On farm survival of Apulian legume and cereal landraces in relation to land cover/land use changes. A case study

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Data availability: the ortho-photos analysed during the current study are available on the official WMS service of the National Geoportal, Italian Ministry of Environment (http://www. pcn.minambiente.it), and AGEA portal (http://agea.gov.it). Details on the license to access are included in the *Materials and methods* section. The images relative to land use/land cover analysed during the current study are available on Copernicus Land Monitoring Service of European Environment Agency (EEA) site (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=mapview).

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Highlights

- *Analysis of present distribution of Apulian legume and cereal landraces.*
- *Short description of the landscape of collection sites.*
- *Comparison of present and past diffusion of landrace cultivation.*
- *Changes in land cover/land use that occurred over the last three decades.*

Abstract

Apulia (southeast of Italy) has always been an agricultural region in the Italian landscape. Nowadays, the countryside is a mix of natural environments and artificial landscapes. From 2014 to 2016, the region has been the object of a project aimed to collect information about geographic position and surface devoted to legume and/or cereal landrace cultivation. The collection missions carried out allowed the acquisition of 352 samples belonging to eight legumes and six cereal species. Chickpeas predominated among legumes, while durum and common wheat landraces prevailed among cereals. The cultivation of these landraces was mainly located in the marginal areas of central and southern Apulia region. The geographical information system technology, used in order to geo-reference the collection sites, allowed investigating the changes in land cover/land use (LCLU) occurred over the last three decades at each collecting site. In addition to the evidences collected at field level, the comparison of old ortho-photos and recent satellite images, available on Copernicus Land Monitoring Service of European Environment Agency, shown that very limited changes of LCLU have occurred. Near the collection sites, the agrarian landscape is remained highly fragmented as it was three decades ago. The cultivation side by side of irregular patches with legumes, cereals, olive trees, and grapevine characterise the agricultural landscape. Based on these evidences it can be infer that the absence of significant changes in LCLU has play a positive role in the safeguard of *on farm* conservation of Apulian landraces.

Introduction

It is well known, that cultivated species evolve and differentiate in response to selective pressure of both growing environment and local farmer selection. Everywhere these processes allow the selection for each crop of one or more landraces well adapted to the climatic conditions of a well-defined cultivation area (Pistorius, 1997). They are maintained within traditional agricultural systems (*on farm* conservation) since are able to satisfy agronomic, nutritional and aesthetic preferences of local farmers usu-

ally growing them (Ceccarelli, 2012; Negri, 2005; Maxted *et al.*, 2002). Frequently, landraces are indispensable ingredient of local recipes or, being included in ritual celebrations, become part of cultural heritage of the community or ethnic minority growing them.

In XX century, the development of large-scale plant breeding programmes, aimed to increase the yield of the most important crops, produced, at worldwide scale, the progressive replacement of landraces with new released varieties. An unknown number of landraces disappeared, while others were progressively relegated in marginal areas where traditional agricultural practices are still applied (Brush and Meng, 1998). Several recent studies have shown that part of the local germplasm of legume and cereal species still survive *on farm* in several European countries and Mediterranean small islands. These investigations evidenced the survival not only of landraces belonging to important crops such as common bean (Sánchez *et al.*, 2007; Mavromatis *et al.*, 2010; Lioi *et al.*, 2012) and wheat (Mangini *et al.*, 2017; Fiore *et al.*, 2019) but also those belonging to minor species such as emmer (Barcaccia *et al.*, 2002; De Vita *et al.*, 2006), barley (Bellucci *et al.*, 2013; Pasam *et al.*, 2014) and lima bean (Piergiovanni *et al.*, 2012). In Italy, the landrace harvest is mainly devoted to self-consumption of producers and occasionally sold in local markets without any food label. Only a low number of Italian élite landraces have earned a key position in the national market as niche products. Examples are the '*lentil from Castelluccio di Norcia*' that obtained the European quality marks Protected Geographical Indication in 1996, and the durum wheat '*Senatore Cappelli*', a variety included in the Italian register of wheat varieties. All relic landraces lacking of a niche market are endangered by disappearance in the next decades since mainly cultivated by aged farmers.

