Plant Sociology, Vol. 51, No. 2, December 2014, pp. 3-15
DOI 10.7338/pls2014512/01

PLANT SOCIOLOGY

The disappearance of traditional agricultural landscapes in the Mediterranean basin. The case of almond orchards in Central Italy

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Abstract
The inland areas of the Mediterranean basin are characterised by numerous traditional agricultural landscapes. These areas have also been subjected to rapid land-use changes, and in particular, to a steep decline in the agricultural acreage. Therefore, many traditional landscapes are at risk of becoming 'forgotten' landscapes and of disappearing. This report aims to highlight this trend through the description of a case study of the almond landscape in the central Apennines (Italy). The study follows an investigation of the almond landscape evolution carried out through bibliographic documentation and geographical information system analysis. The purpose is two-fold: to characterise the almond landscape as a traditional rural landscape; and to highlight what the components are that show that this traditional landscape is in danger of disappearing.

Keywords: Almonds, agricultural landscape, Apennines, land-use mapping, traditional farming.

Introduction

Definitions such as a 'traditional agricultural landscape' or a 'historical rural landscape' can be used interchangeably to describe landscapes that "have a distinct and recognizable structure which reflects clear relations between the composing elements and have a significance for natural, cultural or aesthetical values" (Antrop, 1997). These can be included among the 'cultural' landscapes, which are defined as those areas where anthropic use has led to substantial changes to the original conditions, but has also maintained the functionality of the natural systems or has replaced it with other systems that are compatible with the local environmental conditions (Antrop, 2005).

Many rural traditional or historic landscapes of the Mediterranean basin have been preserved in hilly or mountainous areas, as these are less suitable to the use of intensive farming methods and less attractive for the development of urban settlements. However, numerous studies show that these same areas are extremely affected by land-use changes, and in particular, by changes relating to the transformation of agricultural acreage in natural areas (EEA, 2013).

The abandonment of agricultural areas and the disappearance of these landscapes with their cultural values is today an international issue that is being addressed with an interdisciplinary approach. This is demonstrated by the convergence of landscape policies, such as those expressed by the European Landscape Convention and by the EU Common Agricultural Policy (Galdenzi *et al*., 2011; Finco *et al*., 2007). To cope with this phenomenon, it is essential to draw up an inventory, to provide the government with a map of our landscape heritage, and to help to steer public support towards implementation of active policies that are not afraid of the concept of conservation (Agnoletti, 2013). It is in this inventory process that this study fits, with the aim to identify almond [*Prunus dulcis* (Mill.) D.A. Webb syn. *P. amygdalus* Batsch] landscapes in the Mediterranean inland areas through the analysis of a case study in the central Apennines (Italy).

This study focuses on the identification of historical evidence, on the structural features of almond cultivation, and on the physiographic characteristics of this land. In addition, an analysis based on the Geographical Information System (GIS) of the almond landscape dynamics from the 1950s, when there was still productive stability, to date, shows the land-use changes in terms of the quality and quantity, and of the variations, in the almond cultivation structure. The ultimate goals are therefore to identify generic criteria to determine whether a traditional rural landscape is at risk of disappearing, and to provide these 'forgotten' landscapes with the scientific strength required to include them in the initiatives that are aimed at their recovery.

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Study area

In Italy, Sicily and Puglia provide more than 90% of the national production of almonds. Other productive regions are Abruzzo, Lazio, Molise, Marche and Sardinia, and to a lesser extent, Calabria. The study area is located in the intermontane valleys that lie among the higher peaks of the central Apennines, and it encompasses the southern slopes of the Gran Sasso mountain range, the limestone plateau between Mount Velino and the Fucino Plain, the L'Aquila basin, and the upper valley of the Aterno River (Fig. 1).

This study is focused on this area because here there is no trace of any intensive almond cultivation, and therefore all of the information available exclusively concerns traditional cultures. The whole area is characterised by a limestone sub-layer that is sometimes in the shape of a massive structure, and at other times as alluvial deposits or groundwater debris, a necessary condition for the survival and for spontaneous reproduction of almond trees.

In the study area, the altitude varies from 400 m to 1500 m a.s.l.. This altitude interval results in both Mediterranean and temperate climates that have common continental characteristics. These include relatively low precipitation and relevant temperature variations, which represent extreme conditions for almond cultivation (Fig. 2). From the bioclimatic point of view, although there are local variations, the areas examined are classified as an oceanic temperate bioclimate, of the sub-Mediterranean variant. The thermotype is lower supramediterranean, and the ombrotypes are lower humid, lower subhumid, and upper subhumid (Rivas-Martínez, 2004; Pesaresi *et al.*, 2014).

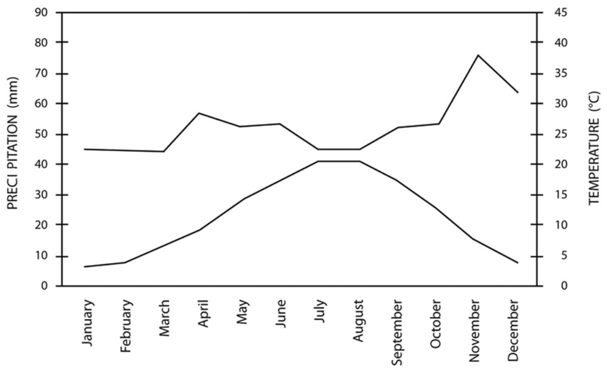

Fig. 2 - Bagnoulus–Gaussen thermo-pluviometric diagram based on the historical data from 1966 to 2008 from the Barisciano (AQ) station (Battistini *et al.*, 2010), a locality that has high almond cultivation.

