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Ornithological communities as indicators of recent transformations on a regional scale: Sicily's case

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Abstract – A study on the Sicilian avifauna changes and its existing connections with the land use variations has been carried out from the 80s till today. We compared the Sicilian ornithological data acquired from the atlas maps with the regional land use maps data. We examined the land use variations and the distribution changes of some bird species on a regional level. To this aim, we analyzed the spatial distribution data of the birds in the period from 1984-1992 and 1993-2006. Moreover we examined the land use data of the period going from 1987-1988 and 1993-2000. After a preliminary analysis, we selected target species linked to different environments. Forest: Great spotted Woodpecker *Dendrocopos major*, Mistle Thrush *Turdus viscivorus*, Long-eared Owl *Asio otus*, Eurasian Nuthatch *Sitta europaea*, Marsh Tit *Poecile palustris siculus* ; scrub and bush: Red-backed Shrike *Lanius collurio*, arable and grazing land: Greater short-toed Lark *Calandrella brachydactyla*, Calandra Lark *Melanocorypha calandra*; complex systems, olive grove and almond trees: European Roller *Coracias garrulus*, Woodchat Shrike *Lanius senator*. The distribution changes of these species in the examined periods were significant and they were not linked to the demography of the species nor to the major or minor level of exploration of the island. According to the results, it is obvious that, for these species, there is a clear connection between the land use changes and the distribution variations. Other species manifested changes that seemed to be linked to demographic trends, which involved the distribution of these species (for example the diffusion of the Wood Pigeon *Columba palumbus*). None of the existing changes could be unequivocally related to climate change.

Key-words: agriculture, climate change, demographic changes, forests, landscape, birds.

INTRODUCTION AND PURPOSES

Agriculture and forestry activities have a key role in the conservation of biodiversity in the countries where the ecosystems underwent a massive change. These two activities were and still are the main factors of alteration of the territory (La Mantia 2009). In the last decades, in Italy and in Europe, farming systems have been evolving towards opposite directions (Ales *et al*. 1992, Genghini 2008): 1) productive intensification and simplification in the suitable areas, for example in the plains and low hill areas, with the spread of monoculture agrosystems, which are ecologically weak and sometimes harmful for the environment; 2) marginalization/extensification (abandonment), especially mountain areas (Sluiter & de Jong 2007). They are characterized by polyculture agrosystems and grazing, that can lead to reforestation and natural recovery of the native vegetation after abandonment. This aspect led to the extension of forestry areas and more often of shrubbery and scrublands, that altered significantly the landscape and the inner relations between the ecosystems (Moreira & Russo 2007), especially in the islands (Coreau & Martin 2007) and in agroforestry systems (La Mantia *et al*. 2007, 2008, Rühl *et al*. 2011). According to BirdLife International (2004) 20% of birds, which are worthy of protection according to the European level, are linked to agricultural environment. "The EU Biodiversity Action Plan" (European Union 2010) underlined some changes in the number of the common bird species in Europe between 1990 and 2006 (in particular they include Passeriformes and ecologically similar species, namely Columbiformes, Cuculiformes, Apodiformes, Coraciiformes, Piciformes) and reports a significant reduction in their number.

Even in Sicily, especially in the 50s, the agricultural activities changed significantly as a consequence of an unprecedented technological revolution. These changes led to the introduction of more and more intensive farming techniques, with a greater impact on farmlands and wildlife (La Mantia & Barbera 2003, Massa & La Mantia 2007, Massa *et al*. 2008). The environmental changes are often

relatively faster, compared to the adaptation time of the majority of the most sensitive species. It depends on several spatial, dimensional and ecological parameters (surface, shape, structure and spatial articulation, level of connections of the habitat remaining fragments) (Apan 2000).

The in-depth analysis of the ecological relations between animal communities and the environment to which they belong, requires both quantitative and qualitative data on the population that is going to be studied, and information regarding the environment where the population is examined (Beecher *et al*. 2002). The exact relation between the characteristics of the animal community and the environment is broadly known and studied. Among the communities of wild animals, birds are perfect ecological indicators for several reasons: 1) relative widespread presence; 2) close connection between some species and their habitat; 3) easy to detect; 4) highly sensitive to disturbing factors.

Although birds belong to the most common animal species, in the agroecosystems they do encounter some disadvantages, for example the lack of nesting areas, composite woods and wetlands. However, they are the biggest vertebrates in the farming and forestry systems both as species and as individuals. This is basically due to the ecological plasticity of different species, which are able to use the resources of agro-forestry environments not only for foraging purpose but also for reproductive functions. This is why an in-depth analysis is essential for the relation between avifauna and habitat. As regards the study of the connection between the agricultural environment (*sensu lato*) and the conservation of biodiversity, a careful evaluation of the environmental context in terms of habitat is particularly important. It must take into account the specific interactions between environment (deeply modified by continuous human actions) and living organisms.

This research aims at pinpointing and evaluating the relations between farming and forestry systems and ornithological communities in the Sicily island, in particular the land use variations and the distribution of avifauna on a regional level.

METHODS

Faunal data

Faunal data were gathered from the ornithological atlases of Sicily (Massa 1985, Lo Valvo *et al*. 1993, AA.VV. 2008) which provide information both on current and historical presence of the species, and on the dynamics of occupied surface as well. The Atlas shows a map of the distribution on the Sicilian territory for each species, with a UTM grid system (side: 10 Km). Atlas data are used for the creation of geo-referenced distribution maps and they are linked to spatial and alphanumeric data for a GIS project.

The atlas published in 1993 (Lo Valvo *et al*. 1993) indicated a quadrant in which the examined species was present (certain, probable or possible breeding) in the periods 1979-83 and 1984-1992 and in the period 1984-92 but not in the period 1979-83. The Atlas published in 2008 (AA. VV. 2008) identified all the quadrants in which each species were present or absent during 1993-2006 and 1979-2006. The project MITO2006 (Monitoraggio ITaliano Ornitologico: Italian Ornithological Monitoring) provided data used for identifying the trend on a national level in 2000-2010 (Rete Rurale Nazionale & Lipu 2011) and 2000-2011 (Campedelli *et al*. 2012). Data were collected in order to create avifauna distribution maps for a GIS project.

Specific maps were created for each species: one linked to the presence of the species in 1984-1992 and one linked to the presence of the species in 2006. The overlap of these two punctual topics produced three possible situations for each quadrants: 1) quadrants that show exclusively the presence of the species between 1984 and 1992 (disappeared after 1992); 2) quadrants in which there are two points that show the presence of the species between 1984 and 1992 and in 1993-2006; 3) quadrants which include only one point that indicates the presence of the species in 1993-2006 (appeared after 1993).

The analysis was conducted on some species after a preliminary analysis (cf. *Choice of bird species*).

Data on land use

The GIS project (*Geographical Information System)* enabled the study of information that was included in some digital maps concerning the land use on a regional level. Programs used for the research were *ArcView* and *ArcMap* of ESRI. The overlap of informative levels, regarding different years, enabled the evaluation of space-time changes of farming and forestry systems on a large scale (Maetzke *et al*. 2008, Rocchini *et al*. 2005, Roy & Tomar 2000). The land use change was examined according to the following documents:

- "Corine Land Cover 2000" Map of the regional territory (scale 1:100,000) (APAT 2005);
- Regional Map on land use in the years from 1987-88, scale 1:250,000.

The study of the ornithological species linked to the forestry systems required a more detailed classification of the forestry land use. Data from Informative Forestry Regional System 2011 (Camerano *et al*. 2011) were used for

this analysis. The information included in these documents enabled the following distinctions: 1) *Eucalyptus* broadleaves within the broadleaves class; 2) reforestation of conifers within conifers class.

Interaction of ornithological and land use data

The comparison between the maps regarding birds and the two regarding the land use (1987-88 and 2000) made it possible to carry out the study on the land use data and the distribution of the species data within a GIS environment, overlapping different informative levels. Moreover, it identified the following information: 1) 1987-88 land use in the quadrants where the species disappeared after 1992; 2) land use of 2000 in the quadrants where the species disappeared after 1992; 3) land use in 1987-88 in the quadrants where the species was present both in 1984-92 and 1993-2006; 4) land use of 2000 in the quadrants where the species was present both in 1984-92 and 1993-2006; 5) land use of 1987-88 in the quadrants where the species appeared after 1992 for the first time; 6) 2000 land use in the quadrants where the species appeared after 1992 for the first time.

Results were analyzed in two different moments: 1) overall evaluation of landscape and identification of big changes and 2) analysis of the specific changes in the interested areas. In this phase, specific tables were created in order to show the land use variations between 1987-88 and 2000 in the areas where the species disappeared, appeared and persisted. Beyond the changes of total surface, changes of the medium surface of farming patches were evaluated.

RESULT AND DISCUSSION

Land use variations

Although the Keys regarding the two documents on the land use are very similar, in the Table 1 some definitions were put together in order to create an exact match between the classes.

