Research Article

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Correlations between organic and conventional management, on-field biodiversity and landscape diversity, in olive groves in Apulia (Italy)

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Introduction

The problem statement

Intensified land use is one of the main cause of global change and biodiversity loss. Destruction and fragmentation of habitats and landscape are major factors in the global decline of populations and species and dealing with all of this changes is one the greatest challenges to conserve biological diversity.[1] Under the current scenario of rapid growth of human population, to achieve efficient agroecosystems in order to produce enough food while conserving biodiversity is a global challenge.[2] Conventional agriculture prioritizes high yields and does little to harmoniously interact with and preserve its immediate environment and therefore, current agricultural practices are regarded as one of the most significant drivers of biodiversity loss and different ecological health problems;[3] On the other hand, low-intensity land-use systems may be important elements of large-scale conservation programs[4] and agriculture can contribute to the conservation of high-diversity systems, which may provide important ecosystem services such as pollination and biological control;[5] for instance, one of the claims recently proposed by different studies is that organic agriculture is beneficial to nature protection and biodiversity conservation.[3] Actually intensive farming happens at two spatial scales, the landscape scale of agricultural intensification adds to the local effects of intensified farming practices;[5] so landscape and agriculture biodiversity are connected in various points.

Olive orchards are a characterizing element in the Mediterranean landscape and olive growers are traditionally between the more effective guardians of such landscapes. In addition to their undeniable cultural and landscape values, these habitats have a major environmental importance since they offer shelter to many plant and animal species, some of which are of considerable conservation interest.[6] In fact, the presence of many types of plant communities, Perrino and Calabrese[7] make the existing agro-ecosystems suitable for hosting several species of amphibians, reptiles, mammals and especially of birds.[8] Today, olives are produced in 39 countries worldwide on an area of over 8million hectares and is the most extensively cultivated temperate fruit crop in the world.[7] Considering the history of the spreading of olive trees throughout the Mediterranean countries,[9] it can concluded that the olive agro-ecosystems are about 2.800years old[10] and, due to the high level of biodiversity they host, they can be a good field of application to investigate the aspects related to the interactions between the surrounding landscape, the agricultural practices and the biodiversity conservation.

Objectives of the research

Aim of the present research work is to further investigate the correlation existing between the biodiversity at field level in the Mediterranean olive groves, the agricultural practices performed to achieve a production and the landscape asset characterizing the agricultural systems around the fields. In order to investigate such correlations, as a first step, biodiversity at field level will Investigated and assessed; in a second moment the agro-ecosystem diversity at landscape level will be described by a set of indicators and analyzed and then the influence of the different management systems will be investigated by comparing olive groves under organic and conventional management.

In this conceptual frame the following steps will be performed:

a. Monitoring and assessment of the on-field biodiversity in organic and conventional olive groves;

b. Description (by using GIS tools) and analysis of the agroecosystem diversity (cropping system diversity) around the farm areas (by using a set of indicators);

c. Investigation of the correlations between the on-field biodiversity of flora, the agro-biodiversity at landscape level and the agricultural practices by applying statistical methods.

Research background

Agroecosystem

Ecosystems are the life support system of the Earth – for humans as well as all life on this planet.[11] The ecosystem processes are controlled by both the diversity and identity of the plant, animal, and microbial species living within a community.[12] Agroecosystems are amended ecosystems that have variety of different properties, to have a sustainable efficient agroecosystem it seeks to shift some of these properties toward natural ecosystems but without significantly trading off productivity.[13]

The biodiversity is an important regulator of agroecosystem function, not only in the strictly biological sense of impact on production and other ecosystem processes, but also in satisfying a variety of needs of the farmer and society.[14] A common perception of agroecosystems is that the diversity and complexity are lower than in natural ecosystems and the structure and function impaired;

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nevertheless the numerous ecological processes that connect people, crops, weeds, animal, micro-organisms, soil, and water together into a functioning, on-going ecosystem are very intricate to be described.[15]

Biodiversity concept and interpretation

The definition given by the Convention on Biological Diversity in Rio de Janeiro of 1992 explains "Biological Diversity" as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".[16] This definition presents the many dimensions of biodiversity showing us that every biota is characterized by its taxonomic, ecological and genetic diversity and the variation over time of such feature is the key of biodiversity. Within the field of natural sciences biodiversity corresponds to the interdependences between the three major components of the diversity of life (within species, between species and of ecosystems) studied by ecologists, taxonomists and geneticists. Consequently only multidimensional assessment of biodiversity can provide understanding of relationships between changes in biodiversity and changes in ecosystem functioning.[17] In the context of human society, biodiversity does not belong only to natural science but places the diversity of living organisms within the wider challenges, preoccupations and conflicts of interest expressed at the Rio conference.[18] According to Büchs[19] the "primary users" of the term "biodiversity" are members of scientific community and they are using this term on more or less clear way. But he pointed that "secondary users" such as policy-makers and the groups of society and even actors in other scientific fields different from ecology, are using term "biodiversity" in a very individual way.

The debate about the use of the term biodiversity according to The Institute of Sustainable Development and International Relations[20] has four point of view or perspectives:

i. An environmental perspective with conservation as a primary objective;

ii. An agronomic perspective that aims to limit losses of genetic diversity with goal of plant productivity improvement;

iii. A commercial perspective (profit oriented) that one some way considers biodiversity as patenting of intellectual property rights (patenting plants, animals or DNA parts);

iv. A cultural or indigenous perspective with growing concern for the loss of diversity in cultural aspects of our life (monumental, linguistic etc.)

From an environmental and agronomic perspective recent interpretations of the term biodiversity are more wide and include varieties, races, life forms and genotypes as well as landscape units, habitat types, structural elements (shrubs, stonewalls, hedgerows, flowering strips), crop or land use diversity, etc. Regardless of the different theoretical approaches to the biodiversity concept, there is wide consensus among the scientists that biodiversity should be protected and conserved.

"Why to protect biodiversity?"

Biodiversity conservation is a very complex problem very much related to natural ecosystems dynamics and to systemic complexity of human activities. The fragmentation of natural ecosystems, due to human activities impact, determines new kinds of land cover and modifies natural systems, creating variations at landscape level, habitat level and floristic and animal composition with consequences for the environment and socioeconomic changes. This is the reason why the use of natural resources must be compatible with both environmental and socioeconomic development.[21]

According to INRA Report[18] there are two groups of motives to take care of biodiversity, economic and ethical. The economic motives are:

a. Biodiversity contributes to the provision of food and industrial products;

b. it is essential for the continuous improvement of domesticated plants and animals;

c. it provides important opportunities in the area of biotechnology;

d. it stimulates economic activity linked to tourism;

e. It plays a role in the regulation of major biological, physical and chemical cycles in the nature thus making costs of pollution lower;

f. It contributes to soil fertility and soil protection, as well as to the regulation of the hydrological cycle.

The second group of motives is driven by ethical and conservation values:

a. Biodiversity is crucial for the maintenance of the process of evolution of the living world;

b. Human beings have a moral obligation to not eliminate other forms of life;

c. Present generations are having an obligation to pass on to our children the living heritage that they have received.

Agriculture and biodiversity

"Biodiversity is essential for ecosystem services and hence for human well-being; biodiversity goes beyond the provisioning for material welfare and livelihoods to include security, resiliency, social relations, health, and freedoms and choices. Some people have benefited over the last century from the conversion of natural ecosystems to human-dominated ecosystems and from the exploitation of biodiversity. At the same time, however, these losses in biodiversity and associated changes in ecosystem services have caused other people to experience declining well-being, with some social groups being pushed into poverty".[17]Agriculture is intimately linked to biodiversity because it is highly dynamic, and the boun daries between the domesticated plants and animals and the wild species are constantly shifting. Agricultural land use affects large parts of terrestrial area, so its contribution to biodiversity is critical for successful conservation in the future.[5]

Agro biodiversity

Agricultural biodiversity refers to the variety and variability of animals, plants, and micro-organisms on earth that are important to food and agriculture, and which result from the interaction between the environment, genetic resources and the management systems and practices applied by people; It has spatial, temporal and scale dimensions. It is specifically concerned with agro-ecosystems and therefore with variation in agriculture-related plants, animals, fish,

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insects, microbes, avian species and their wild relatives. It includes both flora and fauna that are part of an agro-ecosystem, as well as elements of 'natural' habitats that are part of the food-production chain. It has multiple, economic, ecological and social benefits, and it is a crucial and integral component of sustainable development.[22]

Historically, the focus of the work carried on about agricultural biodiversity has been on characterizing and conserving the species and their genetic diversity. But an ecosystem consists of a dynamic complex of living organisms (plant, animal and microorganism communities) and their non-living environment interacting as a functional unit and this is even true for the agro-ecosystem. In general the degree of biodiversity in agro-ecosystems depends on four main characteristics:[23]

a. The diversity of vegetation within and around the agro-ecosystem;

b. The permanence of the various crops within the agro-ecosystem;

c. The intensity of management;

d. The extent of the isolation of the agro-ecosystem from natural vegetation.

According to Vandermeer and Perfecto[24] two distinct components of biodiversity can be recognized in agro-ecosystems. The first component, planned biodiversity is the biodiversity associated with the crops and livestock purposely included in the agro-ecosystem by the farmer, and which will vary depending on the management inputs and crop spatial/temporal arrangements. The second component, associated biodiversity, includes all soil flora and fauna, herbivores, carnivores, decomposers, etc. that colonize the agro-ecosystem from surrounding environments and that will thrive in the agro-ecosystem depending on its management and structure and, in to some extent support the productive process with their functional traits (functional biodiversity). Figure 1.1 illustrates the relationships of both the biodiversity components. Planned biodiversity has a direct function, as illustrated by the bold arrow connecting the planned biodiversity box with the ecosystem function box. Associated biodiversity also has a function, but it is mediated through planned biodiversity. Thus, planned biodiversity also has an indirect function, illustrated by the dotted arrow in the figure, which is realized through its influence on the associated biodiversity.

