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## **Plant biodiversity in habitats of Community interest of Mediterranean large scale grazing systems**

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# Abstract

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Large scale grazing systems are one of the best examples of adaptation of agro-pastoral activities and environmental limitation in the European marginal rural areas. They support high biodiversity levels and therefore they are recognized as an important part of European high nature values farmlands. They are also a source of agro-ecosystem services and they are linked with the history of the resident populations and for this reason many cultural landscapes are associated with them.

Because of the socio-economical changes of the last decades, large scale grazing systems have been greatly reduced. Agro-pastoral activities intensification and abandonment are the main factors that threaten their conservation. With them could disappear an important part of biodiversity and a part of historical and cultural roots of humanity.

Therefore, their conservation is included in the European rural development policies and nature preservation strategies.

In this thesis I describe the studies that I have carried out in order to investigate different aspects of Mediterranean large scale grazing systems with the aim to contribute to the knowledge concerning the conservation status and biodiversity levels in habitats of Community interest linked with them. The surveys were made at different spatial scale in order to investigate the ecosystemic processes using a suitable level of detail.

**Key words:** Grazing systems, biodiversity conservation, Habitat Directive, ecosystem services

# Riassunto

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I sistemi pastorali estensivi mediterranei rappresentano uno dei migliori esempi di adattamento delle attività agro-pastorali alle limitazioni ambientali delle aree rurali marginali europee. Ad essi sono spesso associati elevati livelli di biodiversità, e per questo motivo costituiscono una parte importante delle aree agricole ad elevato valore naturale Europee, e numerosi servizi ecosistemici. Ad essi sono associati paesaggi di rilevanza culturale, legati strettamente al passato storico delle popolazioni umane e ad attività agro-pastorali perpetuate per tempi lunghissimi.

A causa dei cambiamenti socio-economici degli ultimi decenni, i sistemi pastorali estensivi si sono ridotti fortemente e sono tuttora minacciati. L'intensificazione delle attività agro-pastorali e l'abbandono sono i due principali fattori che ne minacciano la conservazione. Insieme a loro rischia di scomparire una porzione importante di biodiversità, e una parte delle radici storiche e culturali dell'uomo.

La loro conservazione rientra, quindi, tra gli obiettivi prioritari delle politiche di sviluppo rurale e di difesa della natura della Comunità Europea.

In questa tesi di dottorato descrivo gli studi che ho condotto allo scopo di approfondire diversi aspetti dei sistemi pastorali estensivi mediterranei con l'obiettivo di contribuire alle conoscenze sullo stato di conservazione e la consistenza della biodiversità degli habitat d'interesse Comunitario ad essi legati. Gli studi sono stati svolti a diverse scale spaziali al fine di indagare i processi ecosistemici coinvolti con il più adatto livello di dettaglio.

**Parole chiave:** Sistemi pastorali, conservazione della biodiversità, Direttiva Habitat, servizi ecosistemici

# Introduction

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In the Mediterranean basin an history of interactions between man and nature has been going on from thousands of years impacting biota and ecosystems and producing large-scale effects (Caballero et al., 2009; Hopkins, 2009). Large scale grazing systems (LSGS) are one of the best example of co-evolution between human activities and nature, and one of the most widespread land use systems in Europe.

LSGS are mainly situated in the marginal rural areas of Europe, where the human activities are constrained by environmental limitations. These constrained territories are also indicated as less favored areas (LFA). In LFA the extensive agro-pastoral activities with low energetic input and mechanization, low stocking rates and modest capital investment represent the prevailing or the unique form of land use (Caballero et al., 2009; Caballero, 2007). The relevance of LFA is linked to their large extent: in the EU 15, LFA represent 56% of the utilized agricultural area (UAA), i.e. 69 millions of ha (IEEP, 2007; Paracchini et al., 2007; Brouwer et al., 1997; Beaufoy et al., 1994). This evidence explain why LSGS are widespread in Europe and around the Mediterranean basin.

LSGS represent a relevant part of High Nature Values Farms (HNVF). The HNVF concept, introduced by Baldock et al. in 1993, indicates those European areas where agricultural activities are the main or the dominant land use and where such agricultural activities support high biodiversity levels or the presence of species or habitats of Community conservation importance (Halada et al., 2011; Andersen 2003). In LSGS the agricultural activities are mainly silvo-pastoral. In the long-term the interaction between these extensive activities and the environment favored the biodiversity conservation and then they could be consider a specific case of HNVF (Caballero et al., 2009; Caballero, 2007). Indeed over 25% of the habitats of community interest are related to pastoral activities and extensive forage crops, and 16 are totally dependent from these activities (Caballero, 2007; Halada et al., 2011). The importance of LSGS is also linked to the high number of agro-ecosystem services they provide (Bagella et al., 2013; Caballero et al., 2009; Hillel & Rosenzweig, 2005). Among them: forage production, erosion control, reduction of burning hazard, maintenance of soil quality and carbon reserves, provision of high agro-food quality, economic sustenance for rural population, support of tourism and recreation (MEA, 2005). Moreover, LSGS, often represent cultural landscapes, because they are linked to the history of the resident populations (Caballero et al., 2009).