Here some clarifications. Protected crops and vegetable garden classes from the years 1987-88 are irrelevant and are not present in the Corine Land Cover 2000. The overlap of the digital maps showed that in 1987-88 this land use class is included in non irrigated arable areas of the Corine Land Cover 2000. However, greenhouses and crop field vegetables are widely spread especially in the Ragusa province and have altered precious habitats so that now it is possible to consider them as ecologically poor and instable (La Mantia & Barbera 2003). For this reason the evaluation of the arable lands must be modified because it is inappropriate and improper. "Permanent farming and particle systems" are a mosaic of small plots of land with different annual crops, permanent meadows and crops, which are less than 75% of the total surface of the unit. They have, or we should say had, a key ecological role (La Mantia 1997). Currently this category often includes protected crops and urban fragmented agriculture which is undermined by urban development (La Mantia & Barbera 2003).

Broadleaves are divided in "broadleaves" and "eucalyptus broadleaves", as it is shown in materials and methods. Conifers are divided in "ripe conifers" (they are usually local pine forests that have an essential ecological role) and "reforestation conifers"

Choice of bird species

Depending on the observation period (1984-2006), each species has quadrants in which it disappears (observed only in the years 1984-92), where it endures throughout the examined period (1984-92 and 1993-2006) and where at the beginning it is not found but it appears later (observed in 1993-2006 but not in 1984-92).

The selection of the *target* species was made according to the following criteria: 1) large variation of its spatial distribution during the observed period, taking into account also the previous atlas data (Massa 1985); 2) some species were more interesting because of their rarity in the entire regional territory.

The observed land use were: 1) "Low natural forest systems" that include eucalyptus, conifers reforestation, mixed forests and partially wooded areas; 2) "high natural forest systems" that include non-eucalyptus broadleaves and ripe conifers (pine forests of black pine trees that are situated in the area of Monte Etna, localized natural pine forests, wrecks of Aleppo pines and maritime pines) (Camerano *et al*. 2011); "Bush and scrublands" is a greenery category which is widespread due to the frequent disturb by forest vegetation. "Arable and grazing" land use was an historical characteristic of Sicily and it has led to the creation of complex ecological networks, which are currently completely altered (Massa & La Mantia 2007, 2010) by use and technique changes (La Mantia & Barbera 2003); "Complex systems, almond and olive groves" suffered from the same fate of the previous category.

In ESM 1 (Electronic Supplementary Material) there is a summary of a first evaluation regarding forest species linked to wood systems. The evaluation pinpointed the right indicators thanks to recent surveys (La Mantia *et al*. in press). There are 42 species, of which two are endemic subspecies.

These species have a specific connection with some

classes of land use that were broadly altered during the observed period, in terms of surface (Tab. 1) or in "ecological" terms (for example farming systems) (La Mantia & Barbera 2003). As regards forest species, they are spreading at an unprecedented speed; these species are Mistle Thrush, Long-eared Owl and Great spotted Woodpecker. The quadrants where these species appeared were studied and evaluated. The same evaluation was done for the Marsh Tit and the Eurasian Nuthatch, although their growth might probably be related to the improvement in exploration. It must be underlined how the Sicilian species ecology of today has many differences compared to the same species that are present on the continental Italy; for example in Italy Mistle Thrush and Eurasian Nuthatch can be found also in orchards and urban parks (Brichetti & Fracasso 2008). This is the proof that it is impossible to use valid indicators for all the geographical areas where these species are to be found: "Defining a bird species as a 'forest' one is often troublesome, owing to the lack of overall ecological knowledge and to differences among regions" (Londi *et al*. 2009).

The Red-backed Shrike is linked to bush and scrublands and has a limited area of concentration. Concerning this species, both the quadrants where the species was detected and the quadrants where the species was no longer found were studied. This species has always been relatively uncommon in Sicily and this is why it is difficult to make some evaluations. However, a monitoring of this species could be very interesting, because it is decreasing in Europe and in Italy.

As far as species linked to arable lands with a strong negative trend in distribution are concerned, the Greater Short-toed Lark and Calandra Lark quadrants, in which they both disappear, were examined and evaluated. In conclusion, in regards to the Woodchat Shrike and the European Roller, which are both species linked to complex systems and dry tree crops, their population is decreasing and it has appeared throughout the examined period.

Species linked to forest environment

Great Spotted Woodpecker *Dendrocopos major*

This species was observed in 134 quadrants. In particular it appeared in 74 quadrants, persisted in 53 and disappeared in 7. In the 74 quadrants where the species appeared, scrublands and broadleaf forests are the most common classes of forest land use. These are the classes that made a positive variations during 1987-88 and 2000 (Tab. 2). Among the mostly altered farming classes (–35.949 ha) there are to be found: complex systems (–35.949 ha), almond groves (–12.620 ha) and grazing lands (–11.960 ha).

This is an indicator of the desertion of traditional farming activities. The distinction between eucalyptus broadleaves and general broadleaves is essential in order to evaluate the importance of eucalyptus trees, which go from 264 ha to 7,140 ha in the quadrants where the woodpecker lives. This species extended its diffusion area, reaching eucalyptus trees which are slowly spreading (La Mantia *et al*. 2002). The Great spotted Woodpecker has instead been favored by the expansion of eucalyptus trees and probably by the expansion of Cerambycidae, since it feeds on its larvae. The areas in which it appeared are characterized by the abandonment of traditional crops (complex systems, grazing and almond groves), the persistence of intensive crops (arable land, olive groves, vineyards, orchards) but, above all, by the increase in reforestation. The presence in conifer forest areas is moderate and did not experience significant variations. The reduction of ripe conifers is followed by an increase in reforestations. In conclusion we must underline the reduction of partially wooded forests (–9.401 ha).

Ientile & Massa (2008) think that it has rapidly grown in comparison with the previous decades (Massa 1985, Lo Valvo *et al*. 1993). Coherently in Italy it is in "sharply increase" (Rete Rurale Nazionale & LIPU 2011) or moderate increase (Campedelli *et al*. 2012).

Mistle Thrush *Turdus viscivorus*

This species was found in 60 quadrants. In particular it appeared in 31 quadrants, persisted in 23 and disappeared in 6. Variations of land use of this species were evaluated in the quadrants where it appeared. In these quadrants, scrublands and broadleaved forests are the most common classes of land use (Fig. 1, ESM 2). In this area the scrubland is increasing (it has doubled in 2000 in comparison with 1987). Broadleaved forests doubled as well. Grazing and arable lands are significantly decreasing. The slight increase in conifers is due to the diffusion of reforestations.

The Mistle Thrush finds a suitable habitat in those areas where there has been a significant increase in deciduous and bushes at the expense of pasture and arable land. It has been therefore favored by the positive trend of the forests (deciduous, mixed forests, conifer reforestation in naturalization) and the persistence of tree crops such as orchards and olive groves, which probably play an important role in the diet of the species. We would point out that this species in Sicily has a different ecology compared to the ecology in other areas where it lives; in fact, in northern Italy and in Europe, it also lives in suburban environments (Brichetti & Fracasso 2008), while in Sicily it is strongly linked to natural or naturalized forests.

Among the non-herbaceous land uses there are: olive

Table 1. Correspondence between the land use classes of the map of the years 1987-88 and 2000 (ha).

Land use classes used in the current study	Land use classes in 87'-88'	Land use classes in 2000	Variations 87/2000
Arable	Dry crops	Non irrigated arable areas	–5,182
	Protected crops and vegetable garden		
Grazing	Grazing	Natural grazing areas and high altitude meadows	–50,233
	Uncultivated		
Complex systems	Farming and complex particle system	Associated annual crops and permanent crops	–150,881
	Arable related to Vineyard	Permanent farming and particle system	
	Mixed woody crops	Areas manly occupied by crops with natural vegetation	
Almond groves	Almond groves		–20,788
Olive groves	Olive groves	Olive tree groves	–11,607
	Olive groves with other woody		
Vineyard	Vineyard	Vineyards	9,784
Orchard	Citrus Grove	Orchard and minor orchard	11,147
Broadleaves	Broadleaves	Broadleaf forests	56,372
Conifers	Conifers	Conifer forests	6,848
Mixed Forest	Mixed Forest	Mixed Forests	7,963
Partially wooded areas	Partially wooded areas	Areas with wooded and shrubed vegetation	–37,725
Bush and shrublands	Bush and shrublands	Areas with Sclerophyllous vegetation	164,713
		Moor and shrublands	
Sparse vegetation	Eroding areas	Areas with sparse vegetation	–8,249
		Bare rocks, cliffs, outcrops	
Urban environments	Dense environment	Regular urban environment	25,143
and infrastuctures	Sparse environment	Irregular urban environment	
	Farming centers		
	Building areas	Buildind site	
	Landfill	Landfill	
	Generic Infrastructures	Road Networks	
	Industrial Areas	Industrial and commercial Areas	
	Airports	Airports	
	Harbor areas	Harbor areas	
	Mines	Mines	
Green urban areas	Green urban areas	Green urban areas	291
	Archeological areas	Sport areas	
Beaches	Beaches	Beaches	–434
Saltworks	Saltworks	Saltworks	–2,204
Watercourses	Riverbeds	Watercourses	10
Water basins	Natural Lakes	Water basins	578
	Artificial lakes		
Marshes	Marshes	Inland wetlands	–223
		Salty wetlands	
Coastal lakes	Coastal lakes	Lagoon	–32

Table 2. Land use (ha) variations (%) (years 1987-2000) in the 74 quadrants in which the Great Spotted Woodpecker appeared.