Biodiversity and intensive agriculture

Intensive agriculture is considered as one of the main causes of species decline in cultivated landscape.[25] Globally, over 4,000 assessed plant and animal species are threatened by agricultural intensification. Pesticide use, synthetic nitrogen fertilizer, and consolidation, drainage and the use of heavy machinery, have all contributed to a drastic loss of biodiversity.[26] In addition to climate change is also increasingly causing shift in the cultivation areas and yields of crops and in indigenous flora and fauna.

Organic agriculture and biodiversity

Numerous comparative studies comparing the impact of conventional and organic agriculture on farming systems, verify the positive effect of organic farming on flora and fauna at field and farm level. A comprehensive analysis of Ocak and Ogun take into consideration 66 scientific studies that show that the positive effect of organic farming is most significant in cleared landscapes, but is also visible in structurally rich region; in particular birds, predatory insects, spiders and field flora benefit most from organic management Ocak and Ogun.[27] Modern agriculture has resulted in a loss of diversity in the agricultural landscape) Benton et al.,[28] and it has been suggested that large-scale conversion to organic farming could partly ameliorate this loss. Organic agricultural practices are believed to be more environmentally sound, biodiversity protective[29] and more sustainable than intensive agriculture, which is dependent on the routine use of herbicides, pesticides and inorganic nutrient applications in the production of crops and animals.[30] Organic agriculture has a large impact on average species richness compared to conventional agriculture and it could undoubtedly play a major role in halting the continued loss of diversity from Conventional practices.[31] Recent statistics proved that organic yields are globally on average 25% lower than conventional yields according to a recent meta-analysis[32] at comparable yields, only plants benefited substantially from organic farming . It is not clear if the relatively modest biodiversity gains can justify the substantial reductions in food production. Indeed, the relatively low yields of organic farms might result in larger areas of land being brought into agricultural production (locally or elsewhere), at a biodiversity cost much greater than the on-farm benefit of organic practice,[33] therefore, organic farming should be encouraged in a wide range.

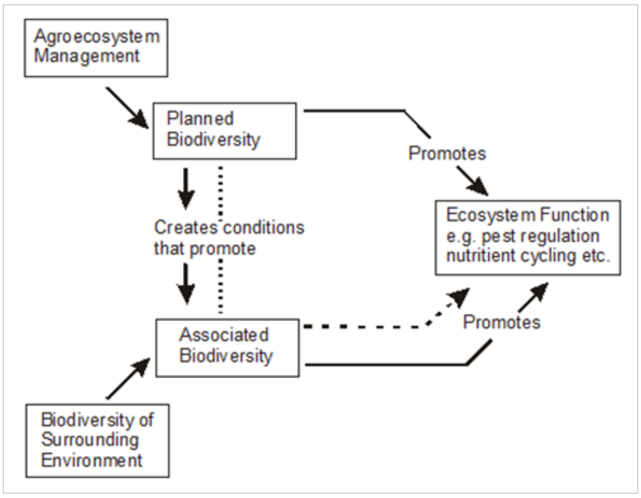

Figure 1.1 The relationship between planned and associated biodiversity and how the two promote ecosystem function.[24]

Landscape and biodiversity (Biodiversity at landscape level)

The close attention paid to agricultural landscapes in recent years is partly due to a growing appreciation of their remaining richness and diversity despite the immense scale of changes they have undergone in this century.[34] This interest is also related to the fact that production functions of the agricultural landscapes have been losing weight in favor of ecological and recreational functions in combination with regulation and information.[34,35] As a consequence, multiple-use of agricultural landscapes, ranging from aesthetic and recreational aspects to habitat conservation and biodiversity, has become a widespread aim in public policy making.

Landscape structure and its functions

Landscape is a heterogeneous area made of clusters of interacting ecosystem[36] The spatial layout between landscape elements together

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with the interactions and linkages between these determine the landscape structure and functions.[37] The landscape structure is the result of complicated interactions between climate, topography and human land use.[38] Human activities on the one side and their cessation on the other side can be regarded as the main driving forces of landscape change. The intensified land use is one of the main cause of global change and biodiversity loss because of the destruction and fragmentation of habitats leading to the decline of populations and species,[1] Landscape heterogeneity[39] and the presence of non-crop habitats[40] are key factors in determining the asset and the level of biodiversity in agricultural landscapes. In a heterogeneous landscape the number of habitats will most likely be higher than in simpler landscapes and this might, per se, affect species richness positively. A heterogeneous landscape also offers more sites with varying micro climatic conditions, and species might therefore have a higher probability of finding sites optimal for over wintering, oviposition or larval development. Farm management could also affect species richness in the agricultural landscape. Diversity losses in plant communities can limit plant recruitment and decrease plant productivity, which will pose transient effects on the ecosystem functioning. Organic farming can counteract the deterioration of the agricultural landscape seen under intensive agriculture.[40] Many scientific literature have been widely reported the positive effects of organic farming on biodiversity, therefore in general, organic farming promotes biodiversity, but variable results among studies suggest that farming system per se may not always be the major driver of the observed species responses.[29] In landscapes where non-crop habitats are small and fragmented, a prolonged response time is expected because there will be fewer source habitat patches of sufficient size and quality, dispersal barriers such as large arable fields hampering colonizations.[41]

Land usage data

The dramatic land use changes include the conversion of complex natural ecosystems to simplified managed ecosystems. Agriculture land use affects parts of terrestrial area, so its contribution to biodiversity is a critical for successful conservation in the future and a landscape perspective is needed to understand why agriculture land use has the well-known negative and less known positive effects on biodiversity and related ecosystem services.[5] Previous studies have demonstrated that increased management intensity of the agricultural fields is one of the main causes of the decline of local species richness[29] and the intensification of resource use including applications of more agrochemical (conventional agriculture) explains why the biodiversity of intensively used agroecosystems has been greatly reduced during the last decades, (Hole et al., 2005). As a consequence of those facts, taking into consideration the landscape context is a very important aspect to determine the speed with which species respond to altered farming practice. This is true in the negative acceptation, when unwise agriculture practices affect biodiversity in a negative way, as well as in positive way when we try to recover on farm biodiversity in the context of the agroecosystem. In fact, it was predicted that local species diversity would be enhanced under organic farming management but this has not always been widely observed and confirmed, probably because of the confounding effects of the surrounding landscape. From this point of view, further studies are needed to find out to which extent the landscape surrounding a farm or a field can affect biodiversity overcoming the effect due to the practices or to typology of management.

Importance of olive groves

The Mediterranean landscape is characterized by the presence of olive trees and olive groves. A large part of the olive production in the world is linked to the Mediterranean area (Figure 1.2) (Figure 1.3) because olive trees are part of the agricultural tradition and history of the area and even of the social environment of the populations living there; Oliviculture and the olive oil sector are the most important agricultural value chain for many European Countries like Spain, Italy, Greece, Portugal and France, and for Southern Mediterranean Countries like Tunisia, Lebanon, Morocco. In terms of surface grown with olive trees, this is an important sector and accordingly for production and market therefore it is of high economic significance and it is linked to many social aspects. In the Mediterranean area, Italy represents one of the main points of olive production. As such, it can be considered as an open laboratory producing the latest and most advanced technologies able to support, for itself and for the world, the development of olive-production techniques and practices. Olive production commenced in Italy in the VIII–VII century BC e thanks to the Phoenicians and, later, the Greeks. At the same time, olive production developed along the coastal and sub coastal areas of the Eastern Mediterranean Sea, including Southern European and Northern African countries, advancing later with the Romans to the Northern areas of Italy, Spain, France and the Balkans. Today, Italian olive production covers approximately 1.700,000 ha, 80percent of which are located in southern Italy, Apulia represents the most important region. Beside this, Italy ranks second in the world (after Spain) for production, with an average oil quantity (over the last four years) of 550,000 tons, mainly represented by extra-virgin and virgin olive oils. The Apulia region is the leader for olive yields, with about 250,000–300,000 tons of olive oil per year. In addition to their economic importance and to their undeniable cultural and landscape values, these habitats have a major environmental importance since they offer shelter to many plant and animal species, some of which are of considerable conservation interest. In fact, the presence of many types of plant communities,[42,43] make the existing agro-ecosystems suitable for hosting several species of amphibians, reptiles, mammals and especially of birds.[6,8] Considering the history of the spreading of olive trees throughout the Mediterranean countries, it can concluded that the olive agro-ecosystems are about 2.800years old[10] and, due to the high level of biodiversity they host, they can be a good field of application to investigate the aspects related to the interactions between the landscape characteristics, the agricultural practices and the biodiversity conservation.