Despite their great relevance for biodiversity conservation and ecosystem service provisioning, since the second world war, the LSGS were threatened by two contrasting forces, driven by socio-economical and political factors: extensification and abandonment (Bagella et al., 2013; Caballero et al., 2009; Caballero, 2007). In the last years the crisis of the agro-pastoral sector and some disharmonic political choices exacerbated the situation. Nevertheless the European Community recently increased the attention on HNMF. The Rural Development Policy (RDP, 2007-2013) ensure a financial support to the member states for rural development programs according to Community strategic goals (IEEP, 2007). Concerning HNMF the economic resources devolved to protect and enforce the natural resources of the EU and rural landscapes, should contribute in three priority areas: 1) Biodiversity, preservation and development of HNMF and of cultural landscapes; 2) water conservation and hydrological risks; 3) climate change (RDP, 2007-2013). Moreover, the main European instrument for nature conservation, i.e the Habitat Directive (EC 92/43), is aimed to the conservation of natural and semi-natural habitats, according to the economic, social and cultural needs (Primack, 2003; EC 43/1992).

The conservation of HNMF and associated habitats of Community interest requires the assessment of (IEEP, 2007): biodiversity and natural values; spatial extension and distribution; management systems; changing trends, threatening factors and conservation priorities.

In this perspective it is important to define methods to assess the nature values of HNMF, and to study these systems at different spatial scale in order to better understand the complex interactions between human activities and biodiversity and how these interaction shape the ecosystem processes and services.

## **Aim and research questions**

The focus of this thesis is on LSGS, which represent a specific case of HN VF.

The general aim of this thesis was to contribute to the knowledge of LSGS biodiversity and ecosystem services in the Mediterranean hot-spot at different spatial scales.

The main research questions were:

- How to define and map areas with high nature values in LSGS?
- Which are the relationships between human activities and environmental factors? How such relationships affect plant biodiversity at landscape mosaic level?
- How the long-term management practices influence plant assemblages in the context of LSGS?
- How composition, structure and phenology of plant communities condition honeybee foraging in Mediterranean LSGS?
- Which are the long-term survival chances of wooded grasslands with *Quercus suber* L. in a typical Mediterranean agro-forestry system?
- How isolated trees affect the variability of soil features, plant and collembola assemblage diversity and composition in a Mediterranean wooded grassland?

## Thesis layout

A relevant number of habitats of Community interest is associated to LSGS and depends on agro-pastoral activities. Oak wooded grasslands are one of these habitats and, moreover, they represent the most extended silvo-pastoral system in Europe. The natural regeneration of the arboreal component in this systems is needed to assure their long-term conservation. **Chapter 1** is devoted to evaluate the long-term survival chances of wooded grasslands with *Quercus suber* L. in a typical Mediterranean agro-forestry system in areas not still assessed in previous studies. The study was conducted at farm scale and landscape scale, in grazed or grazed and tilled cork oak wooded grassland and in woodlands in order to test the compatibility of management type for tree regeneration. In order to evaluate the regeneration of *Q. suber*, the size structure was estimated measuring the diameter at breast height of trees and the seedling/sapling cover and eight were measured in sampling plots. A frequency model of the size structure was calculated in order to estimate the surviving chances of cork oak stands in the medium/long term period of time. The results of the DBH classes distribution for 4 future scenarios was elaborated in order to produce graphical representations of the arboreal stands. The landscape scale study was conducted inside and outside the Natura2000 network in order to assess its effectiveness on the habitat conservation. The results confirmed a generalized lack of regeneration in grazed wooded grasslands and that the Natura2000 sites resulted not effective in protecting the habitat.

Investigate the complex relationships between trees and the biotic and abiotic environment above and below ground is necessary to understand how they affect plant and animal biodiversity and the ecosystem services of these systems. Very few studies explored in small scale the effect of trees on the surrounding biotic and abiotic environment. In **Chapter 2** is presented a study aimed to test the hypothesis that the trees have direct and indirect effects on soil features and carbon sinking, under canopy plants and collembola assemblages. In a typical Mediterranean wooded grassland soil features, plant and collembola assemblages along transects departed from the trunk of six cork oak trees were surveyed. We assessed the variability of Photosynthetically active radiation (PAR), floor litter, soil carbon pools and physical-chemical features, and the effect of this variability on plant and collembola assemblages along the transects. We also tested the interrelationships between plant and collembola assemblages. The results partially confirmed the hypothesis. Significant effects of trees on soil, plant and collembola assemblages were found. Plant and collembola assemblages react in different ways to the effect of trees and no interrelationships between them emerged.



