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Integrated multi-scale approaches to Mediterranean grasslands. A case-study on the Nebrodi Mounts (Sicily)

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SUMMARY – An integrated multi-scale research project was implemented on the pastures of the Nebrodi Mounts, a protected area situated on the north-eastern side of Sicily. This study included landscape analysis through GIS techniques, community structure reconstruction by field sampling, and individual-based experimental tests performed on selected species. The results of this work allowed landscape units to be differentiated for their specific attributes, including soil, climate, water availability, erosion risks, biodiversity, feeding value, and potential for alternative exploitation. Six main community types were identified, each related to different soil and climate conditions or to land history and grazing intensity. Guidelines for pasture exploitation are presented, according to their feeding values, resilience levels and environmental qualities. The routine implemented for this research may provide new tools for a sustainable grassland exploitation as well as for environment protection and enhancement.

Keywords: Biodiversity, GIS, landscape analysis, pastures, sustainability.

RESUME – *"Approches multi-échelle intégrées des pâturages méditerranéens. Un cas d'étude concernant les Monts Nebrodi (Sicile)". On a mis en place une recherche intégrée à différentes échelles sur les pâturages des Monts Nebrodi, une zone protégée de la côte nord-est de la Sicile. On a analysé le paysage avec les techniques G.I.S., la structure des communautés avec des relevés sur le terrain, et on a conduit des essais expérimentaux au niveau individuel sur des espèces choisies. D'après les résultats du travail on peut différencier les unités de paysage en fonction de leurs attributs spécifiques, sols, climat, disponibilité hydrique, risques d'érosion, biodiversité, valeur des pâturages, possibles exploitations alternatives. Six types de communautés ont été identifiés, chacun lié à différentes conditions édafo-climatiques, ou avec l'histoire et l'intensité d'usage. On présente des indications pour l'exploitation de ces pâturages, selon les valeur nutritionnelles, la résilience et les qualités environnementales. L'approche adoptée pourrait fournir de nouveaux outils pour l'exploitation des prairies et pour protéger l'environnement avec sa mise en valeur.*

Mots-clés : *Biodiversité, G.I.S., analyse du paysage, pâturages, durabilité.*

Introduction

New multi-functional goals are associated today to grassland management in mountain areas. Animal husbandry in protected areas, in particular, should favour the valorisation of rural territory through sustainability and biodiversity conservation, as well as by producing typical food linked with the cultural heritage of the area.

Nebrodi mounts are part of a regional park since 1982. Pasture is the main traditional source of income for local population, mainly by cow grazing, though goats and sheep are also well represented. Some interesting domestic animals are present in this area, such as *Modicana* cow (endangered), *Argentata dell'Etna* goat (endangered), *Nero Siciliano* pig (critical) and *Sanfratellano* horse.

Several problems, such as soil erosion, loss of grazing value and invasion by alien flora are presently affecting the pasture of Nebrodi mounts. With this study an attempt was conducted to survey natural resources of these grasslands through a multi-scale approach, in order to provide better tools for an integrated management of pastures.

Materials and methods

The study area was located on Nebrodi mounts, on the north-eastern side of Sicily. Its geological substrate is mainly characterized by flysch and arenaceous rocks. A wide variety of soil types are represented, including xerorthents, xerochrepts, xerunpbrepts and haploxeralfs, with sparse distribution of pyroclastic depositions. Climate is varying from sub-humid thermo-Mediterranean, along Tirrenic coastal belt, up to humid supra-Mediterranean on the top of the mountains. Wide extensions of natural pastures are represented in the 1000-1400 m a.s.l. belt (Poli *et al.*, 1972; Brullo and Grillo, 1978), with a variable floristic composition and feeding value, including mesic grasslands dominated by *Lolium perenne* and *Cynosurus cristatus*, xeric grasslands with increasing presence of annuals, humid areas with hygrophytes and slopes with skeletal arenaceous soils stabilized by chamaephyte communities.