Apulia, the most south-eastern region of Italy, has a surface of 19.358 km^2. The region, is relatively long (350 km) and narrow (60 km), is characterised by broad plains, more than 60% of territory has an elevation below 200 m a.s.l., and low-lying hills. The highest peaks of the two mountainous areas, Gargano promontory and Monti Dauni, both in the north of the region, do not exceed 1.150 m a.s.l. Due to this orography, Apulia has always been an agricultural region mainly producing wheat, wine, olive oil and tomato. The climate is Mediterranean, though influenced by the complex morphology of mountainous and hilly areas (Blasi *et al*., 2014). As a consequence of these territorial discontinuities, there are diversified micro-climatic conditions among the eleven districts recognised by regional laws (Figure 1). The occurrence of climatic differences is associated to dissimilar arrays of both wild and cultivated plant species. Nowadays, the Apulian countryside is a mix of natural environments and landscapes modified by humans, with some districts, characterised by a highly heterogeneous and fragmented agricultural landscape. Agrarian landscape of plains is characterised by extensive cultivations of wheat, olive groves, grapevine or tomato interchanged with vegetable cultivations. Conversely, family run gardens and nature reserves are mainly located into the more marginal and hilly areas. In addition to different micro-clime among the Apulian districts, the region length has affected the seed exchange among the farmers. These environmental and anthropic dynamics factors, together with different socio-cultural preferences, have led to the selection of several landraces, belonging to both legumes and cereals, strictly related to one or a few regional districts.

European and Italian policies (European Union Council, 2004; Vetelainen *et al.*, 2009; Nagoya Protocol, 2011; Apulian Regional Law, 2013; MiPAAF, 2013) have given new opportunities at national and regional research institutes to promote the safeguard of the local germplasm supporting, not only its collection, characterisation and *ex situ* storage, but also *on farm* maintenance of these precious resources (Negri, 2005). In this frame, the Institute of Biosciences and BioResources of the National Research Council (IBBR-CNR), coordinated from 2014 to 2018 the multidisciplinary project entitled '*Recovery, characterisation, preservation and valorisation of legumes, cereals and forage in Apulia*' (SaVeGraINPuglia). The project, financed by Apulia region in the frame of the European Agricultural Fund for Rural Development (Regulation EU, 2013), involved 21 partners among public research institutions, associations and private farmers operating in the region. This paper presents the current *on farm* survival of legume and cereal landraces and attempts a comparison with the landrace distribution recorded in previous missions carried out from 1970 to 1989. Historical documents and bibliography concerning physical and morphological landscape of the past decades and informal interviews of local farmers have been considered to identify the factors that might have facilitated the *on farm* conservation of several landraces. Finally, a rough evaluation of changes occurred in the last four decades relatively to both land use and land cover was attempted by analysing the data acquired at field level and by remote sensors (orthophotos and satellite images).

Materials and methods

The territorial survey of SaVeGraINPuglia teams aimed to the collection of local legume and cereal germplasm took place from 2014 to 2017. The districts to be monitored in detail were identified on the base of the information found in historical documents that describe the local varieties cultivated in the past (Piergiovanni *et al.*, 2017). The reports relative to the collecting missions carried out in the region during the last four decades were also consulted. Areas characterised by intensive agricultural practices, Natural Parks, naturalistic reserves and mountains, were not considered in this study. At the same time of seed sample collection, several data were acquired through brief interviews of farmers. According to the forms included in the Guidelines of Italian Program for Biodiversity Safeguard (MiPAAF, 2013), for each sample was recorded: passport data, geographic coordinates of farm and its

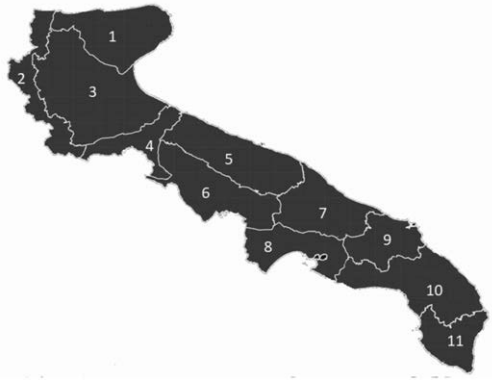

Figure 1. Apulian regional districts: 1. Gargano; 2. Monti Dauni; 3. Tavoliere; 4. Ofanto; 5. Puglia centrale; 6. Alta Murgia; 7. Murgia dei trulli; 8. Arco jonico tarantino; 9. Campagna brindisina; 10. Tavoliere salentino; 11. Salento delle Serre.

