from a limited area in the exterior of Serra Rocca Chiarano, SW of the SCI); re-colonization by shrubs (f.i. *Juniperus nana*) is slowly in progress, in particular in the higher zones.

In summary, it is remarkable that from a few fine-scale structural elements, combined in a dynamic way, a high complexity of landscape arises.

In the complexity of the studied territory, one of the more interesting dynamic is represented by the relationships between the landscape matrix and mosaic species. This dynamic type regards different scale levels, in general a meso or macro-scale for the landscape matrix and micro-scale for the mosaics (Hugget, 1995). Following the changes over time, we observed, for instance, that the survival of the micro-mosaics with *Trifolium thalii* is linked to the maintenance of a moderate grazing; so, the knowledge of the species and communities turnover establishing between different scale levels may provide to resources managers a sound basis for predicting and evaluating the environmental sustainability of the pastures from an economic as well as ecological perspective (Ewald, 2000).

Conclusions

This study focuses the grazing effect on the vegetation of a high mountain area in central Apennines where, although 18 associations have been recognized, the largest extent of the territory of the Massif of Greco Mountain is occupied by unsaturated communities, that cannot be easily defined in the traditional phytosociological frame. Nonetheless, a description of patterns and composition of vegetation is possible, if we abandon strict phytosociological dogmatism and rely instead on landscape-ecological ideas (Hugget, 1995; Ingegnoli, 2001), in particular on the shape and dynamics of the patches of plant populations and on the distribution of the former in the landscape matrix. This approach is particularly useful in areas of intensive disturbance such as Greco Mountain, where, up to a few decades ago, sheep grazing was exceedingly intense, with thousands of sheep in a relatively small area. Today, the vegetation is relaxing from this former disturbance, and a rapid dynamic is following, with rapid rearrangement of vegetation mosaics.

The approach we outline here may be useful in many parts of the Mediterranean Region, where a pluri-millennial history of human pressure leads to poorly structured vegetation and complex patterns of landscape and may contribute to planning and management of ecological resources at different scales.

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Appendix

Synoptic table. Associations corresponding to 18 different clusters are represented; each association is identified by diagnostic species highlighted in bold. Numbers represent the sum of species frequencies percentages in each association.

Clusters/Associations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Polysticho-Fagetum	*Phyteumo orbicularis-Juniperetum alpinae*	*Helianthemo grandiflori-Juniperetum alpinae*	*Poo violaceae-Nardetum strictae*	*Potentillo rigoanae-Festucetum paniculatae*	*Taraxaco apennini-Trifolietum thalii*	*Luzulo italicae-Nardetum strictae*	*Poo alpinae-Festucetum circummediterraneae*	*Koelerio splendentis-Brometum erecti*	*Medicago lupulinae-Festucetum robustifoliae*	*Potentillo rigoane-Brachypodietum genuensis*	*Anthoxantho-Brachypodietum rupestris*	*Deschampsio-Caricetum extensae*	*Seslerietum apenninae*	*Polygalo majoris-Seslerietum nitidae*	*Galio magellense-Festucetum dimorphae*	*Drypido-Festucetum dimorphae*	*Cymbalarietum pallidae*
Relevés number	*10*	*7*	*14*	*13*	*8*	*3*	*9*	*6*	*3*	*3*	*2*	*5*	*3*	*13*	*5*	*8*	*9*	*12*
Location	Bocche di Chiarano/ Bosco Paradiso	Monte Greco	Posta Pantano di Chiarano	Piano Polverino	Bocche di Chiarano	Serra le Gravare	Monte Greco	Serra Rocca Chiarano	Posta Pantano di Chiarano	Anfiteatro delle fate	Piano Le Gravare/ Bosco Paradiso	Posta Pantano di Chiarano	Pantaniello	Serra S. Maria/ Serra Rocca Chiarano	Posta pantano di Chiarano	Serra Rocca Chiarano	Anfiteatro delle fate	Monte Greco
Altitude m a.s.l.	1590	2057	1988	1839	1663	1992	1971	1916	1636	2011	1842	1672	1800	2067	1620	1926	2010	2125
Slope°	23	5	8	3	12	25	15	8	35	30	4,5	20	0	5	7	10	10	30
Exposure	N-NE	E	SW	S-SE	SW	N-NE	W	S	W	N	SW E-SE	W-SW	-	W	W	NE	E-NE	NE
Cover %	85-90	100	100	100	100	90	100	70	75	85	100	100	100	85	70	65	45	15
Area m²	100	10	22	40	40	3	80	40	35	40	33	40	25	40	22	40	10	30
Diagnostic species																		
Fagus sylvatica	100																	
Luzula pilosa	88																	
Cephalanthera damasonium	75																	
Galium odoratum	67																	
Corydalis cava	58																	
Mycelis muralis	50																	
Polystichum aculeatum	17																	
Phyteuma orbiculare			33													50		
Juniperus communis subsp. alpina		100	67							25					58			
Helianthemum nummularium subsp. grandiflorum		50	50							25					50			
Daphne oleoides		50	50						50									
Globularia meridionalis		50																
Saxifraga paniculata		50							50									
Avenula praetutiana		50		100	100				50	50								
Potentilla rigoana				100						50								
Achillea collina				100	67	100				38	50							
Dianthus deltoides			33	100		40		100		38	50							
Nardus stricta				75														
Poa violacea				75														
Agrostis capillaris				50			10											
Botrychium lunaria				50														
Scilla bifolia				50														
Festuca paniculata					100					25	50							
Digitalis ferruginea					100					25								
Veronica orsiniana					100													
Cirsium tenoreanum					67													