A multi-scale study was conducted over this area. The first step was landscape level analysis, focussed on the area included between 38°11'37.00N – 37°49'23.51N and 15°02'15.00E – 14°15'41.05E. Several information obtained by fiel d surveys and literature (CNR, 1958; Ballatore and Fierotti, 1967; Fierotti *et al.*, 1988; Borsellino *et al.*, 1994; Piccione *et al.*, 1995; Duro *et al.*, 1996a,b; Fierotti, 1997; Lentini *et al.*, 1997; Drago *et al.*, 2000) were interfaced through G.I.S. techniques, including climate, soil, land use history, slopes and erosion risk, in order to obtain a broad characterization of grassland environments. A raster overlay was conducted with Ilwis 3.3 software. All data were then elaborated till define and quantifying different land units, each characterized by a peculiar combination of landscape attributes.

Community level analysis was aimed at identifying the main interspecific plant groups, each considered to be characteristic of a peculiar aspect of pasture. Methodology included vegetation survey (Braun-Blanquet, 1964), evaluation of feeding value (Rieder *et al.*, 1983; García-Fuentes and Cano-Carmona, 1992; Roggero *et al.*, 2002), as well as floristic and biodiversity assessment.

Plant individual level experiments were conducted in a controlled environment, in order to evaluate drought resistance, tolerance to grazing and gas exchange parameters on a group of species representatives of the different aspects of grasslands.

Multivariate techniques of statistical analysis (Podani, 1994) were used for landscape and community level data, whereas descriptive and inferential statistics were adopted for individual level analysis.

Results and discussion

About 50 thousands ha of pastures were identified out of land use maps, most of which between 800-1400 m a.s.l. (Table 1). A large portion of the areas laying beneath 1000 m a.s.l. had been classified as crops till about 50 years ago (CNR, 1958), pointing out the role of recent land-use changes on the economy and ecology of the whole area.

Table 1. Grassland areas of the Regional Park of Nebrodi mounts (Sicily), aggregated for soil types and De Martonne climatic index

	Altitudinal belt	*0-800*	*800-1000*	*1000-1400*	*1400-1800*
Soils	Litosoils	111	864	3801	255
	Regosoils	2137	9237	8358	1390
	Vertic-alluvional soils	-	688	21	-
	Brown soils	5357	7958	9256	1455
Climate	Arid	2106	2330	1544	709
	Semiarid	464	5149	3871	139
	Semihumid	5035	10916	12699	1434
	Humid	-	352	3322	818
	Total (Ha)	7605	18747	21436	3100

About half of grazed areas resulted characterised by brown soils, 43% by regosoils and little

extensions by lithosoils. The dominant climate was semi-humid (69% of grazed areas), followed by semiarid (19%), arid (13%) and humid (9%). Humid areas resulted mainly distributed at higher elevations, where Mediterraneity (sensu Rivas-Martinez, 1987) tends to be lower (Fig. 1).

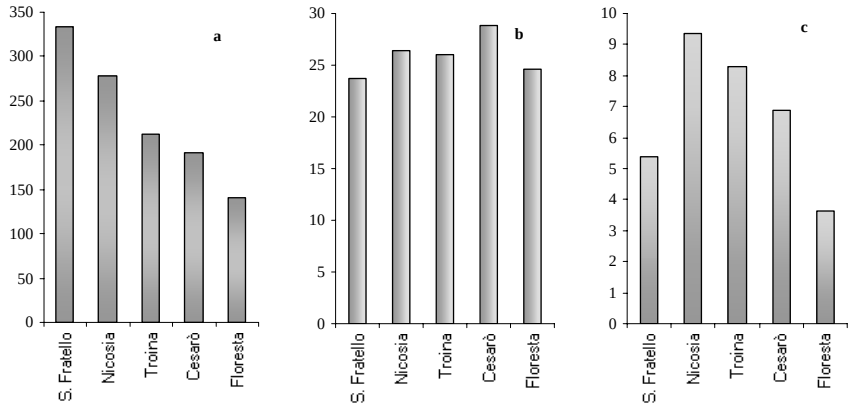

Fig. 1. Climatic indices of termicity (It - a), continentality (Ic - b) and Mediterraneity (Im3 - c), sensu Rivas-Martinez (1987), for the five locations of S. Fratello (690 m a.s.l.), Nicosia (800 m a.s.l.), Troina (1038 m a.s.l.), Cesarò (1100 m a.s.l.), and Floresta (1250 m a.s.l.).