facilities, farmer age and education level, a short description of agro-technique usually adopted, resistance to biotic and abiotic stress, marketing types of the harvest, and vernacular name of each landrace. In addition, a detailed photographic documentation of cultivation fields of each farm as well as of the surrounding agrarian landscape was also acquired. The collection missions allowed gathering 352 samples belonging to 14 species. Legume samples represented 67% of total samples, while the remaining 33% were cereals. In order to obtain a sufficient sampling of genetic variation associated to each landrace, a seed sample was acquired from each farmer growing it. A different number of samples (from 1 to 10) was collected for each landrace in order to obtain a sampling of its genetic variation.

With the purpose to evaluate land use and land cover changes occurred at each collecting site, the available ortho-photos from 1988 or 1989 and from 2009 or 2012 were acquired. They were obtained from the official WMS service of the National Geoportal, Italian Ministry of Environment (http://www. pcn.minambiente.it), and by AGEA portal (http://www.agea.gov.it), respectively. Ortho-photos from WMS were provided by BLOM CGR s.p.a. under the licence CC BY-SA 3.0 IT: https://creativecommons.org/licenses/by-sa/3.0/it/#, while those by AGEA under the licence CC BY-SA 3.0 IT: https://creativecommons.org/licenses/by-sa/3.0/it/#. Photos relative to the same site were included in a geographical information system (GIS) using the WMS OGC protocol and analysed using a visual photo-interpretation at 1:2000 map scale. The post-classification change detection was applied to minimise the need of normalising data for atmospheric and sensor differences among the ortho-photos recorded in different years. Roughly speaking, visual interpretation of photos gives a general knowledge of large-scale changes, such as variations of arable lands, forests, natural or artificial lakes, wetlands, enlargement of human settlements, new man-made structures such as farm facilities, roads, railways, *etc*. In order to obtain time-lapse images for land cover/land use of two zones characterised by a high number of collected landraces Corine land cover maps were also consulted. These maps can be consulted at the site Copernicus Land Monitoring Service of European Environment Agency (EEA) (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=mapview).

Results and discussion

Apulian landraces still under cultivation

As expected, the collecting missions carried out by SaVeGraINPuglia partnership found sporadic cultivations of legume and cereal landraces in Apulia region. Generally, they are still cultivated on small surfaces frequently located in marginal areas. The presence in home gardens of a few plants of legume landraces, mainly common beans and fava beans, or durum and bread wheat was also detected. In these environments, the landraces have been relatively protected by the replacement with modern varieties and by switch from the subsistence agricultural models to the intensive ones. At the end of the project, about 300 farms, differing for cultivated surface, technology of available facilities and cultivated crops were visited. The *on farm* conservation of legume and/or cereal landraces was detected in about 70% of these farms. The presence in the same farm of a few landraces, sometimes belonging to different species, was frequently observed. The persistence of the traditional triennial crop rotation (cereals/legumes/forage species), widely applied in Apulia in the past centuries (De Cesare, 1859; Rivera, 1928), can explain the presence side by side of plots of land with landraces belonging to different species. Of course, since herbaceous species were the object of the present study, the surface devoted to landrace cultivation frequently changes from year to year in the same farm. The custodians met in this study were mainly elders of both genders, running small farms. Almost all are landowners, who address the own harvest to self-consumption and, only occasionally, sale it, lacking of any certified labelling and packaging, in local markets. During the informal interviews carried out at the same time of landrace collection, farmers declared to perpetuate the cultivation of one or a few landraces, because affectively linked to materials that cultivate since from their youth. At the demand to give information about the origin of their landrace generally, they stated to have received it from parents or grandfathers. For these reasons, elder farmers should be considered, at the same time, custodians of the Apulian germplasm, promoters of the incessant landrace adaptation in response to biotic/abiotic stress and keepers of precious non-material information related to traditional management prac-

Figure 2. Geographical distribution of landrace collection sites. Left - legumes; right - cereals.

tices, local recipes, ritual uses, sayings, *etc*.