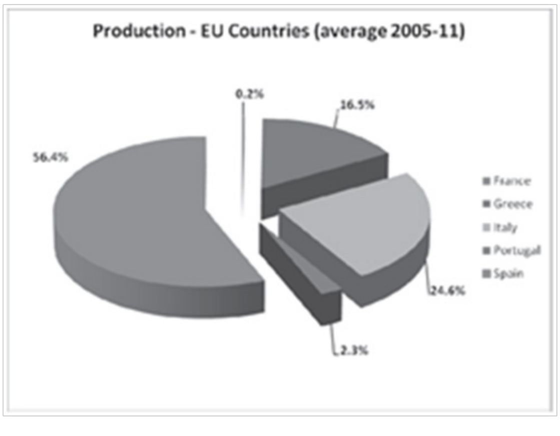

Figure 1.2 Extra-EU countries, Production (average 2005-2011).[7]

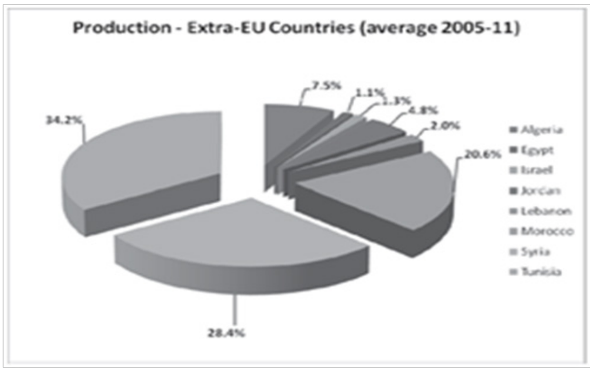

Figure 1.3 EU countries, Production (average 2005-2011).[7]

Materials and methods

In order to investigate the correlation existing between the biodiversity at field level in the Mediterranean olive groves, the agricultural practices performed to achieve a production and the landscape asset characterizing the agricultural systems around the following steps were performed:

a. Monitoring and assessment of the on-field biodiversity in organic and conventional olive groves;
b. Analysis of the agroecosystem diversity (cropping system diversity) by using GIS tools around the farm areas (by using a set of indicators);
c. Investigation of the correlations between the on-field biodiversity of flora, the agro-biodiversity at landscape level and the agricultural practices by applying statistical methods.

Site description

The study was established in 13 different olive groves in Apulia region; the olive orchards under survey are typical of the respective areas of cultivation, and follow different management practices that can be considered ordinary; the fields are located in four of the Apulia provinces: Foggia (1), Brindisi (9), Lecce (1) and Taranto (2). These different sites most likely correspond to different landscape typologies, flora communities and different agriculture practices (Table 2.1) (Table 2.2). Olive orchards and oliviculture can be very different all along the Apulia Region; in particular olive groves are differently managed in term of management of adversities, soil cover, and weed management. In Table 2.2 an overview is reported for the practices applied in the olive groves under survey in the course of the last 5years.

Soil and climatic conditions of olive orchards and areas under survey

The soil around Apulia region is different and they have different types and characteristics. On the base of data gathered in the course of ACLA project[44,45] we were able to report the characteristics of the soils in the fields under survey; these are here reported in the following table (Table 2.3):

Apulia region is characterized by Mediterranean Climate with mild humid winter and dry hot summer with average temperatures varying between 12 and 21°C. The different olive orchards fall in areas having different amount of rainfall and trends of temperature that can affect the overall development of plants and vegetation as well as the presence and absence of spontaneous species, influencing the structure of flora communities. Table 2.4 reports the climate stations more close to each of the olive grove under survey.

Following the climatic characteristics of the areas where the olive orchards are located, we identified the distinctive features of the fields in terms of rainfall, temperature trends and seasonal variations (see the graphs reported in) Table 2.5.

Data acquisition and analysis

In order to collect the data for our analysis, the work will be carried out at two levels, landscape level and field level.

Field level: Monitoring and assessment of the on-field biodiversity in organic and conventional olive groves

To monitor and assess on/field biodiversity we investigated the diversity of flora on conventional and organic Olive groves by using different indicators. In order to collect data we applied two different sampling methods[46] and monitored variations occurred in the flora communities in the fields under survey, i.e. in the cultivated part of the plots and in the ecological infrastructure present on them.

Therefore floristic surveys were done to collect data inside the fields and in Ecological infrastructures around the fields during October, November, December 2014 and March to end of April 2015 in order to cover the changes in the different flora communities existing inside the fields.

The level of flora diversity was expressed by using indices[46,47] Diversity indices provide information about the flora community composition and not simply about species richness (i.e., the number of species present or specific contribution) and relative abundances of different species. To be able to calculate biodiversity it's necessary to conduct an identification of flora species and to collect field data about their on-field presence and quantities by sampling in organic and conventional olive groves in the mentioned sites.

The list of species was built up step by step, according to several surveys made for floristic analysis and for an empirical evaluation of the degree of biodiversity, before and during each planned action and sampling.

Plant analysis was made in the field and in the ecological infrastructures. Three different approaches were used:

A. sampling was made in the field following the method of Raunkiaer,[48] as simplified by Vazzana and Raso,[49] i.e. using a metal frame of 0.25m and performing a number of launches that varied (from 6 to 10) depending on the uniformity of vegetation and the chance to detect new species;
B. sampling was made in the ecological infrastructure following the method of Braun-Blanquet;[46]
C. oriented and sighted sampling, based simply on the experience of the botanical observer, ignoring the A and B methodology. The data collected with the first two methods (A and B) will be used to calculate the Shannon-Weaver indices.[47]

Species were determined according to Pignatti[50] and Tutin et al.[51] Taxa nomenclature follows Conti et al.[52] and subsequent integrations.[53]

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The life-form and the chorology were named according to Raunkiear (1934). The biological and chorological spectra of each field and infrastructure of the all olive groves were carried out and compared with the data collected in the 2014-2015 period.

Taxa are listed in alphabetical order and grouped into families according to Pignatti.[50] For species of conservation interest, different acronyms for indicating their vulnerability were used, i.e. CR: critically endangered; EN: endangered; VU: vulnerable; LR: lower risk; NT: near threatened; I: endemic; Ad: amphiadriatic, PI: phytogeographic interest; B: International Convention of Berne, 1979; CI: Convention on International Trade in Endangered Species;[54] DH: Habitat Directive 92/43 EEC; r: rare; (*) common to all selected and explored olive groves.

Geographic position (U.T.M. – WGS84), site name, distribution data, motivation of conservation interest, general information on plant communities, and the relationships with the habitat of Directive 92/43 EEC[55,56] are provided only for taxa of conservation interest. The syntaxonomic scheme of plant communities follows the hierarchical scheme for Spain and Portugal,[57] and in some cases the work of Brullo et al. (2001).

Details about the methodology followed to perform the field surveys and the monitoring of flora and vegetation, the sampling of the floristic component in the cultivated plots and ecological infrastructures in the olive groves and the calculation of the indexes can be found in the Annex 1 to the present document.

Landscape level: Analysis of the agroecosystem diversity

In order to investigate the correlation existing between the biodiversity at field level in the Mediterranean olive groves and the landscape asset characterizing the agricultural systems around them. The analysis of the agroecosystem, and of the cropping system diversity, was performed. The intention was to analyze chosen area in an integrated way to test the ability of the territories surrounding the olive groves under survey in enhance and/or protect biodiversity. This was achieved through the analysis of the landscape heterogeneity, by achieving a targeted quantification of overall diversity applying a chosen set of indicators. Analysis of the agroecosystem diversity (cropping system diversity) by using GIS tools around the field areas (by using a set of indicators).

The ecology of landscape was greatly motivated by the new perspective offered by aerial photography, in fact with this tool, a landscape can be described and studied as a patchwork of separate cards (habitats or ecotopes), each with an area of transition (ecotone) that is adjacent.

Actually in our case the work of photo interpretation was already performed and, in order to achieve and collet information about the land use existing in the territories of reference we can rely on "official" data from official cartography, and after, to increase the accuracy of our data, we can perform an on-field "validation" in the course of field visits.

The first step of our work of analysis and interpretation of the territories under survey was defining the area (actually the areas) of reference on which to perform the analysis. Usually this area is called "ecoregion" and it's a geographically or ecologically distinct territorial unit to be used as a unit of analysis. In order to describe and characterize the landscapes around the olive groves, GIS tools were used ARC GIS 10.2.[58]

To identify the areas on which to perform the analysis of diversity, a circle of 10km of radium was drawn around each field (buffer zone). Then these round areas (one for each field) having comparable surfaces, were clipped on the official cartography (SIT, 2014) reporting the land use according to CORINE Land Cover.[59,60]

The performed analysis includes the following steps:

i. Analysis and interpretation of landscape by using ARCGIS;
ii. Analysis of data coming from official cartography;
iii. Ground check and field control;
iv. Data validation and map editing;
v. Data Export in a database;
vi. Calculation of indicators.

To complete the analysis a stage for validation of data from cartography and photo interpretation is also provided to be implemented through checks and open field surveys. The phase of validation in the field has been completed by surveys in the territory.

Analysis and interpretation of landscape by using Arc GIS

To evaluate the diversity at landscape level, the databases corresponding to the different areas of landscape around the fields were extracted. The spatial databases of the cover classes were acquired: urban areas or fabrics; rivers, water bodies, wetlands channels; herbaceous crops; permanent crops; as well as different types of ecological infrastructures existing on the territories (areas covered with spontaneous plants, hedgerows, small trees, forests, woods).

The datasets were then grouped in the following macrocatecories including all the cover classes reported for the landscape (Table 2.6):

After this first classification the analysis was performed in order to allow the comparison of results coming from the applications of indicators that are influenced by the dimension of the sampling area.

Calculation of indicators of diversity at landscape level

One of the aims of our work is to describe the link between landscape diversity and on-field biodiversity. Following literature about the topic and on the base of the aim and specific objectives of the investigation, fifteen different indicators were chosen and classed according the characteristics of the landscape we were interested to highlight.

The indicators are designed and suggested to assess the structure of landscape and the relationship with the ecological and agro-ecological functions.

This approach suggests the following categorization of indicators of landscape diversity:

a. Indicators of compositions;
b. Indicators of fragmentations;
c. Indicators of connection.