Land use classes	1987	2000	Variations
Arable	220,730	217,784	–1
Grazing	95,492	83,532	–13
Complex System	114,543	78,594	–31
Almond grove	12,620		–100
Olive grove	64,664	62,803	–3
Vineyard	26,170	26,514	1
Orchard	34,588	39,032	13
Broadleaves	24,664	36,289	47
Eucalyptus broadleaves	264	7,140	2605
Ripe conifers	3,136	1,648	–47
Reforestation conifers	2,369	3,292	39
Mixed forest	5,797	8,575	48
Partially wooded areas	24,506	15,105	–38
Bush and scrubland	33,735	81,668	142
Sparse vegetation	11,203	7,045	–37
Urban environments and infrastructures	20,587	26,347	28
Green urban areas	103	129	26
Beaches	146	146	0
Watercourses	2,277	1,564	–31
Water basins	828	1,017	23
Marsh	247	199	–19
Total	**698,668**	**698,424**	**0**

groves (they increased from 9.3% to 10.4%), orchards (stable at 9%), complex farming systems (they decreased from 10.5% to 9.1%), partially wooded areas (they decreased from 8.5 to 6.9 %), mixed forests (they increased from 1.9 to 2.5 %). It is notable that the above mentioned classes did not have remarkable variations. Landscape changes can be associated mainly with the naturalization of the grazing-arable process and with the complex farming system, which is highlighted by the negative trend of the urban areas, that probably belong to this category. Ientile & Massa (2008)

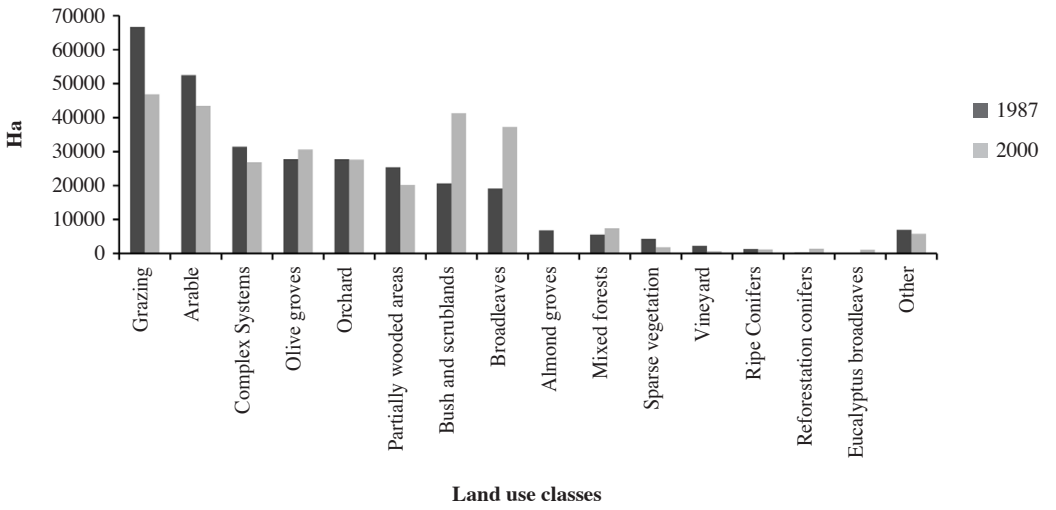

Figure 1. Land use variations (years 1987 and 2000) in 31 quadrants where the Mistle Thrush appeared.

think that this trend has been "recently increasing" in comparison to the previous decades (Massa 1985, Lo Valvo *et al*. 1993). On the contrary in Italy it is "stable" (Rural National Network & LIPU 2011) or moderate (Campedelli *et al*. 2012). The Italian red list of breeding birds (Peronace *et al*. 2012) considers this trend as "a minor concern".

Long-eared Owl *Asio otus*

This species was found in 28 quadrants. In particular it appeared in 23 quadrants, disappeared in 4 and persisted in 1. The analysis examined the 23 quadrants where the species appeared (Fig. 2) (ESM 3). The study highlights the high heterogeneity of the environment in these areas. In the observed quadrants there is no ruling class, but there is a combination of uses, as it was demonstrated by the studies carried out on the species present in the island (Siracusa *et al*. 1996). Among the classes with the largest extension, the arable one had the highest percentage of variation from 1987 to 2000. It decreased from 26.2 to 23.5%. As regards grazing, it decreased from 21.8 % to 13%. Broadleaves significantly increased from 8.9 to 13.1 %, as well as bush and scrublands which increased from 3.5 to 14.6 %. On the contrary, partially wooded areas and sparse vegetation have decreased respectively from 9% to 6.6% and from 3.3% to 2.1%. Among the farming classes with remarkable extension that did not have any significant variations there are to be found: complex farming systems, orchards and olive groves. The complex farming system was the most common non-herbaceous system, which remained stable at 9%. As regards vineyard areas, they were moderate.

The Long-eared Owl seems to prefer heterogeneous environments characterized by the reforestation of pines (the species has bred in Malta just recently in a forest of Aleppo pine: Sultana *et al*. 2011) or even large bush-scrub surfaces and broadleaf ecosystems in which there are also open habitats (arable, grazing, partially wooded areas) and traditional cropping systems that provide shelter and food to many of its prey (mainly rodents). Recently it was also found in uncultivated olive groves (A. and T. La Mantia, pers. obs.). The Italian red list of breeding birds (Peronace *et al*. 2012) considers it as "a minor concern".

Eurasian Nuthatch *Sitta europaea*

This species was found in 34 quadrants. In particular it appeared in 17 quadrants, persisted in 15 and disappeared in 2. The analysis (Fig. 3) (ESM 4) concerns 17 quadrants, where the species appeared. Broadleaves are the most common forest class. Besides this class, partially wooded areas and mixed forests are well-distributed. Conifers are almost absent. The analysis on land use variations of forestry systems shows that broadleaves doubled from 12,691 ha to 26,055 ha. The distinction between eucalyptus broadleaves and general broadleaves underlines how the presence of eucalyptus is irrelevant. Partially wooded forests and sparse vegetations decreased (respectively –3,755 ha and –2,555 ha). Among the most common herbaceous farming classes there are: orchards, complex systems and olive groves. Grazing is the only remarkable herbaceous farming class. Among the most notable farming systems, complex systems and orchards have a positive trend, grazing and olive groves have instead a negative trend. Grazing areas halved (–23,676 ha) due to the significant increase in bush and scrublands (+19,451 ha) caused by the abandonment of pasture activities in the mountainous areas (Falci

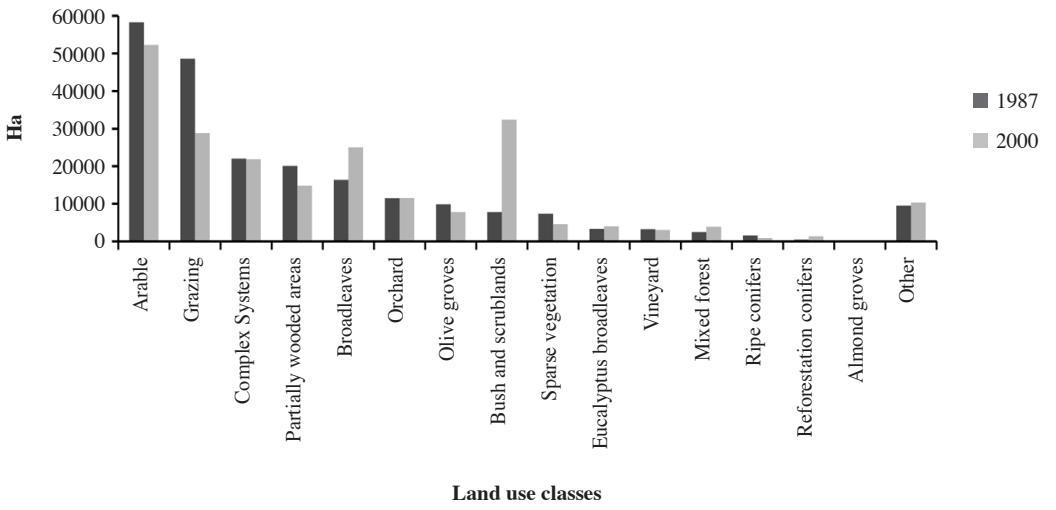

Figure 2. Land use variations (years 1987 and 2000) in 23 quadrants where Long-eared Owl appeared.