LSGS are man-made systems where environmental factors and human activities influence each other driving to complex landscape mosaics and shaping the plant biodiversity and communities. **Chapter 3** is devoted to study the effects of environmental factors on human activities and the effects of human activities on plant biodiversity in a Mediterranean agro-silvo-pastoral system modified and diversified through traditional land uses. A classification of the landscape was applied in order to verify how the different human activities are distributed in relation to the environmental heterogeneity of the study area. The plant communities, surveyed on the field, were classified according to the phytosociological method (Braun-Blanquet, 1964) and the biodiversity concern of each plant community was assessed according to the Annex I of the Habitat Directive. A Principal Component Analysis (PCA) was performed to point out the relationships among plant communities related to the same aPNV and land use. The results of our research showed that the studied Mediterranean agro-silvo-pastoral system was included in the same environmental unit and that human activities enhanced plant biodiversity.

Human activities doesn't affect the plant biodiversity only at landscape scale. At farm or field scale the management type can have deep effect on plant communities of grasslands. In **Chapter 4** is presented a study aimed to evaluate the effect of two long-term management practices on plant assemblages in the context of Mediterranean cork oak LSGS. Fields characterized by uniform management for at least the past 50 years were selected considering grazing livestock species (sheep or cattle), and soil tillage frequency. Vegetation surveys were carried out in fenced plots using the point quadrat method. We assessed the grazing value according to Daget and Poissonet (1971) and species richness was calculated. In each site, a soil profile was dug down to check that the soil types of all sites were uniform and comparable. A set of soil physical-chemical analyses was performed on bulk samples randomly taken in each site. Two separate Canonical Correspondence Analyses (CCA) and a Redundancy Analysis (RDA) were performed to test whether management practices or soil features influenced plant assemblage composition and whether management practices influenced soil features. The results highlighted the influence of management practices and soil features on plant assemblage composition, which was significantly affected by grazing livestock species and stocking rate and by soil pH and K content.

The heterogeneous landscapes of Mediterranean LSGS provide different types of ecosystem services and a multiple use of natural resources could be effective in the conservation of these systems. In this context, honey production represents a traditional, renewable and therefore sustainable resource from an economic perspective. In **Chapter 5** is presented a study aimed to

analyze how the variety, composition and structure of plant communities and the flowering phenology of plant species affect honeybee foraging in a Mediterranean LSGS. Phytosociological and phenological surveys were performed in a circular area of 1.5 km radius with a small apiary placed in the centre. Polleniferous and nectariferous values of plant communities were assessed based on the cover and the polleniferous and nectariferous value of each constituting species. Honey production was quantified during the main flow (March–June) and subjected to melissopalynological analysis. Data were evaluated by ordination through principal components analysis (PCA) and principal coordinates analysis (PCoA). The latter utilized a new index, developed for calculating the phenological distances based on the individual distributions of flowering frequencies. The results showed that there was a close correlation between polleniferous and nectariferous values suggesting that the role of plant communities in honeybee foraging is generally twofold. The temporal flowering sequence ensured the supply of nectar and pollen throughout the spring season.

In **Chapter 6** is presented a study aimed to develop a method to evaluate and map the areas with high nature values in HNMF and apply it in the context of LSGS. In a sample area of 1924 km<sup>2</sup> in the northern Sardinia I conducted a landscape classification in order to define homogeneous land units and its environmental factors in terms of climate, geology, geomorphology and bioclimate. I defined the land uses associated to agro-pastoral activities and carried out field surveys to identify plant communities and habitats of Community interest linked to LSGS. I proposed a method based on scores to evaluate the samples basing on the presence of plants or habitats of conservation interest. Using Geographic Information Systems I spatialized the sample scores in order to create a map of target areas for conservation linked to LSGS.

# Chapter 1

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## Effects of management on *Quercus suber* L. regeneration in Mediterranean wooded grasslands

Rossetti I. & Bagella S.

### Abstract

Wooded grasslands are the most widespread agro-forestry system in Europe and are included in the Natura2000 network because of their importance biodiversity conservation. As many man-made systems, their long-term conservation depends on their sustainable use. The regeneration of the arboreal component is indispensable to assure their maintenance. Several researches made in Spanish *dehesas* and Portuguese *montados* generated concern about the long-term conservation of these systems. In our study we tested if the regeneration issues documented for the Iberian peninsula also affected the wooded grasslands located in other Mediterranean areas and if the Natura 2000 network is effective for the conservation of the habitat 6310. The size structure of *Q. suber* L. stands and the abundance and height of seedlings and saplings were determined at farm and landscape scales, in grazed, grazed and tilled wooded grassland and in not grazed woodlands in order to test the compatibility of management type for tree regeneration. A frequency model of the size structure was calculated in order to estimate the surviving chances of cork oak stands in the medium/long term period of time. The landscape scale study was conducted inside and outside the Natura2000 network in order to assess its effectiveness on the habitat conservation. The results confirmed a generalized lack of regeneration in grazed wooded grasslands and that the Natura2000 sites resulted not effective in protecting the habitat.