The indicators are shown in the table below:

The Indicators are numbered with subsequent progression: 1 to 3 for category of compositions, from 4 to 10 for category fragmentation; 11

to 14 for connection category. In this series of numerical information must accompany a no less important graphic illustration of the chosen areas in terms of placement of Ecotope space, linear structures and other features. The use of maps produced in the investigation greatly facilitates the work in following the design phase and in further Territorial Planning. Some of the following indicators explicitly refer to the agricultural areas so to be able to read the situation as related to the crops and to link the landscape analysis with specific crops impacts. Details about the algorithms followed to perform the analysis of the agro ecosystem diversity and calculation of the chosen indicators can be found in the Annex 2 to the present document.

Multivariate analysis

In the univariate analysis of variance a comparison is made between two or more than two means, and just a single outcome variable is involved. The statistical method used to make the comparison is called ANOVA. The Multivariate Analysis is a set of techniques dedicated to the analysis of data sets with more than one variable and it helps in determining the differences between either two or more than two dependent variables. Methods of multivariate analysis of variance assist in determining differences simultaneously and several of these techniques were developed recently because they require the computational capabilities of modern computers, at least in part.[61]

In the case of my research work the In this research the multivariate analysis was used to decompose and analyze the biodiversity of the Mediterranean olive groves at field level and quantifying the influence of the, different agricultural practices and of the landscape asset that characterize the different agricultural systems. The Canoco software was applied. In order to achieve our objectives, we applied the so called ordination approach with the indirect gradient analysis and the Principal Component Analysis. To investigate the on-field biodiversity in organic and conventional olive groves the data reporting the indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014=1 and Spring 2015 2) were analysed using PCA. Data were considered compositional data, with the indexes of biodiversity considered as environmental variables.

In a second moment, in order to analyze the correlation existing between the biodiversity at field level and the agricultural practices to the 13 olive groves (field id), and to the 10 environmental variables (indexes of biodiversity) some supplementary variables were added (Analysis 'Unconstrained-suppl-vars').

To analyze the correlation existing between the on-field biodiversity and the landscape asset characterizing the agricultural systems around the olive groves under survey, the 13 eco regions indentified by the corresponding field ids were analyzed with 15 Indicators of Landscape Diversity as environmental variables.

Then a more detailed analysis were carried on analyzing the following:

I. The on-field biodiversity and the indicators of landscape composition (13 ecoregions (field id) and 23 Indicators of landscape composition);

II. The on-field biodiversity and the indicators of landscape fragmentation (13 ecoregions (field id) and 25 Indicators of landscape fragmentation);

III. The on-field biodiversity and the indicators of landscape connection (13 ecoregions (field id) and 23 Indicators of landscape connection).

The European Programme CORINE was launched by the Council of the European Communities in 1985, with the primary purpose of verifying the state of the environment in the Community area, in order to dynamically guide the common policies, monitoring their effects and propose possible remedies. Inside the CORINE program, the project-Corine Land Cover is specifically intended for the detection and monitoring, at a scale compatible with community needs, the characteristics of the territory, with particular attention to the needs of protection.

Results and discussion

Results

In order to investigate the correlation existing between the biodiversity at field level in the Mediterranean olive groves, the agricultural practices performed to achieve a production and the landscape asset characterizing the agricultural systems around fields under survey; the following steps were performed:

a. Monitoring and assessment of the on-field biodiversity in organic and conventional olive groves;

b. Analysis of the agroecosystem diversity (cropping system diversity) by using GIS tools around the farm areas (by using a set of indicators);

c. Investigation of the correlations between the on-field biodiversity of flora, the agro-biodiversity at landscape level and the agricultural practices by applying statistical methods.

Field level: **Monitoring and assessment of the on-field biodiversity in organic and conventional olive groves:** The Monitoring and assessment of the on-field biodiversity in organic and conventional olive groves were carried on. The floristic surveys allowed to collect data inside the fields (in cultivated part) and in Ecological infrastructures around the fields in two different sampling periods; the first going from October to December 2014 and the second from March to April 2015 in order to cover the changes in the different flora communities existing inside the fields. The list of species was built up step by step, according to several surveys made for floristic analysis and for an empirical evaluation of the degree of biodiversity, before and during each planned action and sampling. Only in the period going from autumn 2014 to spring 2015, 252 different species were recorded in the olive groves under survey.

The list of species recorded during the whole sampling period in the olive groves under survey is reported in Table an.3.1 of the Annex 3; a synthesis of the number of species present in the different sites, in the cultivated part of the fields (field) and in the ecological focus areas (ecological infrastructures) is here reported (Table 3.1):

The total number of species recorded from Autumn 2014 to Spring 2015 is 252 (Table 3.1), they belong to 61 different families; the more represented families are Asteraceae. Fabaceae and Poaceae. followed by Brassicaceae. Apiaceae and many others. The chorology of the species characterizing the olive groves underline the prevailing of the mediterranean component of the plant species (Table an.3.2 in Annex 3). The different sites under survey host different species because of different climatic conditions and of different agricultural practices (Table 3.1). Although the higher number of different species was recorded in field 1 (Vico del Gargano). Six out of eight of the organic fields under survey show a higher number of species (fields 12, 2, 11, 8, 7 and 9) in respect to the conventional ones; four of them (fields 11, 12, 2 and 9) also show a higher number of species in the cultivated part of the field and this is an important aspect because means the the agricultural practices performed by the farmers do not impact much on the flora component. Another aspect to be considered is that organic olive groves present a higher number of species (from 24 to 16) found either in fields and in the ecological infrastructures. Only one conventional field (field 13) presents 15 species in common and scores fifth in the range.

The flora communities of the fields and of the corresponding ecological infrastructures can differ; the ecological infrastructures can host species very different from the ones reported on the field, only a part of the species is able to bear the disturbance occurring in the cultivated part of the field, consequently, to compare the species of the two flora communities (the one related to the cultivated part of the field and the one living in the corresponding ecological focus areas) can give few indications, but the analysis of the distribution of the life-form can provide further information on the effect of the agricultural practices on the flora.

The life-form spectra of the fields and of the infrastructures of the all olive groves were carried out (Figure 3.1) (Figure 3.2). Data for every site of survey were reported for each field (cultivated part) and for each corresponding ecological infrastructure (ecological focus area).

In the following figures the spectra of flora communities in the cultivated part of the fields (Figure 3.1) and in the ecological infrastructures (Figure 3.2) are reported:

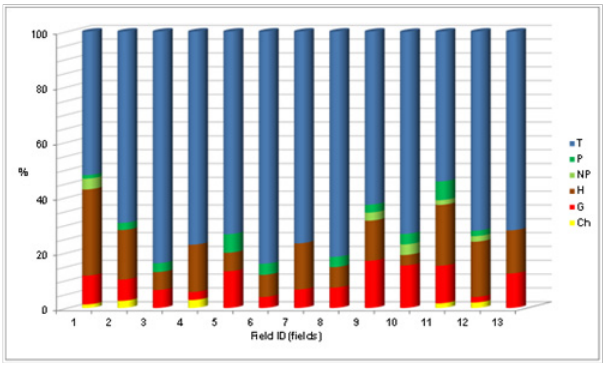

Figure 3.1 Life-form spectra of flora communities in the cultivated part of the fields. T–therophytes; P-phanerophytes; NP-nanophanerophytes; H-hemicryptophytes; G-geophytes; Ch–chamaephytes.

Results of the analysis of the life-forms report that the main one for the fields is therophytes with a precentage going from 84.0% (field 6) to 51.9% (field 1); the second most abundant life-form is that of hemicryptophytes going from 31.2% (field 1) to 3.8% (field 10). Also geophytes have an important role in the structure of the flora with a presence going from 17.1% (field 9) to 2.0% (field 12); phanerophytes are a minor presence going from 6.8 (field 11) to 0.0% (fields 4,7 and 10); finally nanophanerophytes and chamaephytes are the less rappresented life-forms, respectively going from 3.9% (field 1) to 0.0 (fields 2, 3, 4, 5, 6, 7, 8 and 13), and from 2.9% (field 4) to 0.0% (fields 3, 5, 6, 7, 8, 9, 10 and 13).

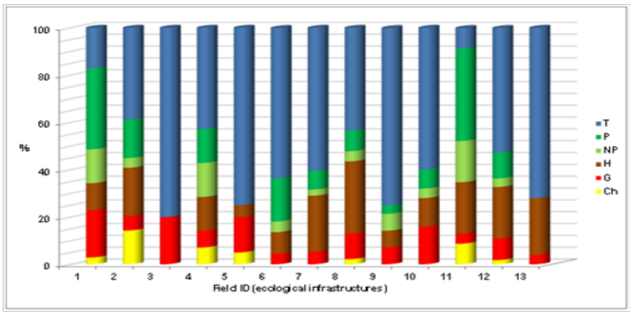

Figure 3.2 Life-form spectra of flora communities in the ecological infrastructures. T –therophytes; P-phanerophytes; NP-nanophanerophytes; H-hemicryptophytes; G-geophytes; Ch – chamaephytes.

In the ecological infrastructures the main life-form is therophytes going from 80.0% (field 3) to 8.7% (field 11); the hemicryptophytes and phanerophytes are represented respectively from 30.4% (field 8) to 0.0% (field 3), and from 39.1% (field 11) to 0,0% (field 13); geophytes are reported from 20.0% (fields 1,3) to 4.0% (field 13); nanophanerophytes are present in a percentage varying from 17.4 (field 11) to 0.0 (fields 3, 5 and 13); chamaephytes are reported with values going from 14.3% (field 2) to 0.0% (fields 3, 6, 7, 9, 10 and 13).