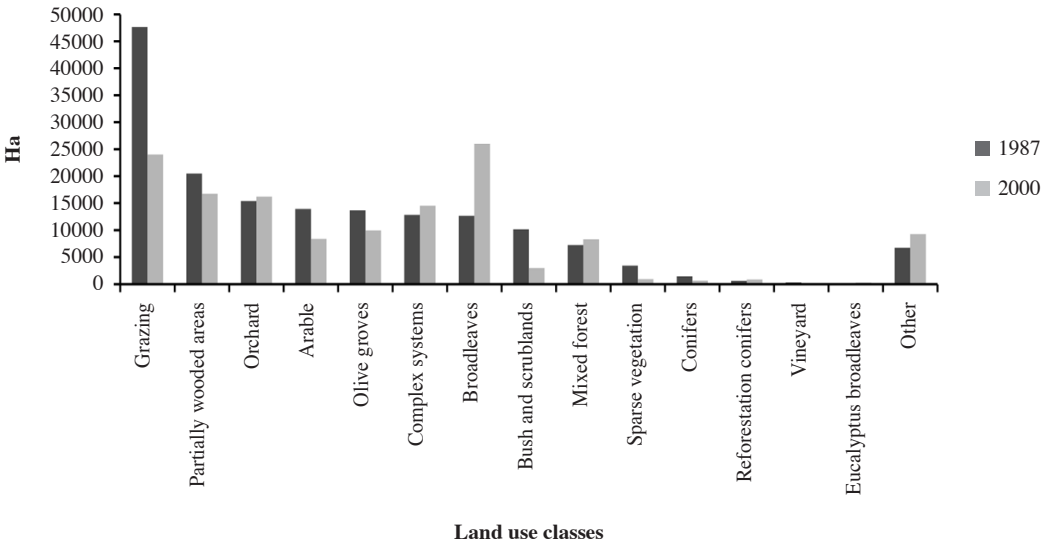

Figure 3. Land use variations (years 1987 and 2000) in 17 quadrants where Eurasian Nuthatch appeared.

et al. 2012). This increase is probably due to the increase of samplers; the Eurasian Nuthatch in Sicily is in fact linked to the deciduous old forests (which do not include eucalyptus forests and reforestation in general).

Ientile & Massa (2008) write how "its positive variation is mainly due to a better coverage of the Peloritani area". In Italy it is considered "stable" (Rete Rurale Nazionale & LIPU 2011) or moderate (Campedelli *et al*. 2012). The Italian red list of breeding birds (Peronace *et al*. 2012) considers it as "a minor concern".

Marsh Tit *Poecile palustris siculus*

This species was found only in 6 quadrants: it appeared in 5 and persisted in 1. The analysis concerns 5 quadrants, where the species appeared (Fig. 4) (ESM 5). Broadleaf forests are the most common class. There are no relevant eucalyptus trees and conifer forests. The analysis on land use variations of forestry systems shows that: 1) broadleaves increase significantly from 8,935 ha to 15,008 ha, becoming the class with the largest surface ever; 2) partially wooded areas halved from 13,894 ha to 5,987; 3) mixed

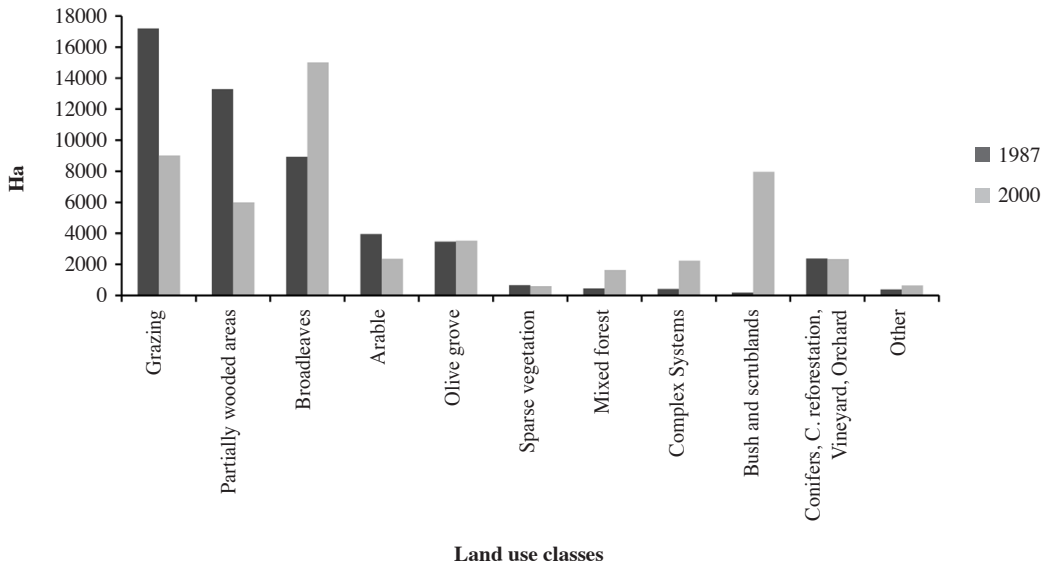

Figure 4. Land use variations (years 1987 and 2000) in the 5 quadrants in which the Sicilian Marsh Tit appeared.

forests tripled their extension. Among non-herbaceous farming classes, olive groves and orchards are stable, while complex systems have a positive trend. Arable and grazing decreased respectively by 40% and by 48%. Their decrease is linked to a significant enlargement of bush and scrubland areas, which increased from 184 to 7,787 ha. As for the Eurasian Nuthatch, the growth of this species is probably due to the improvement in explorations. Studies confirm that this species is connected to ripe forests as well. Ientile & Massa (2008) think that the limited populations were not detected in the past; instead in Italy the subspecies *palustris* is considered "*stable*" (Rete Rurale Nazionale & LIPU 2011, Campedelli *et al*. 2012). The Italian red list of breeding birds (Peronace *et al*. 2012) consider it as "a minor concern".

This subspecies, together with *Aegithalos caudatus siculus* (Whitaker 1901) and *Alectoris graeca whitakeri*, is one of the only three endemic bird subspecies present in Sicily.

Bush and scrubland environment related species

Red-backed Shrike *Lanius collurio*

The species was observed in 24 different quadrants: it appeared in 16, disappeared in 6 and persisted in 2. The analysis on the data of the different land uses in the quadrants where the species is involved, have underlined that the species is strictly linked to an eco-mosaic environment in which the most common types are: the broadleaf forests, the partially wooded areas and the grazing land (Tab. 3). In these areas a general increase in broadleaf forests, scrublands and complex farming systems was recorded, while there has been a decrease in areas such as: arable lands and partially wooded areas. In the quadrants in which the species disappeared (Tab. 3) a light drop in partially wooded areas, going from 15.9% to 12.9%, was observed. However in conjunction with this drop, a significant increase in the average surface of plots of land was registered (165.7 ha in 1987 and 223.9 ha in 2000). Grazing decreased from 31.7% to 15.4%, while the share concerning arable lands is entirely negligible, amounting at 8% in 2000. The higher increase was registered within the broadleaf forests reaching a 20.8%, considered to be significantly higher compared to those of the scrubland that doesn't exceed 14.6%. In the quadrants where the species is not present (Tab. 3) the partially wooded areas nearly disappeared going from 11% to 0.9%. This decrease also leads to a reduction of the average surface (182.5 ha in '87 and 76.6 ha in 2000). The typologies that have shown the highest increase were the mixed forest and the scrublands. Between 1987 and 2000, scrublands have reached a higher percentage (21.7%) compared to the broadleaf forest (16.8%). The analysis has underscored that the Red-backed Shrike favors habitats characterized by broadleaf forests with wide partially wooded

Table 3. Land use (ha) variations (%) (years 1987-2000) in the 16 quadrants in which the Red-back Shrike appeared or disappeared.

Different land use	**Appeared**			**Disappeared**		
	1987	**2000**	**Variations**	**1987**	**2000**	**Variations**
Arable	19,495.6	14,173	–27.3	17,051.9	13,393.8	–21.5
Grazing	51,043.4	24,826	–51.4	9,589.7	8,276.2	–13.7
Complex Systems	11,084.4	16,045	44.8	1,416.8	2,912.5	105.6
Almond Groves	63.3	0	–100.0	4,929.7	5,142.7	4.3
Olive Groves	7,949.7	4,056	–49.0	41.8	0.1	–99.9
Vineyard	1,647.6	145	–91.2	298.2	262.7	–11.9
Orchard	8,857.9	9,846	11.2	7,323.3	10,353.0	41.4
Broadleaves	11,855.5	33,601	183.4	0.0	159.0	
Conifers	1,142.9	909	–20.5	300.6	1,921.8	539.3
Mixed forest	7,762.3	7,115	–8.3	6,751.6	536.3	–92.1
Partially wooded areas	25,685.9	20,820	–18.9	7,326.9	13,364.0	82.4
Bush and scrublands	8,064.1	23,505	191.5	5,326.9	3,859.1	–27.6
Sparse vegetation	2,272.1	1,130	–50.3	1,152.1	1,252.8	8.7
Urban environments and infrastructures	3,527.7	4,093,4	16.0	32.8	34.3	4.6
Watercourses	821.1	1,035	26.0	61,542.2	61,468.0	–21.5
Total	**161,273.5**	**161,298.8**		**17,051.9**	**13,393.8**	

areas. The comparison between the percentage of land use variations of the quadrants where the species was observed from 1984-92 and the percentage of land use variations of the quadrants where the species was registered in 2006, has allowed to establish that Sicily's areas, which are able to house the Red-backed Shrike, are composed by broad-leaf forests (12-21%), partially wooded areas (11-13%), bushes and scrublands (12-14%) and grazing (15%).

The dynamic of the Red-backed Shrike is the mirror image of those species more properly considered to be part of the forestry; this species is, in fact, usually linked to deciduous forests and partially wooded areas, but it really lives in clearings. Our study has also highlighted that this Shrike is sensitive to the surface and the average size of partially wooded areas. In the areas where the species is no longer present, the total area and the size of the surface of this ecosystem have drastically reduced, and the species has shown parallel trends; it needs to be compared to Apennines populations (Brambilla *et al*. 2007). It must also be emphasized that the extreme localization of the species in Sicily, even in the past, precludes drawing clear evaluations as it happens for other areas of the country. In addition, giving rise to concerns related to the limited area distribution of the species, the analysis provides some indications on the species habitat in Sicily and confirms the role carried out by scrubs (Morelli *et al*. 2013).