**Key words:** diameter at the breast height, size structure, grazing, tilling, Weibull, Natura2000

## Chapter 2

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### **Influence of isolated cork oak trees on soil features plant and collembola assemblages in a Mediterranean wooded grassland**

Rossetti I., Bagella S., Cappai C., Caria M.C., Lai R., Roggero P.P., Martin P., Sousa P., Seddaiu G

#### **Abstract**

In Mediterranean wooded grasslands the presence of isolated trees is an important component that enhances its ecological complexity. Study the complex relationships between trees and the biotic and abiotic environment above and below ground is necessary to understand how they affect plant and animal biodiversity and the ecosystem services of these systems. Very few studies explored in small scale the effect of trees on the surrounding biotic and abiotic environment. Moreover, to our knowledge no data are available on the effect of isolated trees on pedofauna (e.g. collembola). In this study we tested the hypothesis that the trees have direct and indirect effects on soil features and carbon sinking, under canopy plants and collembola assemblages. In a typical Mediterranean wooded grassland we surveyed soil features, plant and collembola assemblages along transects departed from the trunk of six cork oak trees. We assessed the variability of Photosynthetically active radiation (PAR), floor litter, soil carbon pools and physical-chemical features, and the effect of this variability on plant and collembola assemblages along the transects. We also tested the interrelationships between plant and collembola assemblages. Our results partially confirmed our hypothesis. Significant effects of trees on soil, plant and collembola assemblages were found. Plant and collembola assemblages react in different ways to the effect of trees and no interrelationships between them emerged.

**Key words:** *Quercus suber*, ecosystem services, floor litter, under canopy

# Chapter 3

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## Traditional land uses enhanced plant biodiversity in a Mediterranean agro-silvo-pastoral system

Bagella S., Caria M.C., Farris E., Rossetti I., Filigheddu R.

### Submitted to Plant Biosystems

#### Abstract

Mediterranean agro-silvo-pastoral systems play a key role in view of the positive contribution that they could offer to a sustainable development of European agriculture. The knowledge of the vegetation dynamics and of the processes and land uses favoring different vegetation types related to the same actual potential natural vegetation could represent a sound reference framework for monitoring and managing plant biodiversity in these systems. The aims of the research were: i) to identify the environmental units more suitable for the human activities and the relative actual potential natural vegetation (landscape scale); and ii) to evaluate the impact of human activities on plant biodiversity along a gradient of use intensity (environmental unit scale) comparing actual vs actual potential natural vegetation.

The results of our research showed that the studied Mediterranean agro-silvo-pastoral system was included in the same environmental unit and that human activities enhanced plant biodiversity. Moreover, the case study here presented confirmed the effectiveness of those landscape approaches comparing actual vegetation vs actual vs actual potential natural vegetation for plant biodiversity monitoring and reinforced previous studies showing the effect of human activities on plant community diversity at the environmental unit scale in different biogeographical contexts.

**Key words:** actual potential natural vegetation, environmental unit scale, land use intensity, landscape scale, phytosociology, *Quercus suber*.

## Chapter 4

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### **Effects of long-term management practices on grassland plant assemblages in Mediterranean cork oak silvo-pastoral systems**

Bagella S., Salis L., Marrosu G.M., Rossetti I., Fanni S., Caria M.C., Roggero P.P.

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## Chapter 5

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### **Effects of plant community composition and flowering phenology on honeybee foraging in Mediterranean sylvo-pastoral systems**

Bagella S., Satta A., Floris I., Caria M.C., Rossetti I. & Podani J.

**Published in: Applied Vegetation Science 16: 689-697 (2013)**

<http://onlinelibrary.wiley.com/doi/10.1111/avsc.12023/abstract>

# Chapter 6

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## **Identifying, assessing and mapping High Nature Value Farmlands (HNVF): a proposal for Mediterranean agro-silvo-pastoral systems**

Rossetti I., Bagella S.

### **Abstract**

High Nature Value Farmlands are considered of great relevance for nature conservation. They support outstanding biodiversity levels and a number of ecosystem services. For this reason they are considered as a relevant part of European high nature value farmlands. Because of socio-economical factors High Nature Value Farmlands are threatened by intensification and abandonment of agro-silvo-pastoral activities. As a consequence, the European Commission intend to identify them and assess their conservation status across Europe. This work is focalized on a specific type of High Nature Value Farmlands, i.e. the large scale grazing systems, where the land use is mostly linked to zootechnical production. We propose a method to define their spatial extension and distribution, management systems and their on biodiversity and natural values, and to identify the target areas for biodiversity conservation.