Also these results are partially in line with what was reported in previous papers; in fact looking at these data we observe a decrease of hemicryptophytes (-11.4%), an increase of therophytes (+9.1%) and also an increase in the other life-forms nanophanerophytes (+2.4%), phanerophytes (+2.1), together with the variation in the presence of geophytes (-0.35%) and chamaephytes (-1.9%). The different sites under survey, host species of different conservation interest; the presence of the species of conservation interest (in percentage on the total number of species) is reported in the Table 3.2. The level of flora diversity was expressed by using indices[46,47] and results are here reported in Table 3.3.

Landscape level: analysis of the agroecosystem diversity

The study was carried on in 13 different olive groves in Apulia region; The olive orchards under survey are typical of the respective areas of cultivation, and follow different management practices that can be considered ordinary (Table 2.2); the fields are located in four of the Apulia provinces: Foggia (1), Brindisi (9), Lecce (1) and Taranto (2). These different sites most likely correspond to different landscape typologies, flora communities and different agriculture practices (Table 1) (Table 2).

In order to investigate the correlation existing between the biodiversity at field level in the Mediterranean olive groves and the landscape asset characterizing the agricultural systems around the fields under survey, the analysis of the agro ecosystem, and of the cropping system diversity, was performed. The cropping systems around the olive orchards (10km radium) were analyzed, land cover use categories were extracted and the cover classes (SIT, 2014) reporting the land use according to CORINE Land Cover[60,61] were grouped in order to calculate the indicators of landscape diversity. The aggregated data coming from the export of the data base from GIS that describe and characterize the ecoregions (or landscapes) under analysis are reported in the Table an.3.3 of the Annex 3 to the present document. These data, validated in the course of the GIS analysis, allowed to analyze the chosen areas in a detailed and integrated way.

On the base of such data, the indicators were calculated in order to measure the landscape heterogeneity and to test the ability of the territories surrounding the olive groves under survey in enhance and/or protect biodiversity. In the materials and methods part, 14 different typologies of indicators of landscape diversity are listed. Some of the indicators have a unique value (reported in table) others are also calculated for the different macro-categories identified in Table 2.6 of the Material and methods part. In total 93 different indicators of landscape diversity were obtained from the analysis; they are reported in the tables from 3.4 to 3.6 as indicators of landscape composition, indicators of landscape fragmentation and indicators of landscape connection, as we mentioned in the material and methods part.

Multivariate analysis

Multivariate analysis was used to decompose and analyse the biodiversity of the Mediterranean olive groves at field level and also the diversity of the landscape around them (expressed by indicators of landscape diversity). The quantification of the influence of the different agricultural practices and of the landscape asset that characterize the different agricultural systems was also perfomed. The Canoco software was applied to analyze the following questions:

a. On-field biodiversity in organic and conventional olive groves

b. The correlation existing between the biodiversity at field level in the Mediterranean olive groves and the agricultural practices ordinarily performed to achieve a production

c. Correlation existing between the on-field biodiversity and the landscape asset characterizing the agricultural systems around the olive groves under survey.

On-field biodiversity in organic and conventional olive groves

In order to analyse this special issue. the data reporting the indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014=1 and Spring 2015=2) (Table 3.3) were analysed using PCA.

Data were considered compositional data. Results of this first analysis are here illustrated in Figure 3.3.

From these first analysis of the biodiversity indexes we can observe that:

The values of the indexes coming from the survey in spring are higher that the values of the indexes coming from surveys in autumn (H-2, Nsp-2, IR -2, E-2).

They are all very close and their arrow heads go in the same direction. This indicate a good quality of biodiversity related to the cultivated part of the fields.

The values of the indexes corresponding to survey performed in Autumn fall in the part of the graph below the axis 2 and go in different directions. showing that the quality of the flora communities in the different fields vary. These differences in the behaviour of the Shannon indexes (H, IR and E) and Nsp can be due to differences on plant species composition of the different orchards because of the different climate conditions and/or to the impact of the agricultural practices.

These hypotetic differences do not affect flora in spring. The ecological infrastructure is described by BB index, a score expressing the naturalness of these ecological focus areas. A special attention deserve the values of BB that are referred to these ecological infrastructures and to the ecotones present in the fields, because have a special value in terms of biodiversity conservation (storage capacity) and include different ecological characteristics belonging to surrounding patches and land covers. It worth to note that their values (BB-1 and BB-2) do not vary much for autumn and spring surveys. This is probably because these focus areas are less affected by cultivation techniques and management options in comparison to the cultivated part of the fields. Both the values (BB-1 and BB-2) fit in the second part of the graph, very far from the groups of the Shannon Indexes (H'-1, H-2, IR-1, IR-2, E-1 and E-2) and from the Number of species (Nsp-1 and Nsp-2). This means that their values are somehow independent from what happen in the fields. The value of the ecological focus areas does not vary much according the season and the period of sampling, appearing more stable.

The different fields are disposed in the graph following the individual values they score for each of the indexes. The fields belonging to the central part of the region clusterize more close to the indexes related to the Autumn surveys.

From the graph it can be seen that some management options related to weed management (herbicide= herbicide use) to soil management (bare= keeping soil bare in winter) and to pest management (chem inp= use of chemical input) are in a part of the graph where no arrow is present.

The Conventional Management option (Conv) fits quite far from the all the arrows of the indexes of biodiversity; this is true either for Indexes of Shannon (H'-1, H'2, IR-1, IR-2, E-1, E-2) and for Nsp (1 and 2) and it is verified also for BB-1 and BB-2 that relate to the ecological infrastructures.

The indexes of Shannon related to the spring sampling are lowly impacted by agriculture management options. This is probably because in winter almost no pest or weed management options are applied and the species that are going to be present in Spring are not disturbed by any practice; some slightly positive influence seems to have the shredding and the "no weed management" option (no w mn), the use of organic input for pest management, as well as leaving the soil covered and the organic agriculture management (Org).

It is observed a positive impact of some of the management options on the indexes of Shannon related to the Autumn surveys; in particular, in terms of weed management option, the shredding seems to be the best for IR-1 and Nsp-1 as well as the soil management option that keeps the soil covered in winter (covered); on the other hand the ploughing increase the diversity of the flora communities (Shannon Index H'-1) and its Evenness (or Equitability) (E-1); the lack of any kind pest management (no adv m) is correlated to these indexes as well.

A special attention is due to the correlation between the BB-1 and BB-2 with the option of pest management based on the application of preventive agronomical practices (pruning, burning of part of plants affected by pests or diseases, soil surface cultivation to avoid water stagnation and/or run-off and soil erosion, …); these practices seem to have a positive effect on the ecological Infrastructures and on their environmental value.

Correlation existing between the on-field biodiversity and the landscape asset characterizing the agricultural systems around the olive groves under survey

In order to to describe the link between landscape diversity and on-field biodiversity, the analysis of the diversity of landscape expressed by the fourteenth different typologies indicators was performed. In order to verify if a correlation exists between the main landscape characteristics expressed as a whole and the on-field biodiversity a first step of the analysis was performed including:

i. The averages of the values of Shannon Diversity Index (H');
ii. The Number of Species (Nsp);
iii. Braun Blanquet (BB) scores;
iv. The indicators of landscape diversity that do not require to be calculated for each of the macro-categories and reported in the following table (Table 3.7).
v. Indicators of Roads and Water Body Length were included also.

The indicators are designed and suggested to assess the structure of landscape and its relationships with the ecological and agro-ecological functions.

Looking at the graph in Figure 3.5 we can see that the Shannon Index of Diversity (H' avg) is correlated to two indicators: one is the Water Body Density (WBD) and the other is the Water Body Length (WBL).

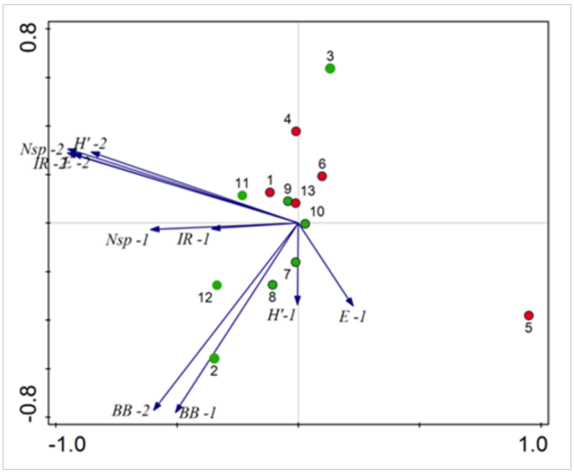

Figure 3.3 Analysis of data reporting the indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014=1 and Spring 2015=2).

H'-1, shannon index autumn 2014; H'-2, shannon index spring 2015; Nsp-1, Number of species autumn 2014; Nsp-2, number of species spring 2015; E-1, evenness index (Equitability i.) Autumn 2014; E-2, evenness index (Equitability i.) Spring 2015; IR-1; index of richness autumn 2014; IR-2, index of richness spring 2015; BB-1, braun blanquet autumn 2014; bb – 2, braun blanquet spring 2015; numbers in the graph correspond to the fields IDs; Organic fields are reported in green; Conventional fields in red.

WBD is an indicator of connection that mainly indicates the function of water bodies to facilitate the flow of biodiversity across the landscape; the second indicator describes part of the structure of the landscape and is related to area of landscape covered by water and somehow to the amount of water present. In Apulia many ephemeral streams and water bodies are present and are included in this land cover category. Therefore the closeness of this two indicators can be related also to the effect of water bodies to influence microclimate and facilitate a higher flora diversity on-field.