Ientile & Massa (2008) believe that the increase is mainly due to a better exploration of the area compared to the previous decades (Massa 1985, Lo Valvo *et al*. 1993); in Italy it is considered to be in "moderate decline" (Rete Rurale Nazionale & LIPU 2011, Campedelli *et al*. 2012). The Italian red list of breeding birds (Peronace *et al*. 2012) considers it "vulnerable".

Arable and grazing environment related species

Greater short-toed Lark *Calandrella brachydactyla*

The species was observed in 158 quadrants; it disappeared in 86, persisted in 49 and appeared in 23. The environment in which the Greater Short-toed Lark is mostly present is the dry arable land (Fig. 5) (ESM 6). Within the 89 quadrants in which the species disappeared, the arable and grazing lands have remained constant, while complex cropping systems have suffered a negative variation going from 14.0813 ha (18%) in 1987 to 72.220 ha (9%) in 2000. This decrease is mainly due to the increase of the following cropping systems, such as: olive groves, vineyards and orchards. Those cropping systems account for a significant process of intensification of agricultural activities (Fig. 5) (ESM 6). The species is in sharp decline throughout the island (Massa *et al*. 2008, Massa & La Mantia 2010) also in those small islands such as Lampedusa where agricultural activity was ceased. (La Mantia *et al*. 2011) This has been said in order to underline the importance that agricultural activities holds, in the preservation of a suitable habitat for the species. Besides the different land use, it is also important to underscore the changes occurred to the cereal crops, which were witnessed by the decrease of the average size of the cropping patches (633 ha in 87-88 e 487 ha in 2000) and from their increase in number (461 in 1987-88 and 603 in 2000).

Ientile & Massa (2008) consider the species as rare

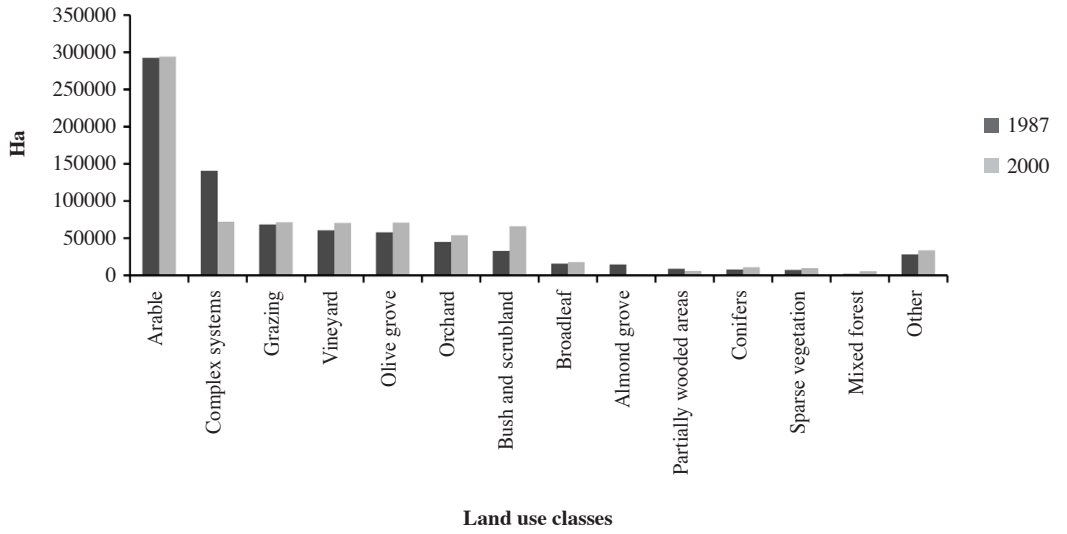

Figure 5. Land use variations (years 1987 and 2000) in the 86 quadrants in which the Greater Short-toed Lark disappeared.

and in decrease compared to the previous decades (Massa 1985, Lo Valvo *et al*. 1993) while in Italy, it is considered in "strong decline" (Rete Rurale Nazionale & LIPU 2011) or "moderate decline" (Campedelli *et al*. 2012). The Italian red list of breeding birds (Peronace *et al*. 2012) considers it "in danger".

The species has suffered a similar decline in Malta, having among the main causes agricultural intensification and urbanization (Sultana *et al*. 2011) These former causes may have also had an influence on the status of the species in Sicily.

Calandra Lark *Melanocorypha calandra*

This species has been undergoing for many years a strong and continuous decrease within the island, but more in general throughout its range (La Mantia 1985a, Massa *et al*. 2008, Massa & La Mantia 2010). It was observed in 112 quadrants, disappeared in 75, persisted in 26 and appeared in 11. The most represented crop areas inside the 75 quadrants, where the species has disappeared, are (Fig. 6) (ESM 7): the arable lands, which account for the main landscape matrix, the complex crop systems, vineyards, grazing and olive groves. The most important change has concerned the reduction of complex crop systems (–73,582 hectares) that have dropped from 21.2 % (1984-92) to 10.4 % (2000) and the disappearance of almond groves (15,224 ha in 1987, accounting for 2.2 % of the total surface). To this negative trend, an increase in bushes, orchards and olive trees has occurred. The arable lands have increased, leading to a reduction of the medium areas of crop patches (659 ha in 1987-88 and 587 ha in 2000) and an increase in their number (380 in 1987-88 and 469 in 2000).

The disappearance of Calandra Lark from large areas devoted to the cultivation of wheat, particularly so from the hinterland of western Sicily (provinces of Agrigento, Palermo and Trapani) is attributable to: 1) changes in crops evidenced by the decrease in the average grain patches of cultivation and the increase in their number; 2) the abandonment of traditional farming systems (complex cropping systems and almond groves).

Ientile & Massa (2008) write that the species "has gone drastically rarefying" compared to the previous decades (Massa 1985, Lo Valvo *et al*. 1993) while in Italy it has been considered to have an "uncertain" trend (Rete Rurale Nazionale & LIPU 2011, Campedelli *et al*. 2012). The Italian red list of breeding birds (Peronace *et al*. 2012) considers it " vulnerable".

Complex system, almond and olive grove environment related species

European roller *Coracias garrulus*

This species was observed in 58 quadrants, it appeared in 10, disappeared in 32 and persisted in 16. The area in which the species was -or has been- historically present, mostly coincides with the interior areas such as Agrigento and Caltanissetta. The analysis of the data on the different land use in which we encounter the species, have pinpointed that the latter is related to environments dominated by the following crop types: arable land (43-50%), complex cropping systems (7-23%), olive groves (5-12%) and grazing (5-10%) (Tab. 4). The 10 quadrants in which the species appeared are sited in the inner areas of the island, areas where the arable land constitutes more than 50% of

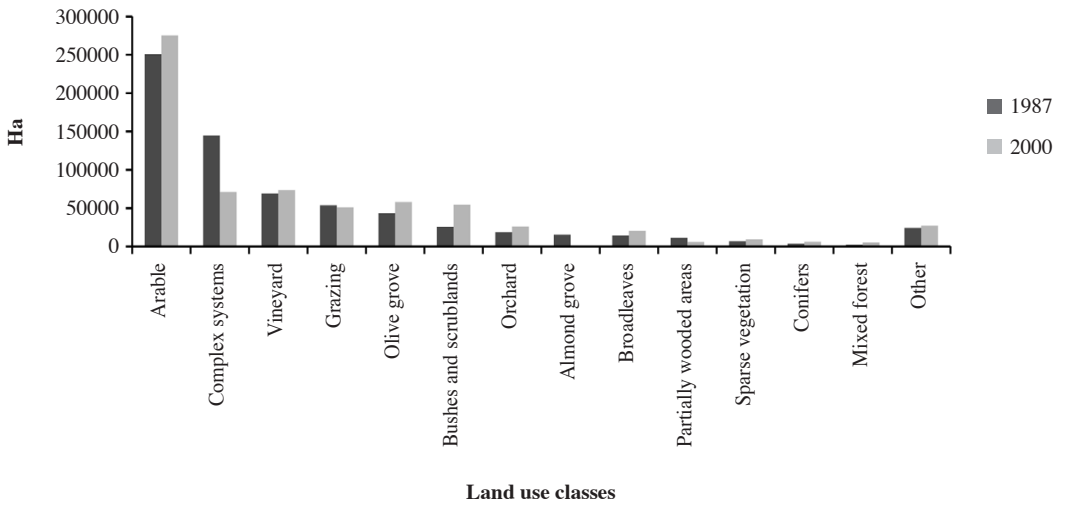

Figure 6. Land use variations (years 1987 and 2000) in the 75 quadrants in which the Calandra Lark disappeared.

Table 4. Land use (ha) variations (%) (years 1987-2000) in the 10 quadrants in which the European Roller persisted, appeared or disappeared.