The geographic distribution of collecting sites among the eleven districts (Figure 1), officially recognised by Apulian authorities (Apulia Region, 2015), showed that legume and cereal landrace cultivations were mainly located in central and southern districts (Figure 2). Landrace cultivation was detected along the north-western regional boundary, an area characterised by hilly environments (Monti Dauni), in the inner areas of central Apulia (Murgia), an environment hard to cultivate, being a rocky and generally, a water-free soil, and in poor soils of the southern end of the region. Small plots devoted to cereal landrace cultivation were detected in '*Puglia centrale*' and '*Arco tarantino*' districts, while a few legume samples were collected in '*Tavoliere*' and '*Gargano*' districts. No landraces were found under cultivation in '*Ofanto*' and '*Campagna brindisina*' districts, because vineyards, olive groves, orchards and horticultural species were widely cultivated in these districts. Several factors may have generated this not-uniform distribution. They might be pedo-climatic conditions not suitable for the cultivation of legumes and cereals, lack of a well-established tradition of their cultivation, sound presence of agricultural models based on improved varieties that assure to farmers higher incomes.

The percentage distribution of collected samples among the species included into the macro categories cereals and legumes is shown in Table 1. Legumes, landraces belonging to eight species, all commonly grown in the Mediterranean countries, were collected. The percentage distribution of samples among these species were similar for the two most dominant species chickpea and fava bean. A special case was the single flower vetch (*Vicia articulate* Hornem). It is a very uncommon cultivation in Apulia, since only one sample was collected. Human consumption of this vetch, some years ago recorded also in Sardinia (Laghetti *et al.*, 2000), is attributable to the high similarity of seed shape with that of lentil. The misunderstanding is testified by the Italian vernacular name '*lenticchia nera*' (black lentil) used by farmers of both Apulia and Sardinia regions to identify this legume.

In the cereal macro-category, among the six groups of collected species, the percentage of durum and bread wheat landraces were the predominant fraction (70%) of all samples (Table 1), while emmer, rye, and some landraces of tetraploid wheats (*'miracle wheat', 'cannulino'* and *'grano buono di Rutigliano'*) resulted very rare, being collected at individual sites. In general, the wheat predominance within cereals is not surprising, since Apulian agriculture is, from very long time, focused on wheat cultivation (Rosati, 1803; De Cesare, 1859). This vocation came better to light considering that, among *Triticum* species, mainly landraces belonging to emmer (*T. dicoccum* Schubler) were collected in central Italy (Porfiri *et al.*, 2001), and no landraces, belonging to corn or rice, extensively grown in northern Italy, were collected during the SaVeGraINPuglia project.

Previous studies showed that each legume or cereal landrace has its own vernacular name usually shared by local farmers traditionally growing it. However, some authors, through detailed genetic characterisations of collected germplasm, evidenced examples of synonymy for samples gathered by farmers living in close villages, or, at the opposite, cases of homonymy for samples sharing the same vernacular name (Lioi *et al.*, 2012; Margiotta *et al.*, 2018). In contrast with a large part of legume landraces cultivated in Italy (Negri *et al.*, 2000; Lioi *et al.*, 2012; Mercati *et al.*, 2013) Apulian landraces generally, lack use of the vernacular name. Moreover, when farmers declared a local name, it consisted of the species name followed by the village or district where it is traditionally cultivated (*i.e.*, *cece di Nardò* - chickpea from Nardò; *fagiolo dei Monti Dauni* - common bean from Monti Dauni; *fava di Carpino* - fava bean from Carpino). Exceptions were *pisello secco di Vitigliano* (dry pea from Vitigliano) and *fava di Zollino* (fava bean from Zollino), both cultivated in southern Apulian districts, locally named '*piseddu quarantinu or cuciulu*' and '*cuccia or kuccia*', respectively.

Evidences collected in the present study showed that Apulian farmers designate both durum and common wheat landraces with appellatives recalling old varieties, races or populations widely cultivated in the past. For example, the name *Saragolla* recalls a group of old durum wheat varieties released at beginning of XX century (De Cillis 1927), while *Bianchetta* remembers bread wheats known long before the twenties. In contrast, Apulian farmers to name the oat and barley landraces commonly used the non-specific adjective '*locale*' (local).