The total Number of Species (Ntot) is also correlated with the previous indicators, but it is correlated to the Land Use Sustainability (LUS) that reports the ratio between the area of ecosystems bearing the lower impact of human activity (vegetated areas with unmanaged soil) and the cultivated areas. meaning the the amount of biodiversity depend from the presence of areas that are not disturbed by antropic activities. The next indicator Sustainability of the Ecotone System (SES), confirms this interpretation adding the value of the presence of a good connection on the landscape.

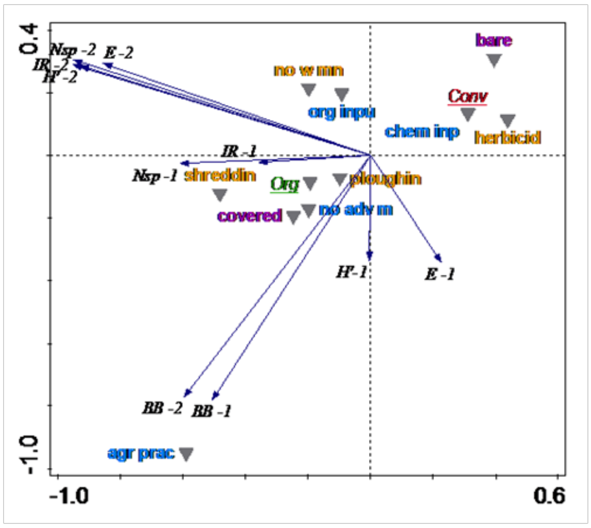

Figure 3.4 Analysis of data reporting the indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014 = 1 and Spring 2015 = 2) including the options of management for soil, weeds and pest management, applied in the fields under survey.

H'-1, shannon index autumn 2014; H'-2, shannon index spring 2015; Nsp-1, number of species Autumn 2014; Nsp-2, number of species spring 2015; E-1, evenness index (Equitability i.) Autumn 2014; E-2, evenness index (Equitability i.) spring 2015; IR-1, index of richness autumn 2014; IR-2, index of richness spring 2015; BB-1, braun blanquet autumn 2014; BB – 2, braun blanquet spring 2015, Numbers in the graph correspond to the fields IDs; Mangement Options are reported in Green italicus for Organic management; and red italicus for conventional management; Options of soil management applied in the fields under survey are reported in Purple; Options of weed management applied in the fields under survey are reported in Orange; Options of pest management applied in the fields under survey are reported in Blue.

The index of BB appear less correlated to the landscape indicators listed in this first analysis. although its position follow that of the other two. In order to have a better insight in the correlation between the on field biodiversity and the landscape indicators more detailed analysis have been performed.

The first of such analyse the correlation between the on-field biodiversity and the indicators of landscape composition. The analysis including the complete set indicators of composition correlate the Shannon Index of Diversity with the presence of water. In particular with the Indicator of Relative Richness Area of the Water (RAW). Very close to this the Index (Havg) is correlated to the class of natural herbaceous (EN) in particular with the indicator expressing the Relative Richness Number (RR) of patches having natural herbaceous vegetation. The Total Number of Species is also correlated to the RAW indicator but is also close to the indicator of Relative Richness Area (RA) of patches having natural herbaceous. The closer indicator after this is the Relative Richness Number (RR) associated crops (CA).

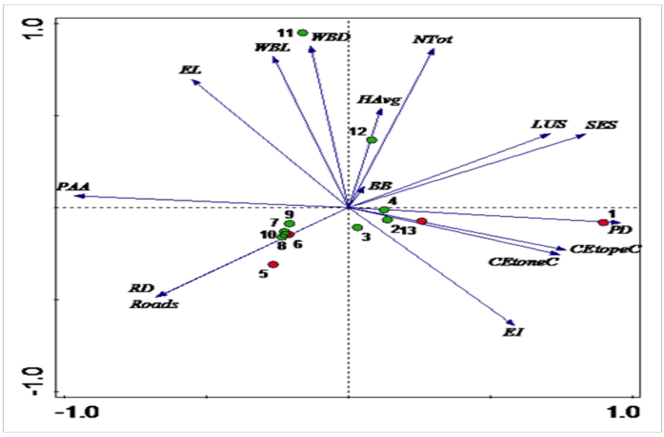

Figure 3.5 Analysis of data reporting the averages of indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014 =1 and Spring 2015=2). including the indicators of landscape diversity not requiring to be calculated for each of the macro-categories.

H' avg, shannon index averag; BB, total score; N tot, total number of species identified (in Autumn 2014 and Spring 2015); WBL, water bodies lenght; LUS, land use sustainability; PAA, patch average area; PD, Patch density; SUS, sustainability of the ecotone system; CEtopeC, agricultural ecotope composition; RD, Road density; CEtoneC, crop ecotone composition; WBD, water body density; EL, ecotone length; EI, ecotone Intensity. Numbers in the graph correspond to the fields IDs. Organic fields are reported in green; Conventional fields in red.

The indicator of BB appears not to be much correlated with the indicators of landscape composition. although a certain correlation is shown with Relative Richness Area of Herbaceous crops (RA CE) and RA of Salted Water (RA SW).

This last analysis show the relationships between H'avg and water in particular with Ecotone Intensity of salt water (EI SW)at the same distance from the H'avg we can find the presence of two indicators of of Ecotone lenght related to Water (EL W) and to Natural erbaceous (EL EN). The same element is recalled in close relationship with the Ntot althoug more important are EL W and EI SW. At the same distance there is a connection with EL of natural arboreous vegetation (EL AN) and EI of Associated Crops (EI CA). The BB index confirms its correlation with El in general and with WBD as in the first more general analysis; also close to BB is the EL of natural herbaceous vegetation (EL EN).

Discussion

The results reported in Table 1 about species and corresponding families, confirm the findings of previous papers and allow to add 25 "new" species to the list previously published for the olive groves of the Apulia Region, that reported 408 taxa. This is a contribution to achieve a better knowledge about the structure of the flora communities of the olive groves in Apulia. Because of many different climatic and pedologic conditions, different agricultural managements and practices applied, that altogether greatly influence the quality and the abundance of species, it is very difficult to achieve a whole census of flora community in olive groves of such region and this knowledge needs to be built step by step. The chorology of the species in the whole remains very typical of the mediterranean area (Table an.3.1 in Annex 3) in particular of the eastern mediterranean area.[7]

From data about the presence of species (Table 3.1), we can observe a better performance of the fields managed according organic agriculture; organic farms also show a higher number of species found in the cultivated part of the fields (Fields 11, 12, 2 and 9) compared with conventional ones (with the exception of field 1); this result appear to be in line with a lower impact of the agricultural practices and this result in line with a previous studies showing the positive effect organic agriculture has on flora and fauna in field level.[3,26,62] It can be important to note that olive groves managed according conventional agriculture, on the cultivated part of the field, host only few species that are also present in the corresponding ecological infrastructures; this mean that the flora communities and their structures are very different from the cultivated part and since they share the same climatic and soil conditions this is mostly due to the higher impact of agricultural practices performed. Organic fields present from 24 to 10 species in common between fields and their ecological focus areas; field 1 consitutes an exception to this "rule", being managed according conventional agriculture.

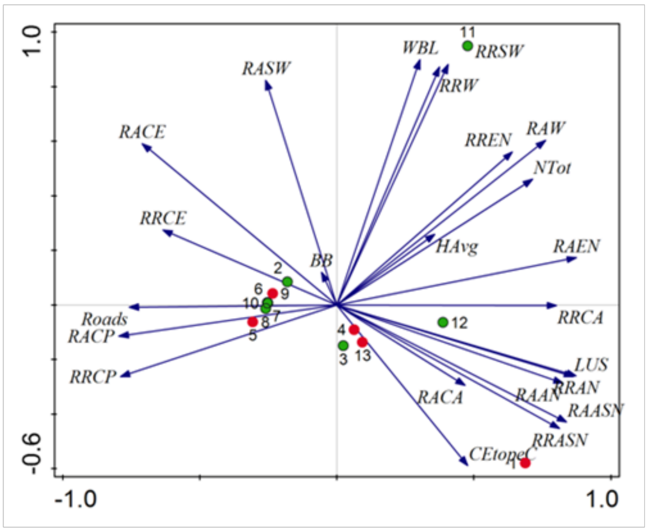

Figure 3.6 Analysis of data reporting the averages of indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014 = 1 and Spring 2015 =2) including the indicators of landscape composition calculated for the single macrocategories of land use.

H' avg, shannon index average; BB, braun blanquet total score; N tot, total number of species identified (in Autumn 2014 and Spring 2015; Roads, roads; WBL, water body lenght; LUS, land use sustainability; CEtopeC, agricultural ecotope composition; RR, relative richness number; RA, relative richness area. The indicators RR and RA are calulated for the following macrocategories, EN natural herbaceous vegetation; AN natural arboreous vegetation; ASN natural herbaceous and arboreous; W wetlands; SW salty wetlands; CP permanents crops; CE herbaceous crops; CA associated crops. Numbers in the graph correspond to the fields IDs; Organic fields are reported in green; Conventional fields in red.

In order to better investigate the flora communities of fields and of the related infrastructures, it is important to refer to the life-forms recorded in the course of the surveys (Table an.3.2 in Annex 3). The results of the analysis of the life-forms, are only in part in line with data reported in previous researches on olive groves.[7] These papers, for the cultivated part of the fields, report therophytes 59.2%, hemicryptophytes 24.5%, geophytes 8.2%, phanerophytes 5.2%, nanophanerophytes 1.7% and chamaephytes 1.2%. From the present survey we can observe an average increase in the presence of therophytes (+12.5%), a decrease of hemicryptophytes (-10.1%) and other differences in geophytes (+1%) and nanophanerophytes

(-0.60%). These differences can be due to the recording of new species that, being mostly therophytes, changed the final distribution of the life-form spectra. In the cultivated part of fields, 14 new species have been identified, 10 of them are therophytes and four of them are hemicryptophytes.