Different land use	Persisted			Appeared			Disappeared		
	1987	2000	Variations	1987	2000	Variations	1987	2000	Variations
Arable	77.250,1	78.981,3	2,2	42,268.0	47,781.7	13.0	137,714.4	152,535.8	10.8
Grazing	14.052,6	16.120,7	14,7	6,851.0	5,540.7	–19.1	16,432.3	20,235.9	23.1
Complex systems	25.245,1	15.191,2	–39,8	18,889.1	6,463.2	–65.8	72,772.0	35,205.9	–51.6
Almond grove	8.053,0		–100,0	20.6			10,397.9		–100.0
Olive grove	8.935,5	13.609,6	52,3	7,615.8	10,198.8	33.9	16,287.3	30,551.3	87.6
Vineyard	5.287,2	5.033,2	–4,8	6,267.3	8,310.4	32.6	19,837.0	15,328.7	–22.7
Orchard	1.134,8	1.968,2	73,4	2,208.7	2,095.5	–5.1	5,132.4	9,873.3	92.4
Broadleaves	3.786,5	3.887,1	2,7	4,208.8	4,275.1	1.6	13,059.2	15,004.8	14.9
Conifers	1.331,0	2.113,2	58,8	471.4	1,118.1	137.2	2,695.3	2,668.3	–1.0
Mixed forest	1.173,8	2.653,0	126,0	48.8	370.1	659.1	1,434.7	1,798.9	25.4
Partially wooded areas	2.763,2	253,4	–90,8	1,905.1	577.7	–69.7	4,793.2	1,787.4	–62.7
Bushes and scrubland	5.863,4	13.693,8	133,5	1,290.4	5,153.8	299.4	8,986.8	22,125.5	146.2
Sparse vegetation	1.828,8	2.682,6	46,7	1,111.1	1,823.7	64.1	2,037.7	3,473.5	70.5
Urban environments and infrastructures	4.524,2	4.468,5	–1,2	1,925.2	1,580.0	–17.9	4,600.4	6,396.7	39.0
Beaches	0,6	108,1		62.3	1.2	–98.1	80.1		
Watercourses	207,9		–100,0	161.8		–100.0	371.7	260.7	–29.9
Marshes	502,5	848,5	68,9	0.0	13.5		316,632.4	317,246.7	
Total				**95,305.4**	**95,303.6**		**137,714.4**	**152,535.8**	**10.8**

land use and the average size of the relevant patches is very large (730 ha) (Tab. 4). Concerning this species, the only tree crops that in 2000 had significant surface variations resulted to be: olive groves 11%, vineyards 9% and complex crop systems (7%).

In the 32 quadrants where the species has disappeared, there has been an increase in surface of: arable land (+14,821 ha: percentage change of 11%), olive groves (+14,264 ha: percentage change of 88%), orchards (+4,741 ha: percentage change equal to 92%) and bushes and scrubs (+13,139 ha, with a percentage change of 146%) (Tab. 4). This increase has given way to a strong decrease in complex cropping systems (–37,566 ha: percentage change of –52%) and the disappearance of almond groves (–10,398 ha, meaning 3% of the total area) (Tab. 4). These classes of land use have shown the same negative trend as the territories within the 16 quadrants in which the species persisted, (Tab. 4) experiencing a significant reduction in complex systems (–10,054 ha: percentage change of –40%) and the disappearance of almond groves (–8.053 ha, equal to 5% of the total area). The decrease in traditional cropping systems, however, is not matched by a significant increase in arable and orchard fields. The only crops that have shown a significant increase were: the bushes and scrubs (+7,830 ha. percentage change equal to 134%) and the olive groves (+4,634 ha: percentage change equal to 52%). It should also be noticed how the urban environments increased where the species disappeared, and remains practically stable in the areas in which the European Roller persisted or appeared. The European Roller nests in hollow trees (but also inside holes in rails, under bridges and rural buildings) and therefore requires big trees such as the old almond trees. Perhaps its decrease is due to the coincidence between the disappearance of big trees and the destruction of the old artifacts that can accommodate the nests. In the Latium region, where the species used artifacts, it has increased its population (Meschini and Savo 2011).

Ientile & Massa (2008) consider it "in notable decline" compared to the previous years (Massa 1985, Lo Valvo *et al*. 1993) while in Italy it is considered to have an "unsure" trend (Rete Rurale Nazionale & LIPU 2011) or a "moderate increase" (Campedelli *et al*. 2012).

Woodchat Shrike *Lanius senator*

This species was observed in 58 quadrants, it appeared in 54, persisted in 110 and disappeared in 61. In the 54 quadrants in which the species appeared, there is a reduction in complex systems (-36 %), grazing (–17 %) and olive groves (–3,4 %), while the orchards remain stable (Tab. 5).

In the quadrants in which the species disappeared, complex systems decrease to 41.5%, while olive groves slightly increased (3.8%) (Tab. 5). The districts where the species persisted, have the same trend for these land uses with the exception of the orchard which shows a significant increase (+37.5%) (Tab. 5).

The species was once present even in irrigated orchards from which it has now disappeared, but especially in the dry orchards it is in sharp decline (La Mantia 1985b). The Woodchat Shrike has suffered a sharp decline, that is only partially explained in the analysis corried out on the change of land use. Populations are in fact much smaller compared to the past.

Ientile & Massa (2008) consider it "significantly decreased in the last decades" (Massa 1985, Lo Valvo *et al*. 1993) even though they do not consider the changing of the habitat a sufficient matter in order to explain their reduction; in Italy, the species is considered in "strong decrease" (Rete Rurale Nazionale & LIPU 2011, Campedelli *et al*. 2012). The Italian red list of breeding birds (Peronace *et al*. 2012) considers it "in danger".

According to the Sultana *et al*. (2011), the species was more common in Malta in 800s and beginning of 900s.

CONCLUSIONS

The integrated study of land-use variations and changes in the distribution of species allows to make an assessment on the evaluations of the running processes. All bird species related to forest environments appeared to be favored by the changes that took place between 1987-88 and 2000. The same trend is observed in Italy (Falcucci *et al*. 2007). The species that have decreased are those related to agricultural environments, among them the Calandra Lark. In the areas where the species disappeared, an increase of arboreal cropping systems with a high energy input such as: olive groves, vineyards and orchards was experienced. Also a profound change was experienced in arable cultivations, led by the decrease in the average size of cultivation patches and the increase in their number. The contraction of the distribution of the species was mainly contributed by the important process of intensification of agricultural practices. The same trend has characterized the species linked to traditional dry orchards such as the European Roller and the Woodchat Shrike. The two species prefer open areas with the presence of scattered and isolated trees, used for nesting and as a perch for hunting.

Table 5. Land use (ha) variations (%) (years 1987-2000) in the 54 quadrants in which the Woodchat Shrike persisted, appeared or disappeared.

Different land use	**Persisted**			**Appeared**			**Disappeared**		
	1987	**2000**	**Variations**	**1987**	**2000**	**Variations**	**1987**	**2000**	**Variations**
Arable	349,335.3	353,255.5	1.1	134,581.6	129,453.1	–3.8	190,263.2	185,352.2	–2.6
Grazing	132,962.2	113,677.1	–14.5	65,906.2	54,731.4	–17.0	52,257.9	50,425.7	–3.5
Complex systems	169,074.3	107,350.1	–36.5	82,276.9	52,219.6	–36.5	80,279.7	46,974.9	–41.5
Almond grove	17,673.1	0.0	–100	335.9		0.0	2,482.1		–100.0
Olive grove	109,936.5	105,812.0	–3.8	50,324.2	48,599.6	–3.4	36,671.9	38,074.0	3.8
Vineyard	45,692.1	46,027.4	0.7	33,248.7	33,049.7	–0.6	34,731.8	37,314.6	7.4
Orchard	27,890.3	38,347.7	37.5	45,735.4	45,753.8	0.0	30,831.1	31,380.6	1.8
Broadleaves	35,496.1	57,515.1	62.0	23,928.2	37,770.7	57.9	7,729.6	15,590.1	101.7
Conifers	16,442.6	18,043.7	9.7	818.7	2,256.1	175.6	3,500.8	6,903.8	97.2
Mixed forest	7,830.5	10,096.4	28.9	4,847.3	6,975.9	43.9	944.8	2,982.7	215.7
Partially wooded areas	35,253.8	19,817.1	–43.8	21,421.4	13,320.6	–37.8	14,778.0	9,516.2	–35.6
Bushes and scrubland	42,372.7	115,552.5	172.7	19,806.0	53,577.3	170.5	17,291.7	42,078.1	143.3
Sparse vegetation	28,260.3	24,184.9	–14.4	8,492.0	8,313.2	–2.1	8,359.4	8,222.9	–1.6
Urban environments and infrastructures	28,712.7	37,437.4	30.4	16,893.0	20,938.4	23.9	23,358.3	28,990.8	24.1
Beaches	155.3	279.2	79.7	147.6	57.7	–60.9	580.2	587.4	1.2
Saltworks	85.9	131.4	53.1	872.5	841.3	–3.6	329.2	20.1	–93.9
Watercourses	35.1	32.3	–8.0	1,011.8	1,364.3	34.8	404.1	578.9	43.3
Water basins	1,866.9	1,400.5	–25.0	371.6	483.4	30.1	1,677.9	1,577.9	–6.0
Marshes	1,703.5	1,719.3	0.9	548.1	305.0	–44.3	57.4	25.2	–56.2
Total	**1050,779.2**	**1050,679.5**		**511,567.0**	**510,011.1**		**506,529.**	**506,596.**	