Clusters/Associations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Polysticho-Fagetum	*Phyteumo orbicularis-Juniperetum alpinae*	*Helianthemo grandiflori-Juniperetum alpinae*	*Poo violaceae-Nardetum strictae*	*Potentillo rigoanae-Festucetum paniculatae*	*Taraxaco apennini-Trifolietum thalii*	*Luzulo italicae-Nardetum strictae*	*Poo alpinae-Festucetum circummediterraneae*	*Koelerio splendentis-Brometum erecti*	*Medicago lupulinae-Festucetum robustifoliae*	*Potentillo rigoane-Brachypodietum genuensis*	*Anthoxantho-Brachypodietum rupestris*	*Deschampsio-Caricetum extensae*	*Seslerietum apenninae*	*Polygalo majoris-Seslerietum nitidae*	*Galio magellense-Festucetum dimorphae*	*Drypido-Festucetum dimorphae*	*Cymbalarietum pallidae*
Relevés number	*10*	*7*	*14*	*13*	*8*	*3*	*9*	*6*	*3*	*3*	*2*	*5*	*3*	*13*	*5*	*8*	*9*	*12*
Location	Bocche di Chiarano/ Bosco Paradiso	Monte Greco	Posta Pantano di Chiarano	Piano Polverino	Bocche di Chiarano	Serra le Gravare	Monte Greco	Serra Rocca Chiarano	Posta Pantano di Chiarano	Anfiteatro delle fate	Piano Le Gravare/ Bosco Paradiso	Posta Pantano di Chiarano	Pantaniello	Serra S. Maria/ Serra Rocca Chiarano	Posta pantano di Chiarano	Serra Rocca Chiarano	Anfiteatro delle fate	Monte Greco
Altitude m a.s.l.	1590	2057	1988	1839	1663	1992	1971	1916	1636	2011	1842	1672	1800	2067	1620	1926	2010	2125
Slope°	23	5	8	3	12	25	15	8	35	30	4,5	20	0	5	7	10	10	30
Exposure	N-NE	E	SW	S-SE	SW	N-NE	W	S	W	N	SW E-SE	W-SW	-	W	W	NE	E-NE	NE
Cover %	85-90	100	100	100	100	90	100	70	75	85	100	100	100	85	70	65	45	15
Area m^2	100	10	22	40	40	3	80	40	35	40	33	40	25	40	22	40	10	30
Cruciata laevipes					67	60												
Erodium alpinum					67													
Geum urbanum					67													
Trifolium thalii				25		80												
Plantago atrata subsp. atrata						80					50							
Ranunculus apenninus		50				60												
Taraxacum apenninum				25		50												
Achillea tenorii						50		50		25	50				50	50		
Sagina glabra						50												
Taraxacum glaciale						50												
Festuca nigrescens					67	70	100				50							
Phleum ambiguum						20	80	50	50		50							
Arabis alpina L. subsp. caucasica							40											
Poa variegata							60											
Linaria purpurea							60											
Primula auricula							40											
Polygala alpestris subsp. angelisii				25		10	40											
Gnaphalium sylvaticum				50		20	40											
Cynosurus cristatus							40					33						
Veronica serpyllifolia subsp. humifusa							40											
Festuca circummediterranea				50		60	100	50		25	80							
Bromus erectus		50	67	25			60	100	50	25	50							
Koeleria splendens			33	25				100	50			60						
Armeria majellensis			33	25				100	50	25								
Satureja alpina subsp. alpina			33					100	50	25								
Arenaria serpyllifolia				25				50										
Anthyllis vulneraria subsp. praepopera								50										
Arenaria bertolonii								50										
Astragalus depressus			33					50										