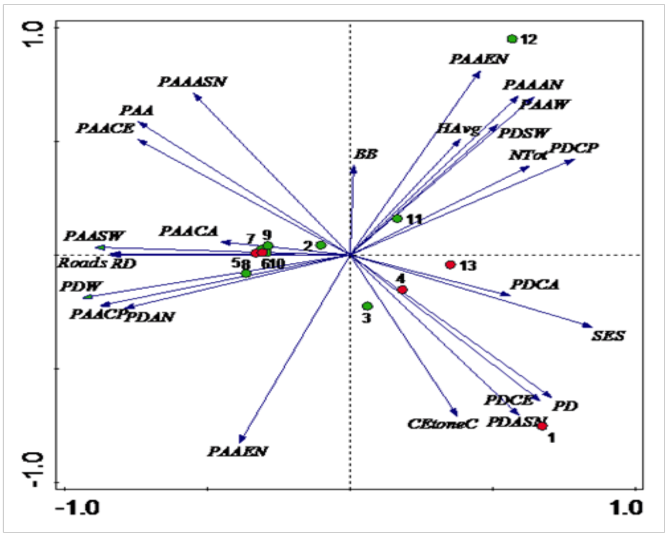

Figure 3.7 Analysis of data reporting the averages of indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014 = 1 and Spring 2015 = 2). including the indicators of landscape fragmentation including those calculated for the single macrocategories of land use.

H' avg, shannon index average; BB, braun blanquet total score; N tot, total number of species identified (in Autumn 2014 and Spring 2015); Roads, roads; PAA, patch average area; PD, patch density; SUS, sustainability of the Ecotope System; CEtoneC, Crop ecotone composition; RD, road density. The indicators PAA and PD are calulated for the following macrocategories, EN, natural herbaceous vegetation; AN, natural arboreous vegetation; ASN, associated natural herbaceous and arboreous; W, wetlands; SW, salty wetlands; CP, permanents crops; CE, herbaceous crops; CA, associated crops. Numbers in the graph correspond to the fields IDs; Organic fields are reported in green; Conventional fields in red.

In the case of the ecological focus areas the difference in the average values for the therophytes (Table an.3.2 in Annex 3) is less evident as it is compensated by an increase in other life-forms (phanerophytes and nanophanerophytes), a slight decrease in the geophytes is observed, probably as a re-arrangement of the values of the other life-forms, but an important decrease in the presence of hemicryptophytes is observed.

The life-form spectra reported in the graphs Figures 1 & 2 shows that in the cultivated part of the fields, balanced spectra (reporting all the life-forms) are present in fields 1 (conventional), 11 and 12 (organic); field 2 (organic) present a good balance although the nanophanerophytes are lacking; the fields 9 and 10 (both organic) lack the chamaephytes.

The life-forms for the ecological focus areas (Figure 2) of the olive groves under survey reported balanced spectra (reporting all the life-forms) for the fields 1 and 4 (conventional), 2, 8, 11 and 12 (organic); the ecological infrastructures of the olive groves 6, 7, 9 and 10 lack the chamaephytes; a bad condition is reported for the ecological infrastructure (field margins) of the olive grove 3, that hosts only therophytes (80%) and geophytes (20%).

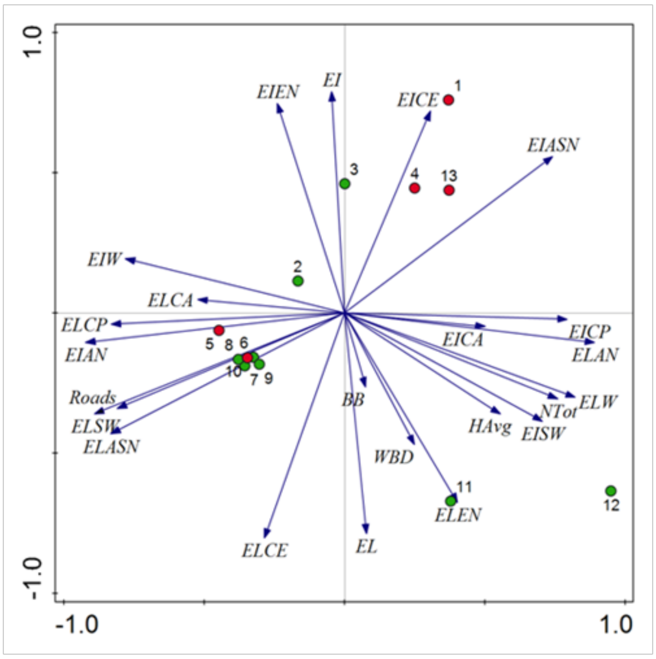

Figure 3.8 Analysis of data reporting the averages of indexes of biodiversity acquired in the course of the two sampling periods (Autumn 2014 = 1 and Spring 2015 = 2). including the indicators of landscape connection including those calculated for the single macrocategories of land use.

H' avg, shannon index average; BB, braun blanquet total score; N tot, total number of species identified (in Autumn 2014 and Spring 2015); Roads, roads; CEtoneC, crop ecotone Composition; WBD, water body density; EL, ecotone lengt; EI, ecotone intensity. The indicators EL and EI are calulated for the following

macrocategories, EN, natural herbaceous vegetation; AN, natural arboreous vegetation; ASN, associated natural herbaceous and arboreous vegetation; W, wetlands; SW, salt wetlands; CP, permanents crops; CE, herbaceous crops; CA, associated crops. Numbers in the graph correspond to the fields IDs. Organic fields are reported in green; Conventional fields in red.

At level of the ecological focus areas of the olive groves, 12 new species have been identified, three of them are therophytes, three hemicryptophytes, three phanerophytes, two chamaephytes and one geophyte. The indices express, in different measure, two main characteristics of biodiversity, their richness (how many species) and their abundance (how much of each species). Shannon index (H') synthesizes in a balanced way those two aspects, but then, in order to achieve information about the health of the flora communities, other indices are calculated: E express the ability of the species to contribute in an even way to the overall diversity (expressed by H'); IR says if the diversity of the flora is satisfactorily represented by a proper number of species. In order to have a balanced flora community the values of the indices have to be coherent.

Looking at the values of the indices of biodiversity for the cultivated part of the fields (H'-1: Shannon index autumn 2014; H'-2: Shannon index Spring 2015; Nsp-1: Number of species autumn 2014; Nsp-2: Number of species Spring 2015; E-1: Evenness index (Equitability i.) Autumn 2014; E-2: Evenness index (Equitability i.) Spring 2015; IR-1; Index of Richness Autumn 2014; IR-2: Index of Richness Spring 2015) we can observe a completely different behaviour of the indexes calculated on the data surveyed in Autumn and those coming form the surveys performed in spring.

Indexes expressing the diversity and the othe characteristics of the flora communities living in the olive groves in Spring are coherent, to high values of H'-2, correspond high values in terms of Nsp-2, IR-2 and E-2, meaning the the flora communities living in the olive groves in the period going from March to April are well balanced and consequently we can expect to have a good resilience.

Looking at the indices calculated on the base of the data collected in Autumn the situation is completely different because they are not coherent: the diversity does not correspond to a good level of evenness (equitability) showing that there are some species prevailing in the composition of diversity; moreover in some fields the diversity doesn't correspond to higher numer of species (Nsp-1) or to the IR-1. This effect on the flora communities of the different fields can be due to two main factors: a) the wheather conditions during the period of development of the flora or b) the impact of agricultural practices. Checking the values of the index of BB-1 related to the correspondent ecological infrastructures (and corresponding to the same days of survey) these are not affected by big variations; BB-1 and BB-2 are coherent, meaning that the flora of those areas is not affected by weather conditions. The other hypothesis is that un-coherence of the indices of biodiversity of flora present on the cultivated part of the fields, could be due to the impact of the agricultural practices, that being different for the different olive groves exert a different pression on the species and on the flora, leading to values of the indices that express un uneven distribution of diversity among the present species.

This is confirmed by the next step that we have followed in the development of multivariate analysis, where we included in the analysis and on the graph (Figure 3.4) the supplementary variables describing the management and the different management options applied by farmers to achieve a production. Figure 3.3 display that the values of the indices of biodiversity related to Spring survey are lowly impacted by the management options that are implemented in a period of the year when the species characterizing Spring communities are not present (if not as seeds).

All management options are correlated to some index of biodiversity related to autumn surveys.

As for the options of soil management (in purple), leaving the soil bare is negatively related to all the indices, and this can explain the low values of the indices and also the low quality of flora community that we can find in the field 3, that although is organic, applies ploughing to keep soil bare following the principle of dry land farming. Keeping the soil covered increase the possibility to achieve a good level of biodiversity. Weed management options are also important in the everyday farm management, we expected that the best options for biodiversity would be no weed management, but actually, the best management option seems to be the shredding (field 11 and 12) and as a second choice the ploughing, performed by most of the organic farmers and also in field 1. The shredding of flora covering the soil allows a better structure of the community as it is clear from the life-form spectra of fields 11 and 12, and by the presence of species having a high conservation interest (Table 3) because endangered (EN) (field 11 on field) or vulnerable (VU) (field 11 in the ecological infrastructure) and cited in the CITES (CITES, 1973) (Cl) or declared rare (r) for Apulia (on field).