In a recent contribution on the avifauna and ecoregions in Sicily (Londi *et al*. 2012), all of these species are considered to be part of the "Temperate mountains" having an "ornithological area considered to be well characterized even from a climate point of view; many of the indicator species are in fact not only part of the forestry but also clearly mesophytic, as for example: the Subalpine Warbler, the Nuthatch, the Marsh Tit. They can also be considered mountain birds, as the tit...". However, the fact that these species are on the rise, is in deep contrast with what is nowadays considered to be the main factor that is changing the animal population: climate change. In addition, the termophilous species related to the agricultural environments are in decrement, these species, however, compared to the mountain ones, being thermophilic, should rise. Their contraction appears to be dependent on many factors, only partly explainable by changes in cultivation techniques and with fragmentation that plays an important role (Sirami *et al*. 2009). This should prompt to evaluate with more carefulness the possibility of constructing "nets", "ecological connections" etc. While the forest species take advantage of the increase of the surfaces, infact, the most demanding species require an improvement in the "quality" of the woods. As for the full range species (which also include other local species, such as the Stone Curlew *Burhinus oedicnemus*, and the Collared Pratincole *Glareola pratincola* etc.), they require non fragmented open spaces in which diversity point-like elements can be inserted (La Mantia 2010). On the contrary, interventions on wood arboricultures have not given any benefits to Sicily's biodiversity (La Mantia 2002), although undoubtedly, as it has occurred in many other Mediterranean countries (Gil-Tena *et al*. 2010) the increase in forest areas through reforestation and above all naturalization have had a generally positive impact on forestry birdlife.

Probably land sharing, defined the "traditional European approach" (Herzog & Schüepp 2013) allows greater biodiversity preservation in areas historically transformed by human activities (von Wehrden *et al*. 2014).

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Electronic Supplementary Materials (ESM): http://ciso-coi.it/wp-content/uploads/2014/12/LaMantia_et_al_ESM.pdf

ESM 1 - Birds related to arboreal environments in Sicily; their habitats, chorology and evaluation on their role as indicators (the trend is evaluated with reference to Sicily's atlases: Massa 1985, Lo Valvo *et al.* 1993, AA.VV., 2008).

Species	**Habitat**	**Could it be considered as a good health and quality indicator for Sicily's woods?**
Eurasian Sparrowhawk *Accipiter nisus* (L.)	It breeds in mixed forests; in recent years it has also been expanding in reforestations.	The trend to which it is subject (expansion also in reforestations) makes it a good indicator but it is still distributed in a fragmentary manner.
Common Buzzard *Buteo buteo* (L.)	In Sicily, unlike what happens in other areas, it also nests on rocky cliffs or trees if necessary. Their privileged habitat during nesting is that of the mosaic, having rocks or isolated trees, combined.	It avoids dense forests regardless of their specific composition; it is therefore not a good indicator.
Eurasian Hobby *Falco subbuteo* L.	In Sicily, it could be defined as a "cloak" species; it nests in the woods but at the edge of open habitats (especially grazing lands).	The extreme localization, does not allow to make any assessments, however, it seems to be related to sparse tree environments. It has also nested in eucalyptus trees.
Common Wood Pigeon *Columba palumbus* L.	Once linked to the woods, it is today booming in all areas having trees as a component.	Until a few years ago it could have been considered as a good indicator, but it is not one anymore.
European Turtle Dove *Streptopelia turtur* (L.)	It is linked to the dry arboreal formations and forests up to 1100 m altitude.	It lives either in dry arboretums (almond groves, olive groves, etc.) and in the scrub-forests. It does not generally nest in pine and eucalyptus tree reforestations. Appears to be in recovery.
Common Cuckoo *Cuculus canorus* L.	It is widespread in the vegetation and forest mosaics. It is a parasite species that lays its eggs in other birds nests, mostly in shrubby areas or scrubland.	For this species, their density could be used as an indicator but it actually appears to be dependent on food resources (caterpillars).
Barn Owl *Tyto alba* (*Scopoli*)	With regards to forests, it could be considered as a "mantle" species.	It cannot be considered as an indicator for woods.
European Scops Owl *Otus scops* (L.)	A widespread species; it always lives at the edge of woods, however, it reaches its altitudinal limit at the reach of Mount Etna in the forests of the black pine trees.	It can not be considered as an indicator for woods.
Tawny Owl *Strix aluco* L.	The species is also found in open habitats as long as there are rocks for nesting. Also in the woods, the presence of rocks or hollow trees, is fundamental.	If present in the woods with no rocks, its ability to nest is mainly due to hollow trees that can accommodate the nests. However it is not considered a good indicator because it also nests in rocky areas that lack tree covering.
Long-Eared Owl *Asio otus* (L.)	A species that has colonizing Sicily for a few years and that	Although it is found in small size reforestations, which it uses as winter

Species	**Habitat**	**Could it be considered as a good health and quality indicator for Sicily's woods?**
	seems to be expanding its niche; It is nontheless linked to forest environments.	recovery, is in great expansion in the forest areas.
European Nightjar *Caprimulgus europaeus* (L.)	It appears to be linked to sparse forests and open mountainous areas.	It is not widespread and its ecology is little known in Sicily. It can not be considered as an indicator.
Hoopoe *Upupa epops* (L.)	It can not be defined as a forest species for it lives in different tree environments.	It can not be considered as an indicator for those woods which it sporadically lives in.
Eurasian Wryneck *Jynx torquilla* (L.)	It nests in natural mixed forests.	The localized distribution does not appear to be easily correlated to environmental parameters.
Great Spotted Woodpecker *Dendrocopos major* (L.)	As for the common pigeon, it has expanded its niche and now also lives in mature reforestations.	It may be considered as an indicator of "naturalness" achieved by afforestation. The different densities make it a good indicator.
Woodlark *Lullula arborea* (L.)	Mosaic and edge species.	It lives on the edge of woods and reforested areas, it is not a good forest indicator.
Eurasian Wren *Troglodytes troglodytes* (L.)	Woodland and scrub species that has broadened its niche in recent years (orchards, etc..).	Perhaps density, for this species, may be used as an indicator, but the species is distributed in many different habitats, even suburban ones.
European Robin *Erithacus rubecula* (L.)	It nests in natural forests but it seems to be expanding.	As a breeder, and certainly not as a wintering, it appears to be a good indicator, which is in expansion in non-forest areas.
Common Blackbird *Turdus merula* (L.)	It is a well-spread species in many different environments that can also include a low vegetation cover.	It is a very common species and it is not considered a good indicator since it prefers marginal areas.
Mistle Thrush *Turdus viscivorus* (L.)	It breeds in mixed woods such as: holm oaks and downy oaks.	It is expanding into areas such as the Sicani mounts, where pine reforestations are in the process of naturalization carried out by broadleaf trees.
Eurasian Blackcap *Sylvia atricapilla* L.	It is widespread in tree covered areas, but also in orchards and scrubs.	Is not considered as a good indicator, since it is easily found even in urban greeneries and orchards.
Common Chiffchaff *Phylloscopus collybita* (Vieillot)	As a breeder it is linked to natural deciduous and conifer forests or reforestation areas in which conifers have been planted for at least 40 years.	It may be considered as an indicator for mesophilic forests diversity.
The Common Firecrest *Regulus ignicapillus* (Temminck)	It nests in deciduous oak and beech forests having Ilex aquifolium, and sometimes in conifers too. It also nests along the	It lives in high humidity conditions, even at low altitudes when facing north and it probably is not a good indicator.

Species	**Habitat**	**Could it be considered as a good health and quality indicator for Sicily's woods?**
	coastal areas in specific conditions.	
Spotted Flycatcher *Muscicapa striata* (Pallas)	It usually lives in wooded areas but it also appears in sparse forests and reforestation areas.	It can not be considered as an indicator.
Long-tailed Tit *Aegithalos caudatus siculus* (Whitaker)	It lives in broadleaf forests.	Perhaps it may be considered more properly as an indicator of humidity conditions within the forest.
Marsh Tit *Poecile palustris siculus* (De Burg)	It is related to beech forests having a stratified vegetation by the presence of undergrowth in *Ilex aquifolium, Prunus spinosa, Crataegus oxycantha*.	It is considered as a good indicator for mountain forests; the subspecies that lives in Sicily is endemic. Nontheless the vegetation structure of forests in Sicily, should be studied in more depth.
Coal Tit *Periparus ater* (L.)	It lives in natural mesophilic and mountain forests. It has recently colonized conifer reforestations planted for over 40 years.	It may be considered as a good indicator. Species such as the following can also use cavities in the stone walls for nesting, but often it nests at the base of trees, inside holes among the roots. The species is increasing its number.
Eurasian Blue Tit *Cyanistes caeruleus* (L.)	It lives in many different arboreal formations but mostly in forests.	Its density may be considered a good parameter that indicates the quality of the woods, but this depends on its diet and it is very ubiquitous for it is found also in olive groves.
African Blue Tit *Cyanistes teneriffae ultramarinus* (Lesson)	It lives in trees and tree-shrub formations on the island of Pantelleria, the only place in Europe where this species is present.	Even for this species density could be a good indicator but il can also be observed outside woods and it lives exclusively in Pantelleria.
Great Tit *Parus major* L.	It is more widespread compared to the previous species.	It cannot be considered as a good indicator due to its ubiquity.
Eurasian Nuthatch *Sitta europaea* L.	It lives in natural forests, in a range of 700 and 1700 mt of height. It can be found especially in the areas from Mandonie to Etna.	It can be considered as a good indicator in that ripe forests area.
Short-toed Treecreeper *Certhia brachydactyla* C. L. Brehm	It lives in tree-lined areas, and besides natural and artificial forests it can also be found in dry arboretums as well.	Its diffusion could be considered as a good indicator but it can be easily found in green urban environments. It is an indicator of plants size.
Eurasian Golden Oriole *Oriolus oriolus* (L.)	In Sicily it has an irregular distribution as a breeding bird.	It cannot be considered as an indicator because of its irregular distribution.
Red-Backed Shrike *Lanius collurio* L.	It lives in clearings and high Mountain forests.	It is a landscape indicator. It highlights the balance between open and closed