Although, no sufficient evidences were collected to make sure of the existence of structured networks among farmers growing the same landrace, the linkage between each landrace and the traditional cultivation area was manifest for legumes and some minor cereals, but weak for durum and bread wheat. The *fava di Carpino* and *cece nero di Muro leccese* are cultivated only in the countryside near Carpino and Muro leccese villages (Figure 1: '*Gargano*' and '*Salento delle Serre*' district, respectively). A territoriality at district level was observed for rye and barley landraces, being their cultivation practiced only in limited areas of 'Monti Dauni' and 'Salento delle Serre' district, respectively. In the last district barley landraces are used to prepare traditional breads or toasted breads, the most popular ones, named '*friselle* or *frise',* have donut shape. A more open seed circulation can be supposed for those durum and common wheat landraces, which were found sporadically grown in several districts. These are the cases of *Saragolla locale di Puglia* and *Bianchetta,* durum and common wheat, respectively, which cultivation was detected in farms located from northern to southern districts.

Table 1. Distribution of collected samples.

Cereal species	Percentage (%)	Legume species	Percentage (%)
Durum wheat	38	Chickpea	34
Bread wheat	32	Fava bean	21
Barley	14	Grass pea	13
Oat	12	Lentil	6
Emmer	2	Pea	5
Rye	2	Lupine	2
		Vetch	1

Land use/land cover changes in the areas of landrace cultivation

In general, the conservation of environment and agrobiodiversity often drives towards the adoption of several forms of sustainable agriculture as well as changes in land cover and land use. This changing is essentially determined by modification, alteration and so on of land cover (surface characteristics and immediate subsurface of the land including biota, soil, topography, groundwater, human structures), and by variation of land use (economic and social management of the land) (Turner *et al.*, 1994; Haines-Young, 2009). The conservation of landraces, in the habitat where

they have been cultivated for at least 70 years, was included in the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (FAO, 2009), being considered a focal point of the agrobiodiversity conservation (FAO, 2017).

From 1979 to 1990, some exploration missions to collect local germplasm of herbaceous species were carried out in Apulia region by different teams of researchers, some of them working at CNR-IBBR of Bari. These missions evidenced that, despite an appreciable diffusion of landraces in several Apulian districts (Figure 3), a heavy genetic erosion of crop species was noticeable (Perrino *et al.*, 1982, 1984; Perrino and Hammer, 1983; Hammer *et al.*, 1989).

The collection missions carried out in the SaVeGraINPuglia project began with the awareness that from 1990 to the present Apulian agriculture has experienced deep transformations. They are the progressive abandonment of traditional agro-techniques, a constant increase of monocultures based on improved varieties, changes of cropping environment in response to new market requests, the reduction of people employed in agriculture and a progressive soil erosion (Ladisa *et al.*, 2010, 2012; Inbrenda *et al.*, 2014). All these factors are widely recognised as responsible for landrace disappearance at worldwide level. Unexpectedly, the in-depth monitoring of selected target areas carried out in the SaVeGraINPuglia project evidenced that several landraces are still cultivated. The comparison of the maps relative to recent and past collection sites (Figures 2 and 3, respectively) shows that landrace cultivation has persisted essentially in the same areas. These results stated as the strong linkage between each landrace and its traditional cultivation area has favoured the passage of this local germplasm from at least two farmer generations. As testified by the photographic documentation acquired at field level, the agrarian landscape surrounding the collecting sites did not show uncultivated plots. Moreover, the diffuse presence of different crops cultivated side by side testifies a highly diversified land use in marginal areas. It is widely accepted that management to maintain the still present agrobiodiversity requires the recognition of all features promoting *on farm* conservation in advanced agricultural backgrounds (Frison *et al.*, 2011). For this reason, along with visual observations at field level, the collection protocol adopted during the SaVeGraINPuglia missions encompassed the use of GIS technology in order to geo-reference all the collection sites. This allowed attempting a preliminary evaluation of land cover/land use evolution occurred at local scale by comparing old aerial photos with the more recent satellite images. Previous studies demonstrated that visual examination of ortho-photos and satellite images, without their digitalisation, allows the correct identification of changes in forests, water areas, industrial and urban settlements, construction of new roads or other human structures, while confusion between crops and grasslands is possible due to the seasonal changes in vegetation occurring for these cultivations (Chabert *et al.*, 2019). Based on this approach, the available ortho-photos and satellite images relative to each collection site were acquired and analysed to trace local dynamics of land cover/land use over the last three decades. Overall, the comparison of available images evidenced that changes in land cover/land use affected about 50% of collection sites (Piergiovanni *et al.*, 2019). However, they occurred on small plots, suggesting a contained anthropogenic pressure on the environment. The most frequent modifications concerned the increase of wooded surface or of the farm facilities (37 and 33% of sites, respectively). The left panel of Figure 4 show the increase of wooded surface and farm facilities occurred in parcels located near Martina Franca ('*Murgia dei Trulli*' district) where the cultivation of *'Bianchetta'* bread wheat was detected. The right panel shows an opposite example. The comparison of two images relative to the parcel where the cultivation of '*pisello secco di Vitigliano*' was detected (Vitigliano village, '*Salento delle Serre*' district) clearly shows as the land cover is unchanged over the investigated period.