Species of conservation interest are also present in other fields that do not perform weed management (field 1) or apply ploughing as weed management option: some species of amphiadriatic (Ad) and of phytogeografic interest (Pi) are present in the ecological infrastructures of field 2 and in the cultivated part of field 10 (Pi).

Another important management option related to the indices of flora diversity is the application (or the no–application) of input to manage pests and diseases (adversities); the best solution for biodiversity is not to apply them (no adv m); it worth to not that the option foreseeing the on farm implementation of preventive agronomical practices (pruning of part of plants attacked by pest or disease, soil cultivation to prevent water lodging, …) is strongly correlated to the values of both the indexes of Braun Blanquet (BB-1 and BB-2) and therefore with the value of ecological infrastructure in terms of environmental capital. This is highly important because of the dynamic properties related to these ecological focus areas in terms of functional biodiversity, i.e. in direct support to the production as well as for decreasing the environmental impact of agriculture on environment.

The comparisons of the life-form spectra of the flora on-field and of the flora present in the correspondent ecological infrastructures confirm this interpretation (Figure 3.1) (Figure 3.2). In general having all life-form represented in the flora community of an area is the sign of a complex agro-ecosystem, able to deliver ecosystem services and to be responsive to disturb actions. In the case of the fields under survey, we can appreciate very good situations in which all the life-forms are present either in the cultivated part of the fields either in the ecological infrastructures (field 1, 2, 11 and 12). In all these cases the soil is cultivated once every two years (field 1) or just once a year (field 2 and 12) and weed management is performed by shredding (fields 11 and 12). In other cases the life-form spectra of fields (fields 5 and 8) and the ones of the ecological infrastructures are balanced, but the life-form spectrum of the cultivated part of the olive grove lack of chamaephytes. In all the fields' therophytes are the most represented category.

Therophytes are mainly annual plants which survive the unfavorable season in the form of seeds and complete their life-cycle during favorable season, in the climatic conditions of Apulia, this means that they germinate mainly in winter or early spring, and close their cycle in late spring. Therefore this probably means that the impact of agricultural practices performed in the olive groves from late spring to late autumn do not affect much the presence of these species. Hemicryptophytes that are plants with buds at the level or near the soil surface, (e.g. daisy, dandelion) and are mainly perennial (or biennal), therefore their development and seeds production can be interrupted or disturbed by cultivation and by agricultural practice in general. Geophytes are also in general very sensitive to soil disturbance, therefore bulbs are less present in areas where the soil cultivation is often practiced; in our climate they germinate in early autumn or late winter and flower in late autumn or spring, therefore their presence and number is depending from the performing of soil cultivation in the period of vegetation and flowering; this is mainly true but there are some exceptions like the case of Oxalis pes-caprae, that spreads mainly by vegetative propagules and is usually very much present in olive groves where the cultivation is performed by disc-ploughing that help spreading the bulbils all over the surface of the olive orchards. Chamaephytes are characterized by woody plants with perennial buds borne close to the ground at no more than 25cm above the soil surface. (e.g. thyme and periwinkle); they need no-disturbance of soil, they are perennials and only grow when the ecological focus areas reach a certain stability. Their presence depend by no-use of chemical input and by the absence of soil cultivation, therefore they are present on the cultivated part of the fields only in case they are already well represented and established in the field margins or in the other ecological focus areas inside the olive groves, due to the continuous trades existing among those parts of the olive grove.

Since from the first analysis including a first group of indicators of the landscape diversity (Figure 3.5) appeared a strong correlation of the flora biodiversity with the element of the landscape related to the presence of water, as the Water Body Length (WBL) and the Water Body Density (WBD). Going more in detail and analyzing the composition of the landscape and the correlation between the H avg and the presence of water also the Indicator of Relative Richness Area of the Water (RA W) is important for a high diversity of the olive groves (Figure 3.6) and in terms of fragmentation very important elements for the values of H' are the Patch Density of Salt Water (PD SW) and the Patch Average Area of Water (PAA W) (Figure 3.7). Water is a limiting factor for the growth and the development of species in all Apulia Region, because of the mediterraean climate and also because of the hydrological system characterizing the region. The diversity of flora species increase in dependence of the presence of water (WBL). In Apulia many ephemeral streams and water bodies are present and are included in this land cover category, these ephemeral body of water creates more favourable conditions in terms of temperature and of humidity. The presence of water buffers the steep variations that may occur in some period of spring, autumn or early winter and acts also increasing the humidity of air and allowing a better development of flora and of vegetation. Therefore, in general the closeness of those indicators relate to the classes of water (including salt water) is related to the effect of water bodies to influence microclimate and facilitate a higher flora diversity on-field.

Water streams are also important because connect different elements of the land cover and are important for animals; this dynamic function of facilitating the flow of biodiversity across the landscape, is very important in increasing, maintaining and also re-colonizing the flora diversity in our olive groves, this is the meaning of the high correlation between H avg and the WBD or also with the Ecotone Intensity of Salt Water (EI SW) as well the presence of the indicators of Ecotone Lenght related to Water (EL W). Another important element of the landscape to be considered is the degree of fragmentation. This expresses the degree of diversification of the landscape or, if very high, can be an element hampering biodiversity. In our case H'avg appear to be very correlated to some indicators, but the most important correlation is with the Patch Average Area of Natural Arboreous vegetation (PAA AN).

The total Number of Species (Ntot) is also correlated with the previous indicators dealing with the presence of water bodies in the landscape around the olive groves under survey, but, in terms of landscape composition it is correlated also to the Land Use Sustainability (LUS) that reports the ratio between the area of ecosystems bearing the lower impact of human activity (vegetated areas with unmanaged soil) and the cultivated areas. This indicator shows the importance of having a diversified land cover that includes areas (protected or not) having different typology of cover where biodiversity (flora and fauna) can find shelter and thrive. This is very important most of all if considered in relation to the presence of a good system of ecotones; the number of species present in the olive groves depend also by the trades between the ecological infrastructures that are present around the fields and that characterize the agroecosystems and this can be only granted by the level of connection existing with other typology of land cover. The indicator Sustainability of the Ecotone System (SES), measure the dynamic functions of the ecotones present in the areas of interest.

The Total Number of Species is correlated to the RA W indicator but is also close to the indicator of relative Richness Number of natural Herbaceous (RR EN) and Relative Richness Area of patches having Natural Herbaceous Vegeatiton (RA EN). The closer indicator after this is the Relative Richness Number of Associated Crops (RR CA). In the fields and in the infrastructure of the olive grove many species typical of species hosted in herbaceous natural vegetation (EN class of cover) and in the associated crops (CA class of cover), therefore in order to have a higher number of flora species it is important a certain degree of diversity of the landscape that should include patches, of the right dimension (for one to five hectares) of different land covers.

To have a high performance the N tot also need a certain degree of fragmentation of the Patch Density of Permanent Crops (PD CP). A good connection in terms of EL W and EI SW is important as well as with EL of natural arboreous vegetation (EL AN) and EI of Associated Crops (EI CA). Regarding the index of BB, it appears to be less correlated (length of the arrows in the different graphs) to the landscape indicators than it is with the "good" agricultural practices.

In general its position in the graphs follows those of H'avg and of Nsp, but BB appears not to be much correlated with the indicators of landscape composition, although a certain correlation is shown with Relative Richness Area of Herbaceous crops (RA CE) and RA of Salted Water (RA SW). A certain degree of correlation is shown with some indicators of connection sas WBD, El (in general) and EL EN in particular.

Conclusion and recommendations

Intensive agriculture and intensive land use are all connected with the global biodiversity loss and also management practices are contributing in huge way to conserve or destroy biodiversity.

From the results of our research, it is clear that the conventional management options are only negatively correlated with biodiversity in olive groves, because the ordinary and intensive practices applied in such management system do not help in achieving balanced, stable flora communities. On the other hand the efficacy of organic agriculture in protecting and enhancing biodiversity and the environment is confirmed once again, although the final effect is strongly depended from the management options applied. Many practices, though they are allowed and applied in organic agriculture, actually are not much effective in achieving a better resilience of the systems. In general a low number of tillages and the shredding are the key to achieve a better status of on field biodiversity. From our landscape analysis in general it can be said that a good level of biodiversity on fields requires a diversified landscape. The level of diversification depend on the quality, quantity and dimension of the patches. For higher level of flora diversity in our climate, a very important element is the presence of water, not only in terms of surface covered but also in terms of connection that is important to allow the trades of the species. The number of different species is more related to the stock and combination of different land cover typologies where a variety of different species can thrive. In particular to achieve a high number of species and, consequently, a higher on-field biodiversity of olive groves, it is important the presence of herbaceous natural patches of vegetations, associated crops and a certain degree of fragmentation of permanent crops. The level of connection is of utmost importance to allow and facilitate the flows of different species across the landscape. Often, when competition for the land use and the level of fragmentation hamper the ability of the system to maintain a certain level of biodiversity, the increasing of the level of connection can be a solution to increase the level of functional biodiversity and the overall resilience of our agricultural systems. From this work we can find that the analysis of the on-field biodiversity and landscape structure surrounding the fields can be useful to better understand the interactions of all of those aspects in order to protect and save biodiversity.

Organic agriculture can be a very good tool to protect the on-field biodiversity but further analysis and studies are needed to investigate the application of specific management options to be applied in different territorial contexts because their impact on environment and their effect is highly context dependent. More studies are also needed in order to connect the field and farm biodiversity level with the landscape level at a large scale in order to be able to give politicians concrete tools and suggestions for a proper decision making and territorial planning to conserve biodiversity.

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Conflict of interest

Author declares that there is no conflict of interest.

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