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# Abstracts

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## Servizi Ecosistemici Associati all'Eterogeneità Spaziale della Componente Erbacea dei Pascoli Arborati Mediterranei

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### Introduzione

I pascoli arborati, tipici dei sistemi pastorali estensivi mediterranei di Spagna, Portogallo, Grecia e Italia (Caballero et al., 2009) svolgono un ruolo rilevante per la conservazione della biodiversità e per i servizi ecosistemici ad essa associati (Eichhorn et al., 2006). Sono habitat di interesse comunitario riferibile al tipo 6310-dehesa con *Quercus* spp. sempreverdi (Council of Europe, 1992) e il loro mantenimento è associato alla sostenibilità delle aziende agro-pastorali. Queste ultime si basano su diversi tipi di gestione e sistemi di allevamento (Bagella et al., 2013).

Questo lavoro si inserisce nell'ambito del progetto "PASCUUM" (Servizi ecosistemici di sistemi pastorali estensivi mediterranei: produttività e sequestro di carbonio) finanziato dalla Regione Autonoma della Sardegna. L'ipotesi specifica è che, indipendentemente dalla specie animale allevata, la vegetazione erbacea sia caratterizzata da una elevata eterogeneità spaziale della produttività e della composizione floristica determinata dalla posizione rispetto agli alberi e quindi che si riscontrino delle differenze tra le aree sotto la proiezione della chioma (SC) e quelle della fuori chioma (FC). Il lavoro ha come obiettivo la valutazione dell'effetto della copertura arborea e del sistema di allevamento associato a ovini da latte o bovini da carne su (i) produttività primaverile della vegetazione erbacea (ii) composizione floristica e (iii) valore pastorale della vegetazione erbacea.

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**Land use enhanced plant landscape biodiversity in a Mediterranean agro-sylvo-pastoral system**

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Environmental European policies are aimed to the conservation of seminatural habitat and cultural landscapes and to support marginal/less productive farming systems. In this framework Mediterranean agro-sylvo-pastoral systems play a key role in view of the positive contribution that they could offer to a sustainable development of European agriculture. They result from a complex interaction between ecosystems and society and are nowadays strongly threatened by abandonment.

In this context the aims of our research were: i) to model the plant landscape in a typical Mediterranean agro-sylvo-pastoral system; ii) to evaluate how the landscape was affected by the traditional land uses unchanged over the centuries.

The study area, located in north eastern Sardinia, was characterized by a wide variety of land uses related with different types of production activities which are mainly represented by livestock farming, grape-growing and cork extraction (Bagella et al. 2013).

The plant landscape was modeled identifying the potential natural vegetation within each land unit (Blasi et al. 2000). The effects of human management were evaluated throughout the analysis of the actual vegetation.

The potential natural vegetation represented a sound reference for the assessment of the effects of management on plant biodiversity at landscape and community level (Farris et al. 2010).

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**EcoFINDERS: verso una comprensione del ruolo della diversità fungina tellurica nel funzionamento degli ecosistemi**

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Il suolo è riconosciuto come la matrice naturale più complessa, l'habitat della biosfera più ricco di forme di vita e, pertanto, uno degli ultimi rifugi della biodiversità (1). I microrganismi e la fauna tellurica, e le loro interazioni, svolgono molte funzioni essenziali per l'economia della natura e dell'uomo. In virtù del riconosciuto legame tra biodiversità, funzionamento e produttività degli ecosistemi (2, 3), e del crescente apprezzamento del valore economico dei servizi ecosistemici (4, 5), esiste un forte interesse alla caratterizzazione della biodiversità tellurica, attualmente esposta a rischi di origine essenzialmente antropica.

Nell'ambito di un progetto europeo su larga scala (EcoFINDERS: Ecological Function and Biodiversity Indicators in European Soils;

[http://cordis.europa.eu/fetch?CALLER=FP7\\_PROJ\\_EN&ACTION=D&DOC=1&CAT=PROJ&RCN=97538](http://cordis.europa.eu/fetch?CALLER=FP7_PROJ_EN&ACTION=D&DOC=1&CAT=PROJ&RCN=97538)), finalizzato a fornire all'Unione Europea strumenti scientifici e tecnologici per una gestione sostenibile dei suoli, siamo impegnati nell'analisi metagenomica della diversità sistematica e funzionale dei funghi tellurici a diverse scale spaziali e temporali. Le indagini, basate sull'analisi del DNA fungino direttamente estratto dal suolo, si avvalgono delle recenti tecniche di sequenziamento "high throughput" (454 pirosequenziamento), in grado di restituire centinaia di migliaia di sequenze in tempi brevi, consentendo pertanto un grado di risoluzione senza precedenti nella descrizione dei consorzi fungini tellurici.

I primi risultati, relativi ad una cronosequenza di usi del suolo (pascoli arborati, vigneti, foresta) nell'Osservatorio di Lungo Termine di Berchidda-Monti, in Sardegna, hanno indicato l'esistenza di cospicue differenze tra le comunità fungine telluriche associate a facies distinte del sistema agro-silvo-pastorale in esame. Le indagini, estese ad altri periodi di campionamento e siti, contribuiranno ad identificare entità indicatrici della qualità del suolo, ed a determinare il "normal operating range" (spettro accettabile di variabilità spaziale e temporale) delle diverse tipologie di uso del territorio in differenti aree climatiche europee.