Still presently, there is a significant lack of studies investigating the relation between *on farm* survival of landraces and land cover/land use changes involving the area traditionally devoted to these cultivations. Generally, biologists study the biodiversity of natural habitats rather than agricultural landscapes. Single species conservation is the principal focus of studies on biodiversity conservation, while biogeographic maps are a combination of physical, animal and vegetational data but do not necessary reflect the distribution of threatened species at local scale (Blasi *et al.*, 2014).

To try to shift the evaluation of land use/land cover changes from a punctual level, such is the collecting site, to an intermediate level we focused our attention on the areas that, at sub district level, were characterised by a high density of collection sites. Two areas, named core units, were identify within the region (Figure 5). They are located in '*Murgia dei Trulli*' and '*Salento delle Serre*'

Figure 3. Geographical distribution of landrace collection sites relative to the past missions. Left - legumes; right - cereals.

districts (Figure 1). The photographic documentation acquired at field level near the collecting sites belonging to these core units showed that agrarian landscape was generally characterised by an appreciable differentiation of cultivated crops. Figure 6, showing the succession of different cultivations (a vineyard, a parcel of non-irrigated arable crops and olive trees) is an explanatory example of these agrarian landscapes. To shed light on the existence of a relation between landrace survival and land cover/land use evolution over the last three decades the Corine Land Cover maps relative to the selected core units were compared. In agreement with the evidences acquired at field level, a high crop fragmentation persistent over the considered decades in both these core units is

Figure 4. Ortho-photos relative to two collection sites. Left - landrace '*Bianchetta*', site Martina Franca, (lat. 40.6267, lon. 17.3905), 'Murgia dei Trulli' district. Right - landrace '*pisello secco di Vitigliano*', site Vitigliano, (lat. 40.035, lon. 18.431) 'Salento delle Serre' district. Image acquisition date: top - 1988-1989; bottom - 2009-2012.

Figure 5. Land cover relative to: '*Murgia dei Trulli*' and '*Salento delle Serre*' districts (left and right side, respectively). Circles enclose the area where the highest number of landraces was collected within each district. Image colour code: red - towns; pink - industrial settlement; light green - deciduous forest; light brown - vineyards, orchards, olive groves; light yellow - non-irrigated arable crops; yellow - complex cropping systems. (Source of images: Copernicus Land Monitoring Service, https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=mapview).

evident (Figures 7 and 8). The presence of side-by-side irregular patches devoted to the cultivation of olive trees, grapevines, cereals, legumes and vegetable species was constantly detectable in the available satellite images recorded in the last three decades. As expected, only modest increases or changes for the areas addressed to urban and industrial settlements (red and pink, respectively) and complex cultivation patterns (yellow) were detectable. It is interesting to note, as the fragmentation of these core units is diametrically opposed to agrarian landscape of '*Tavoliere*' district, the Apulian plain highly specialised in wheat cultivation where the permanently irrigated lands expanded at the expense of the areas with complex cultivation patterns. Statuto *et al.* (2019), who investigated the rural landscape evolution in Basilicata, the region neighbouring with Apulia, also observed the fragmentation of rural areas over the two centuries investigated. However, data collected by the authors trace a different evolution of land use in this region. The depopulation occurred over the last seven decades produced a significant abandonment of areas previously devoted to cereal cultivation and their progressive renaturalization.