Up to 800 m a.s.l., grazed areas were mainly found on 11-22° slopes, occupying most of the areas not suited to agriculture. Between 800-1000 m a.s.l. flat areas prevailed, mainly coming from crop abandonment. Above 1000 m a.s.l., pastures resulted equally distributed in plains and slopes, with about 1.4 thousands ha laying on slopes with a gradient higher than 22°, these areas resulted mainly constituted by litho- or regosoils and were then considered highly endangered of soil erosion.

About 500 plant species were identified during vegetation survey. Most of them (about 92%) were sporadic, with a frequency on the whole territory lower than 10%. About 20 endemisms were found, among which the rare *Petagnia saniculifolia* Guss., *Helianthemum canum* (L.) Baumg. subsp. *nebrodense* (Heldr. ex Guss), *Cirsium vallis-demonis* Lojac, *Genista aristata* C. Presl and *Trifolium bivonae* Guss. Few dominant species, mainly by eurasiatic or euri-Mediterranean areal (i.e. *Lolium perenne* L., *Cynosurus cristatus* L., *Trifolium pratense* L.), resulted dominating upon the most distributed plant communities, providing the highest portion of their feed resources.

Six main community types were identified, each characterized by a different feeding value (Fig. 2):

- *A* - *Lolium-Cynosurus* communities, on deep organic brown soils, with the best feeding value;
- *B* - *Plantago cupani* dominated type, on overgrazed and degraded pastures;
- *C* - *Genista aristata* and chamaephyte communities, on arenaceous slopes with skeletal soils;
- *D* - *Pteridium aquilinum* dominated stands, on acid and pyroclastic soils;
- *E* - *Asphodelus microcarpus* and therophytic communities, in the most xeric environments;
- *F* - Hygrophyte community, in local basins with impermeable substrates.

The best feeding values were found on *A* community type, mainly distributed above 1000 m a.s.l. on plains or moderate slopes provided with deeply structured soils; these are the more suited stands to feed autochthonous livestock. *B* community type was found on the same environments of *A* type, only differing for the history and intensity of grazing; these areas were considered to need a transitory reduction of grazing, in order to re-establish the best cover values. *C* community type were recognised to play a very important preservation role on the slopes more subjected to erosion, and consequently was considered to need a very high protection level. Woody seedlings were often found to be sheltered under *D* community type, pointing out a successional role that such community could play, leading towards shrub covered stands. *E* community type, limited by scarce water reserve, resulted mainly composed by annuals, depending either on limited amount of rainfall or on very thin soil profiles; these stands were then considered to tolerate only light seasonal grazing, as higher

charge would cause heavy soil erosion. Hygrophyte communities (*F* community type) were locally found in dump areas, often characterised by relevant biodiversity values.

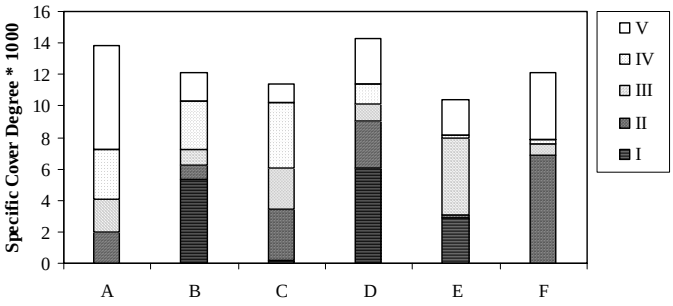

Fig. 2. Specific cover of the 6 pasture community type, disaggregated for their relative feeding value (I: plants never eaten by animals; II: rarely eaten; III: poor fodder, eaten by animals; IV: good fodder; V: excellent fodder). See text for details on community types.

The individual-based analysis, aimed at studying the functional roles played by some key species, pointed out the differential contribution given by each plant type in terms of feeding value, biodiversity and vegetation resilience. The most productive species, mainly belonging to eurasiatic areals, resulted to be relatively more sensitive to water stress; whereas local taxa tended to show a better tolerance to drought and an higher sensitivity to leaf cutting (Mingo *et al.*, 2008).

Conclusions

Nebrodi mounts are among the most ancient sites of Sicilian civilization. Cultural heritage linked to pasture on these grasslands has been considered one of the rarest anthropological witnessing of Mediterranean mountain civilization (D'Onofrio, 2000). Preserving such a culture in the age of global change is a focal goal of rural policy on these areas. Integrated multi-scale studies, such as the one we presented here, are needed prior to define adequate plans for sustainable resource management.

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