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- 5) S. Gianinazzi et al. (2010) *Mycorrhiza*, 20, 519-530

**Estimating ecosystem services of vegetation: vegetation structure and composition, plant phenology and honey production in a mediterranean sylvo-pastoral landscape estimating**

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**Presented at the: First International Symposium of the FIP: “Global Strategy for the Plant Conservation”. Valencia (Spain) 13-17/09/2011.**

Mediterranean sylvo-pastoral landscapes are characterized by a great variety of vegetation and land use types which ensure multiple benefits and ecosystem services. Among them honey production represent a traditional, non- destructive and sustainable economical resource.

The aims of this research were to assess: i) the influence of different vegetation types and plant species on the quality of honey production and ii) the relationship between plant phenology, biological parameters of bee population and honey production.

The study area was located in NE Sardinia in a cork oak tree landscape on gently sloping land grazed by local crossbred beef cattle, on granitic Upper Carboniferous-Permian substratum at an elevation of 250-300 m a.s.l. in the Meso- Mediterranean phytoclimatic belt. This landscape type is widespread in the island as well as in large areas of the Mediterranean basin.

The experimental apiary was positioned in May 2009. Vegetation mapping, based on phytosociological surveys, was realized inside a circular area, 3 km in diameter, having its centre in the point where the apiary was located. Phenological surveys on different flowering stages, were performed during spring-summer 2010 every 15 days along 4 perpendicular radius of the circular area. Each hive was detected for different biological parameters (population dynamic of bees and brood extension) and for honey production. In addition, at different periods, foraging bees with pollen loads and honey from super were sampled for palynological analyses.

The results showed a strong connection between flowering period, population dynamic and honey production. Furthermore palynological analysis pointed out the relationships between vegetation types and plant species abundance in the studied area, their distribution pattern and the representativeness of their pollen in the honey.

**EcoFINDERS - linking soil trophic processes and above-below ground diversity: the Mediterranean Long-Term Observatories at Berchidda-Monti (Sardinia)**

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**Presented at the: Dryland ecosystem functioning and resilience: integrating biophysical assessment with socio-economic issues. International Conference. Alghero (Italy) 6-8/07/2011**

Biotic interactions between above- and below-ground communities act as powerful drivers of plant community dynamics and ecosystem properties, and play a fundamental role in regulating the response of terrestrial ecosystems to human-induced global change. A key aim of EcoFINDERS project (**E**cological **F**unction and **B**iodiversity **I**ndicators in **E**uropean **S**oils) – [www.ecofinders.eu](http://www.ecofinders.eu) – is to identify the soil biodiversity components that regulate plant diversity and composition across a range of environmental conditions in Europe. The longterm observatories (LTOs) identified by the project will allow to evaluate the impact of different environmental filters on soil biodiversity and associated functions supporting ecosystem services. In the framework EcoFINDERS, the LTO of Berchidda (North-Eastern Sardinia) is representative of the Mediterranean bioclimatic region. Sampling sites were chosen along a vegetation chronosequence developed on similar topography and edaphic conditions, and their selection was driven by vegetation type, land-use and level of land-use intensity. There is no control over the management of the fields and rely on agreements with farmers to have the access. Three levels of land-use intensity within the chronosequence were selected: i) low (cork oak forest), ii) medium (wooded grassland) and ii) high (haycrop and fallow grassland). In the first two cases sampling was performed below and beyond canopy trees. At each selected sampling site (3 replicates for each treatment) plant community structure (specie composition and relative abundance) was analysed inside a 2x2 m<sup>2</sup> sampling area. On May 2011, within each sampling area about soil samples were collected after 2 mm sieving at a 0-20 cm soil depth. Main soil physical and chemical traits (texture, total organic carbon, total nitrogen, soluble

phosphorus, pH, etc.) will be determined. DNA and RNA will be extracted and analyzed to investigate soil fungal systematic and functional diversity. Previous analyses indicated differences in fungal communities mirroring the land-use gradient.

**Keywords:** soil organic carbon, vegetation analysis, fungi biodiversity, grassland, cork oak woodland.



**Relazione tra fitofenologia e produzione mellifera. Un caso di studio in sardegna nord-orientale\***

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**Presented at the: XXIII Congresso Nazionale Italiano di Entomologia. Genova (Italy) 13-16/06/2011.**