Conclusions

In the contrast with wild plant species, the fragmentation of arable land detected in this study seem to be a favourable trait for *on farm* conservation of landraces in Apulia region. The perpetuation of legume and cereal landrace cultivation can be related to some factors become known during this study. The most obvious encompassed low anthropic pressure, farmer self-consumption, affective factors, traditional recipes, and the increasing request of traditional niche products considered healthier by consumers. This study show that the integration of historical information, reports of past collection missions, old orthophotos with recent satellite imagines and evidences acquired at field level is a promising methodology to retrace the evolution of the agrarian landscape at regional level. Garcia-Vega and Newbold (2020) evidenced the

Figure 6. Typical agrarian landscape of '*Murgia dei Trulli*' district.

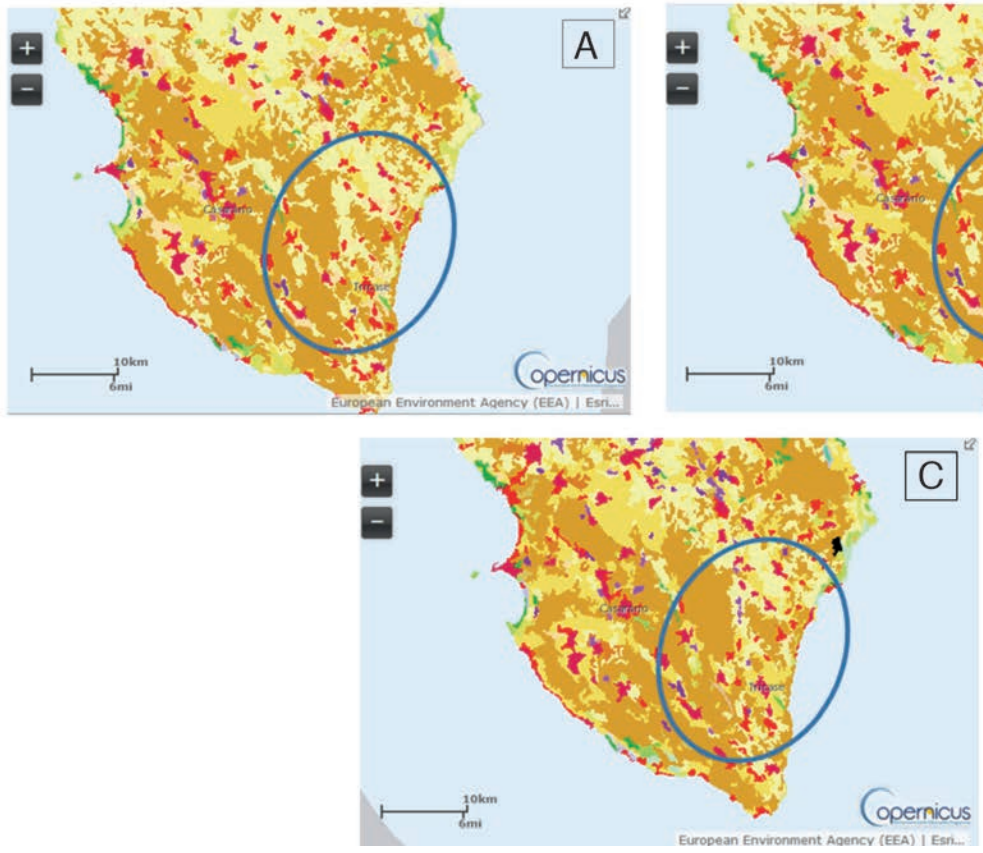

Figure 7. Land cover changes relative to the core unit of '*Salento delle Serre*' district. Image date: A) 1990; B) 2000; C) 2018. Image colour code: red - towns; pink - industrial settlement; light green - deciduous forest; light brown - vineyards, orchards, olive groves; light yellow - non-irrigated arable crops; yellow - complex cropping systems.