Species	**Habitat**	**Could it be considered as a good health and quality indicator for Sicily's woods?**
		spaces.
Woodchat Shrike *Lanius senator* L.	It is a mosaic species. It lives in new reforested areas as well.	It cannot be considered a forestry indicator.
Eurasian Jay *Garrulus glandarius* (L.)	It lives in tree-lined areas	Its density could be used as an indicator, but the species is spreading in orchards as well.
Eurasian Magpie *Pica pica* (L.)	It lives in tree-lined areas.	It does not live in forests.
Common Chaffinch *Fringilla coelebs* L.	Although it appears in tree-lined areas, this species is not very common as a breeding bird. During the winter Center-Europe populations use Sicilian forests as dormitories.	After its decrease, today its presence could be used as an indicator of forest quality
European Serin *Serinus serinus* (L.)	It appears in tree-lined areas	It cannot be considered as a good indicator because it lives in conifer reforested areas, cultivated gardens and green urban areas.
European Greenfinch *Carduelis chloris* (L.)	Although it appears in tree-lined areas, it is not as common as breeding bird.	It is not a good indicator because it lives in conifer reforested areas.
European Goldfinch *Carduelis carduelis* (L.)	Although it lives in tree-lined areas, it leaves those that are too dense.	It cannot be considered as a good indicator.
Eurasian Siskin *Carduelis spinus* (L.)	It appears in Etna natural black pine forests as a breeding bird.	It confirms the extraordinary value of natural black pine forests, as other species do, but it cannot be used as an indicator.
Common Linnet *Carduelis cannabina* (L.)	It lives in non-too-dense tree-lined areas, as does the European Goldfinch.	It is not a good indicator.
Red Crossbill *Loxia curvirostra* L.	It is originally linked to Etna natural black pine forest (Priolo & Sarà 1981), it sometimes appears in Aleppo pine reforested areas of the Island (Baglieri and Iapichino, 1990) where its population is stable (AA. VV. 2008). This species make periodic invasions (Sturniolo 1910, Whitaker 1910).	It can be considered as an indicator of the ripeness of gymnosperm reforested areas. In the Etna area there is a stable population of this species, which underlines the balance of conifer forest.

ESM 2. Land use (ha) variations (%) (years 1987-2000) in the 31 quadrants in which the Mistle Thrush appeared.

Land use classes	1987	2000	Variations
Arable	52,491	43,470	-17.2
Grazing	66,659	46,906	-29.6
Complex systems	31,443	26,825	-14.7
Almond groves	6,829		-100.0
Olive groves	27,779	30,575	10.1
Vineyard	2,293	724	-68.4
Orchard	27,741	27,637	-0.4
Broadleaves	19,096	37,250	99.5
groves	222	1,075	384.2
Ripe Conifers	1,340	1,157	-13.6
Reforestation conifers	298	1,437	382.2
Mixed forests	5,585	7,420	32.9
Partially wooded areas	25,368	20,201	-20.4
Bush and scrublands	20,607	41,323	100.5
Sparse vegetation	4,316	1,800	-58.3
Urban environment and infrastructures	5,657	4,093	-27.6
Beaches	14	99	587.0
Watercourses	1,150	1,466	27.4
Water basins	181	102	-43.7
Total	299,071	293,559	

ESM 3. Land use (ha) variations (%) (years 1987-2000) in the 23 quadrants in which the Long-eared Owl appeared.

Land use classes	1987	2000	Variations
Arable	58,293.7	52,224.6	-10.4
Grazing	48,621.6	28,841.4	-40.7
Complex systems	22,040.8	21,890.7	-0.7
Almond groves	283.0		-100.0
Olive groves	9,910.9	7,748.7	-21.8
Vineyard	3,195.2	3,022.6	-5.4
Orchard	11,455.5	11,483.2	0.2
Broadleaves	16,396.7	25,056.3	52.8
Eucalyptus groves	3,270.0	4,054.0	24.0
Ripe conifers	1,587.5	852.9	-46.3
Reforestation conifers	471.0	1,281.0	172.0
Mixed forest	2,459.8	3,845.2	56.3
Partially wooded areas	20,093.4	14,784.8	-26.4
Bush and scrublands	7,712.5	32,362.7	319.6
Sparse vegetation	7,388.5	4,572.2	-38.1
Urban environment and infrastructures	8,774.0	9,555.3	8.9
Watercourses	673.7	691.3	2.6
Water basins	74.9	92.2	23.1
Total	222,702.7	222,359.0	

ESM 4. Land use (ha) variations (%) (years 1987-2000) in the 17 quadrants in which the Eurasian Nuthatch appeared.

Land use classes	1987	2000	Variations
Arable	13,951	8,431	-40
Grazing	47,676	24,000	-50
Complex systems	12,819	14,501	13
Olive groves	13,661	9,999	-27
Vineyard	294	117	-60
Orchard	15,433	16,229	5
Broadleaves	12,691	26,055	105
Eucalyptus groves	5	264	5517
Conifers	1,422	609	-57
Reforestation conifers	600	868	45
Mixed forest	7,291	8,344	14
Partially wooded areas	20,483	16,727	-18
Bush and scrublands	10,158	29,610	191
Sparse vegetation	3,482	928	-73
Urban environment and infrastructures	5,750	7,991	39
Watercourses	808	1,197	48
Water basins	153	108	-29
Total	166,678	165,978	

ESM 5. Land use (ha) variations (%) (years 1987-2000) in the 5 quadrants in which the Sicilian Marsh Tit appeared.

Different land use	1987	2000	Variations
Arable	3,948	2,364	-40
Grazing	17,195	9,000	-48
Complex systems	411	2,240	444
Olive groves	3,472	3,524	2
Vineyard	0	55	
Orchard	2,353	2,255	-4
Broadleaves	8,935	15,008	68
Eucalyptus groves	0	0	
Conifers	18	19	7
Conifers reforestation	4	11	157
Mixed forest	440	1,640	273
Partially wooded areas	13,294	5,987	-55
Bush and scrublands	184	7,972	4223
Sparse vegetation	667	596	-11
Urban enviroments and infrastructures	279	437	57
Watercourses	73	180	148
Water basins	40	26	-35
Total	51,314	51,314	0

ESM 6. Land use (ha) variations (%) (years 1987-2000) in the 86 quadrants in which the Greater Short-toed Lark disappeared.

Different land use	1987	2000	Variations
Arable	292,514.4	294,122.7	0.5
Grazing	68,410.0	71,196.3	4.1
Complex systems	140,813.2	72,220.8	-48.7
Almond grove	14,725.5		-100.0
Olive grove	57,942.5	70,911.2	22.4
Vineyard	60,573.2	70,481.4	16.4
Orchard	44,659.6	54,015.1	20.9
Broadleaf	15,572.0	17,598.8	13.0
Conifers	7,808.2	10,890.0	39.5
Mixed forest	2,142.3	5,456.1	154.7
Partially wooded areas	8,890.8	6,129.5	-31.1
Bush and scrubland	33,014.7	66,149.9	100.4
Sparse vegetation	7,069.2	9,505.7	34.5
Urban environments and infrastructures	24,895.6	30,483.7	22.4
Green urban areas	196.0	353.4	80.3
Watercourses	527.4	210.5	-60.1
Water basins	2,044.8	2,349.8	14.9
Marshes	286.0	309.1	8.1
Total	782,085.4	782,383.7	

ESM 7. Land use (ha) variations (%) (years 1987-2000) in the 75 quadrants in which the Calandra Lark disappeared.

Different land use	1987	2000	Variations
Arable	250,573.3	275,087.6	9.8
Grazing	53,708.0	51,072.1	-4.9
Complex systems	144,701.8	71,119.7	-50.9
Almond grove	15,224.0		-100.0
Olive grove	43,229.2	57,997.1	34.2
Vineyard	69,156.5	73,521.3	6.3
Orchard	18,724.3	26,098.1	39.4
Broadleaves	14,086.3	20,498.3	45.5
Conifers	3,754.6	6,045.8	61.0
Mixed forest	2,230.5	4,955.4	122.2
Partially wooded areas	11,340.6	5,860.3	-48.3
Bushes and scrublands	25,746.8	54,504.6	111.7
Sparse vegetation	6,709.7	9,233.2	37.6
Urban environments and infrastructures	19,617.1	24,101.9	22.9
Green urban areas	146.0	290.6	99.1
Beaches	1,623.8	993.6	-38.8
Watercourses	1,026.2	987.3	-3.8
Water basins	1,183.6	1,379.7	16.6
Marshes	618.4	361.7	-41.5
Total	683,400.6	684,108.3	