E stata sviluppata un'indagine finalizzata a migliorare la comprensione del valore mellifero di un'area di interesse apistico rappresentativa della Sardegna settentrionale e a porre così le basi per definire un modello previsionale della produzione di miele. L'area in studio ricade nel Distretto Forestale "Coghinas-Limbara" (prov. OT), caratterizzata da sugherete (50%), formazioni arbustive (10%), aree a vegetazione rada (15%), pascoli erbacei (9%) e coltivazioni varie (11%). La postazione di alveari è stata allestita nel maggio 2009. I rilievi hanno riguardato: dinamica delle colonie; produzione di miele; analisi palinologiche di raccolti di polline da api bottinatrici campionate sul predellino dell'alveare e di campioni di miele prelevati in differenti periodi di produzione dai favi del melario. I rilievi fenologici sono stati eseguiti nella primavera-estate 2010 con cadenza quindicinale lungo 4 transetti perpendicolari tra loro con origine dalla postazione di alveari. Su ogni transetto sono stati individuati 50 punti distanziati di circa 30 m e memorizzati con un GPS Garmin e-trex SummitR. In corrispondenza di ciascun punto è stato individuato un plot di 1 m di diametro per il quale è stato compilato l'elenco di specie presenti, annotando, per ciascuna, la fase di fioritura (boccioli, fiori aperti e fiori appassiti). I dati fenologici e sinfenologici così ottenuti sono stati utilizzati per produrre tabelle di sintesi e diagrammi. Comparando i dati biologici e produttivi degli alveari con quelli fenologici delle fioriture è stato possibile evidenziare una stretta relazione tra la curva sinfenologica, la dinamica delle colonie e la produzione del miele in riferimento ai due periodi produttivi: primaverile e autunnale. I rilievi palinologici hanno altresì permesso di evidenziare la relazione tra rappresentatività del polline nel sedimento dei mieli e diffusione della specie nell'area di studio.

Inoltre, poiché la check-list delle specie pollinifere e nettariifere comprende 85 entità, questa è risultata ben rappresentativa (circa il 40%) dell'intera flora di interesse apistico della Sardegna.

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– Ivo Rossetti –

*“Plant biodiversity in habitats of European interest of Large Scale Grazing Systems”  
PhD Thesis in Environmental Biology - University of Sassari 2013 - XXVI cycle*

**Parole chiave:** fioriture, mieli, dinamica delle api, produttività degli alveari.

\* Lavoro realizzato nell'ambito del PRIN07: Integrazione di conoscenze apistiche attraverso lo sviluppo e la calibrazione di un modello per la simulazione dell'alveare (Coordinatore: Prof. F. Danuso, Università di Udine).

## Naturalità e biodiversità nei paesaggi agrari del Mediterraneo: il sistema silvo-arabile delle sugherete

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**Presented at the: Workshop della Società Italiana di Scienze della Vegetazione: “Lembi residui di vegetazione nei sistemi agricoli”. Roma (Italy) 29/04/2011**

Nel paesaggio agrario del Mediterraneo i sistemi silvo-arabili, caratterizzati dalla presenza di alberi sparsi all'interno di colture annuali o perenni, costituiscono un elemento di grande interesse sia per la conservazione della biodiversità che per il contributo positivo che possono offrire per uno sviluppo sostenibile dell'agricoltura a livello europeo (Eichhorn et al., 2007; Bergmeier et al., 2010). Questi sistemi occupano vaste superfici all'interno di unità ambientali entro le quali si rinvengono anche *patch* di vegetazione arborea e arbustiva e aree interessate dalla presenza di colture specializzate anche intensive.

Un esempio emblematico è quello dei sistemi silvo-pastorali delle sugherete, indicati come *dehesa* in Spagna e *montados* in Portogallo, nei quali vengono coltivate specie foraggere (leguminose o graminacee) utilizzate per lo sfalcio o per il pascolo (Olea e San Miguel, 2006; Caballero et al. 2009).

Gli obiettivi di questa ricerca, che è stata svolta nell'ambito del progetto SOILSINK (<http://soilsink.entecra.it>), sono stati: i) confrontare la naturalità e la biodiversità del sistema silvo-arabile delle sugherete con quelle relative ad altri tipi di uso del suolo più intensivi e alle *patch* di vegetazione seriale e ii) indagare sui loro rapporti dinamici in un'unità ambientale riferibile alla serie Serie Sarda centro-occidentale calcifuga, meso-mediterranea della sughera (*Viola dehnhardtii-Quercus suberis* Σ).

L'area di studio è localizzata nella Sardegna nord-occidentale su substrati granitici, ad una quota compresa tra i 250 e i 300 m s.l.m. nel piano bioclimatico meso-mediterraneo. L'unità ambientale è stata identificata in accordo con il sistema gerarchico di classificazione del paesaggio (Blasi et al., 2000). Per ciascuna tipologia di uso del suolo sono stati effettuati rilievi di vegetazione con il metodo fitosociologico. Le comunità vegetali sono state caratterizzate dal punto di vista floristico-ecologico e le superfici da esse occupate sono state cartografate all'interno di un GIS. La matrice dei dati (specie x rilievi) è stata quindi sottoposta ad una analisi delle corrispondenze (CA). Il confronto in termini di biodiversità è stato effettuato in termini quantitativi (ricchezza e indice di

Shannon) e qualitativi (habitat di interesse comunitario, presenza di specie di interesse per la conservazione ecc.).