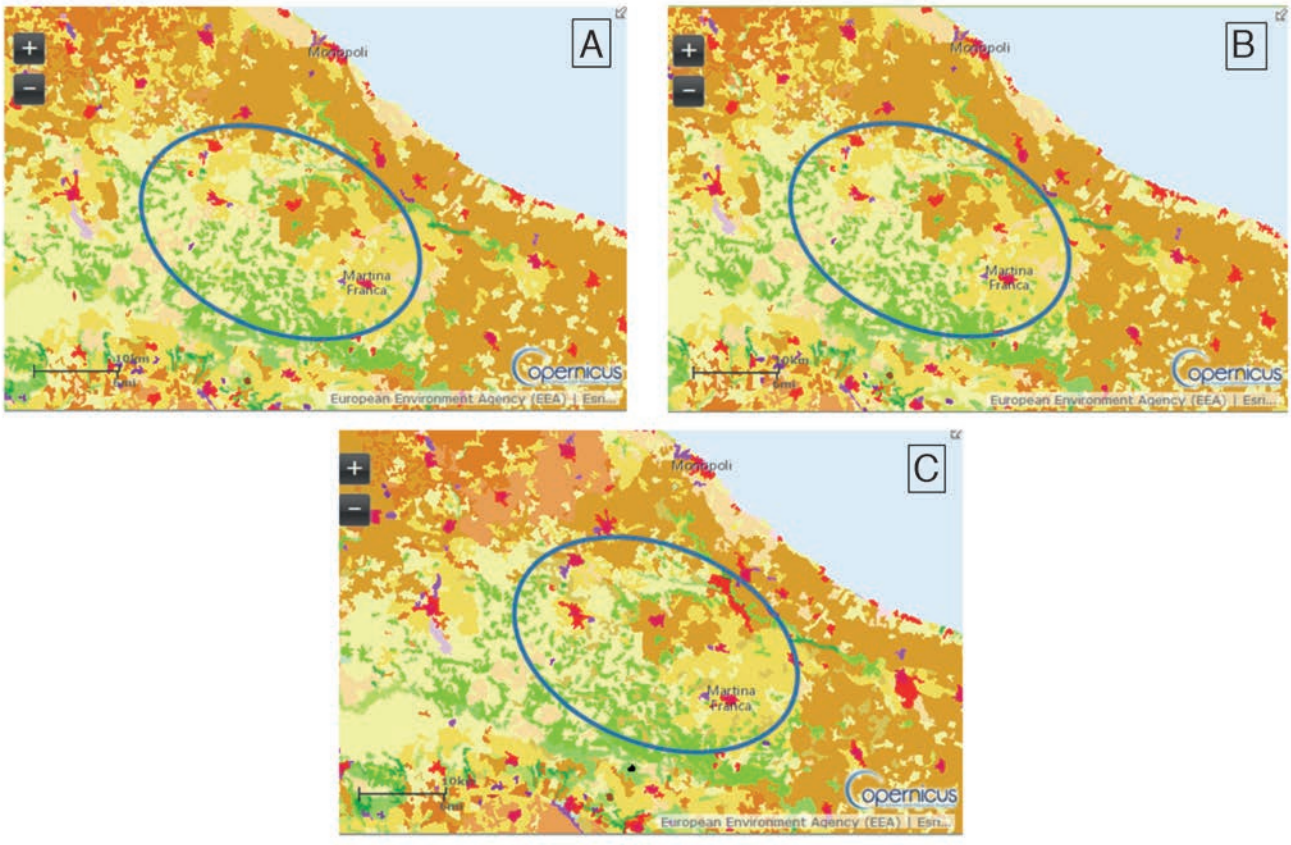

Figure 8. Land cover changes relative to the core unit of '*Murgia dei Trulli*' district. Image date: A) 1990; B) 2000; C) 2018. Image colour code as in Figure 7.

sensitivity of Mediterranean biodiversity to change in land use, though they suggested that the impact is not the same in all the countries. The methodological approach used in the present study, recently applied also to Basilicata region, Southern Italy (Statuto *et al.*, 2019), offers the advantage of regionalised the knowledge on the evolution of specific cultivations such as legume and cereal landraces.

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