Cerastium arvense subsp. arvense							50									
Crepis vesicaria							50									
Edraianthus graminifolius		33					50									
Leontodon crispus							50									
Knautia calycina							50	50	25							
Medicago minima							50									
Minuartia verna							50									
Sanguisorba minor							50									
Valeriana tuberosa							50									
Festuca robustifolia		33					50	100	38	50						
Plantago lanceolata								50	25							
Achillea millefolium								50								
Carlina acaulis subsp. simplex								50								
Daphne mezereum								50								
Gentiana ciliata								50								
Brachypodium genuense	50	83	50	67			100		75	100		67		58		
Pimpinella tragium				67			50	50	75	50			55			
Trifolium pratense subsp. pratense				67					50	50	44			50		
Campanula rapunculus									38	50						
Hippocrepis comosa									38							
Luzula campestris									38	50						
Plantago argentea									38	50						
Anthoxanthum alpinum			25						38	50						
Brachypodium rupestre										60						
Campanula glomerata subsp. glomerata										50						33
Galium album			25					50	38	50						
Anthoxanthum odoratum										50						
Dianthus carthusianorum								50		50						
Potentilla recta										50						
Silene vulgaris										50						
Leucanthemum ceratophylloides subsp. tenuifolium							50			50						
Lotus corniculatus									63	100						
Inula montana								50		50						
Sesleria tenuifolia subsp. tenuifolia	50											67				
Trifolium pratense subsp. semipurpureum	50					40						78		50		
Astrantia pauciflora subsp. tenorei	50	33										67			50	
Thymus praecox subsp. polytrichus												67		50	50	
Androsace villosa								50				56				
Festuca violacea subsp. italica												56				
Deschampsia cespitosa subsp. cespitosa				67							100					
Carex ovalis					30						67					
Galium palustre			25		10						33					
Molinia caerulea subsp. caerulea											22					
Carex hirta											22					
Juncus compressus											22					
Leontodon autumnalis subsp. autumnalis											22					
Ranunculus acris subsp. acris											33					
Sesleria nitida													82			
Laserpitium garganicum subsp. garganicum													91			
Carex macrolepis													82			
Galium anisophyllon													73	42		
Galium lucidum													73	42		
Sedum rupestre subsp. rupestre		33					50	50	25				64	50		
Allium sphaerocephalon													64			
Helianthemum oelandicum subsp. canum													64			
Coronilla minima													64			

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Location	Bocche di Chiarano/ Bosco Paradiso	Monte Greco	Posta Pantano di Chiarano	Piano Polverino	Bocche di Chiarano	Serra le Gravare	Monte Greco	Serra Rocca Chiarano	Posta Pantano di Chiarano	Anfiteatro delle fate	Piano Le Gravare/ Bosco Paradiso	Posta Pantano di Chiarano	Pantaniello	Serra S. Maria/ Serra Rocca Chiarano	Posta pantano di Chiarano	Serra Rocca Chiarano	Anfiteatro delle fate	Monte Greco
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Exposure	N-NE	E	SW	S-SE	SW	N-NE	W	S	W	N	SW E-SE	W-SW	-	W	W	NE	E-NE	NE
Cover %	85-90	100	100	100	100	90	100	70	75	85	100	100	100	85	70	65	45	15
Area m²	100	10	22	40	40	3	80	40	35	40	33	40	25	40	22	40	10	30
Chamaecytisus spinescens														55				
Euphorbia cyparissias														55	50			
Sedum album														55		50		
Festuca dimorpha															54	100	33	
Pulsatilla alpina subsp. alpina													56		100	50		
Galium magellense		50		25					50						79			
Campanula scheuchzeri			33	25	67					25			78		100	50	67	
Biscutella laevigata										38	50				79	50		
Gentiana lutea subsp. lutea			33							25	50				79	50		
Anthyllis vulneraria subsp. pulchella															100			
Armeria canescens									50		50				100	50		
Doronicum columnae		50							50						100	50		
Helianthemum oelandicum subsp. alpestre															50	50		
Urtica dioica							40								50			
Valeriana montana															50			
Plantago atrata subsp. fuscescens				50		20			50						50			
Stachys tymphaea				25	100	10	60			50	100				50			
Asperula aristata subsp. scabra		50								25					50			
Adenostyles australis	8														50	50		
Cynoglossum columnae										25					50			
Erysimum majellense															50			
Medicago lupulina			50	25				100	50						50			
Rumex acetosa				25											50			
Leucanthemum tridactylites															50	100		
Drypis spinosa subsp. spinosa															50	50	33	
Pedicularis comosa																50		
Pedicularis elegans																50		
Anthyllis montana																50		
Aster alpinus																50		
Coeloglossum viride		50														50		
Euphorbia myrsinites																50		

Juncus monanthos															50	
Linum capitatum															50	
Trifolium medium															50	
Silene multicaulis subsp. multicaulis								50			50				50	
Carex kitaibeliana	50											44			50	
Gentiana dinarica					10										50	
Cymbalaria pallida														50	100	100
Rumex scutatus														50	100	67
Heracleum sphondylium subsp. orsinii														50	50	67
Lamium garganicum														50	100	67
High frequency Companion species																
Carduus carlinaefolius	50	33	75		10	60		100	100	25	50	56		46		
Cerastium tomentosum	100					80		50	50	25		44	55	100	50	
Poa alpina subsp. alpina		33	50		60	80	50	100	50	38					50	
Stachys alopecuros subsp. divulsa	50	50	25						50	25	50			46	50	
Verbascum longifolium			75	100		80		50	50		100			50		
Cerastium arvense subsp. strictum			50		60				100	25		44	73	46		
Asperula cynanchica		50	25					100	50	38	50	78				
Hieracium pilosella		33	100			40		100		38				46		
Galium verum subsp. verum				100		60		50	50	38						
Dianthus sylvestris subsp. sylvestris	100	33				40						89		50		
Sporadic species																
Anemone narcissifolia subsp. narcissifolia												44		50		
Coronilla vaginalis												44				
Rhinanthus wettsteinii								50				44		50	50	