I risultati ottenuti hanno consentito di stabilire un gradiente di naturalità in base alla vicinanza di ciascuna comunità alla vegetazione matura di riferimento, di quantificare l'incidenza in termini di copertura di ciascuna tipologia individuata e la configurazione spaziale delle *patch*, di valutare il contributo alla  $\gamma$  diversità delle diverse tipologie di vegetazione, di individuare gli stadi dinamici di maggior interesse per la conservazione.

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## Courses and seminars

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- February 14<sup>th</sup>, 2011: Seminar “Macroinvertebrati lacustri: dal campionamento agli indici di qualità”. Life+ Project 08/ENV/IT/000413 - INHABIT. Dr. Angela Boggero, CNR ISE of Verbania Pallanza, visiting professor in the Department of Scienze Botaniche Ecologiche e Geologiche, Sassari;
- March 14-15-16<sup>th</sup>, 2011: “Introduction to Multivariate Analysis” course. Prof. Stephanie Gascón Garcia, Institute of Aquatic Ecology, University of Girona – Campus Montilivi, Faculty of Sciences –Girona, Spain visiting professor in the Department of Scienze Botaniche Ecologiche e Geologiche, Sassari;
- March 29<sup>th</sup>-31<sup>st</sup> and April 01<sup>st</sup>, 2011: “Ecology, evolution and conservation of plant diversity in the Mediterranean” course. Prof. John D. Thompson, Centre d’Ecologie Fonctionnelle et Evolutive, Montpellier, France, visiting professor in the Department of Scienze Botaniche Ecologiche e Geologiche, Sassari;
- May 24-25-26-27<sup>th</sup>, 2011: “Analisi Multivariata e uso del software SYN-TAX 2000” course. Prof. Janos Podani, Department of Plant Taxonomy and Ecology Eötvös University, Budapest, Hungary, visiting professor in the Department of Scienze Botaniche Ecologiche e Geologiche, Sassari;
- September 05<sup>th</sup>, 2011: English course level B1 (100 hours). Organized by CLA Sassari;
- December 16<sup>th</sup>, 2011 – June 7<sup>th</sup>, 2012. Specialization course in “Cartografia numerica, geodatabase e sistemi informativi territoriali: GIS” (240 hours). Organized by Catalogo Interregionale di Alta Formazione;
- March 22<sup>nd</sup>-23<sup>rd</sup>, 2012. “ArcGIS Desktop I – Iniziare con i GIS” module. Esri Italia C/O IAL Sardegna;
- March 24<sup>th</sup>, 2012 – June 9<sup>th</sup> giugno 2012. “ArcGIS Desktop II – Strumenti e Funzioni” module. Esri Italia C/O IAL Sardegna;
- June 5-6<sup>th</sup>, 2012. Course on Spatial Statistics for Ecologists. Centre Tecnologic Forestal de Catalunya, Solsona, Spain;

- October 8-12<sup>th</sup>, 2012. Training Course on “Environmental and Natural Resource Economics. Theoretical Foundations and Applied Issues”. Organized by Regione Autonoma della Sardegna and FORGEA International;
- 7-8 febbraio 2013. 1° Workshop on the Database of the Italian Vegetation, Vegitaly, Pavia;
- September, 2013 – January, 2014. Quantitative ecology module for Master and PhD students. Faculty of Science University of South Bohemia, České Budějovice, Czech Republic.

## Collaboration to projects

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- UE-FP7 2011-2014 “EcoFINDERS”: ECOlogical Function and biodiversity INDicators in EuRopean Soils;
- L.R.7/2007 Progetti di ricerca di base – Bando 2010. “Pascuum”: Servizi ecosistemici di sistemi pastorali estensivi mediterranei: produttività e sequestro di Carbonio;
- PRIN 07 “APIPOP”: Integrazione di conoscenze apistiche attraverso lo sviluppo e la calibrazione di un modello per la simulazione dell’alveare.
- L.R.7/2007 “Gli stagni temporanei mediterranei: distribuzione, biodiversità e stato di conservazione in Sardegna”, condotto dal Dipartimento di Scienze Botaniche, Ecologiche e Geologiche dell’Università di Sassari.

## Supervision of MSc and Bachelor students

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- “Effetti della gestione sulla capacità di rigenerazione della componente arborea nei pascoli arborati a *Quercus suber* L.”, Master of Science Degree in Gestione dell’ambiente e del territorio. University of Sassari;
- “Caratterizzazione della biodiversità vegetale dei sistemi pastorali estensivi ad elevato valore naturale”. Master of Science Degree in Gestione dell’ambiente e del territorio. University of Sassari;
- “Effetto della gestione e della densità della copertura arborea dei pascoli sulla composizione delle comunità erbacee”. Bachelor Degree in Scienze della Natura. University of Sassari.

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