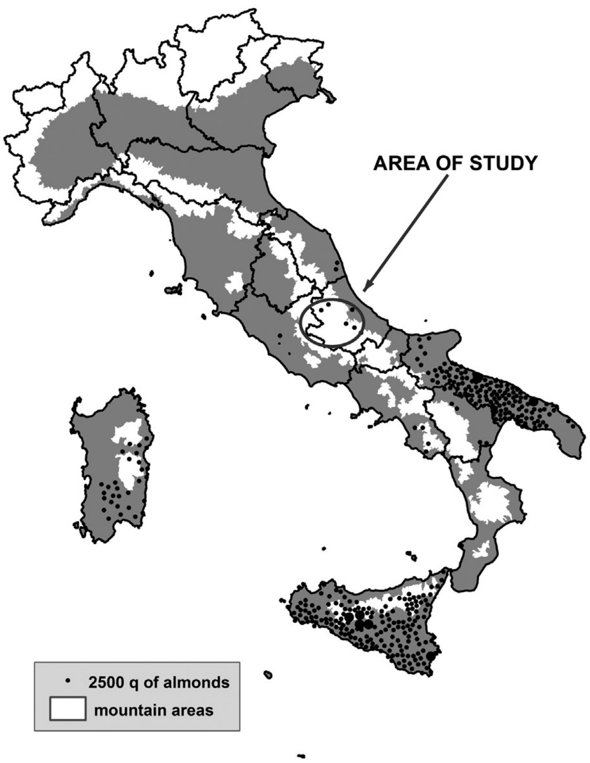

Fig.1 - Distribution of almond cultivation in Italy in 1953. Compared to the others regions, the study area in the central Apennine (as indicated) is mainly mountainous (ISTAT, 1954).

The historical use of the land overlays the geological and bioclimatic features, and it has helped to significantly diversify the landscape. At the higher altitudes, grazing is the only land use; at intermediate altitudes, this grazing is accompanied by agriculture, while settlements (e.g., urban, industrial, infrastructure) are more and more frequent on the lower plains, alongside the dominant agricultural use.

For the vegetal landscape of this study area, with reference to integrated phytosociology (Biondi, 2011), the most advanced and stable vegetation primarily consists of oak woods (association *Cytiso sessilifolii-Quercetum pubescentis*), as the mature stage of *Cytiso sessilifolii-Querco pubescentis* sygmetum, and hornbeam woods (association *Scutellario columnae-Ostryetum carpinifoliae*), as the mature stage of *Scutellario columnae-Ostryo carpinifoliae* sygmetum. In this context, the most frequent replacement vegetation is represented by the pre-woods of *Populus tremula,* shrubs of the alliance *Cytision sessilifolii*, garrigues of the alliance *Chamaecytiso-Saturejion*, xerophilous pastures of the alliance *Phleo-Bromion,* and mesophilous pastures of the alliance *Bromion erecti*, as well as the weed communities of the abandoned fields. Finally, there are several reforestation areas of *Pinus nigra* subsp. *nigra*.

The hedges are an important vegetation element, which form a bushy texture in low-lying contexts and in some slope areas. The most common species are *Cornus sanguinea, Crataegus monogyna, Euonymus* *europaeus, Rosa canina, Prunus spinosa, Ligustrum vulgare,* and *Malus sylvestris*, and with lower frequency, *Lonicera etrusca, Berberis vulgaris, Sorbus domestica* and *Ulmus minor.*

The study area falls partially within Special Protection Areas (SPAs): IT7110128 "Parco Nazionale Gran Sasso Monti della Laga" and IT7110130 "Sirente Velino", and the rural agro-ecosystem in which this almond cultivation is sited is also home to some species that are listed in Article 4 of EU Directive 2009/147/EC, and in Annex II of EU Directive 92/43/EEC: *Elaphe quatuorlineata* (four-lined snake) (Di Tizio *et al*., 2008), *Emberiza hortulana* (Ortolan bunting), *Lanius collurio* (red-backed shrike), *Lullula arborea* (woodlark), *Lanius minor* (lesser grey shrike) (Special Areas of Conservation Standard data form).

Materials and Methods

According to the approach of Cullotta & Barbera (2011) for the identification of traditional cultural landscapes in Mediterranean areas, some primary components must be considered. These can include the landscape composition and configuration, traditional techniques of land management, rural linear elements and features, and other material and non-material heritage elements (e.g., poems, historic paintings and pictures, tophonyms, dialects) (Cullotta & Barbera, 2011).

Following these principles, this study of the almond landscape was carried out in an interdisciplinary and multitemporal way. First, the non-material elements, such as the social and historical contexts and the techniques of land management, were studied through searches of the literature and databases relating to agricultural yield and cartography. Secondly, the landscape composition and configuration were analysed through the interpretation of photographs and GIS analysis. For the historic role of almond cultivation, the analysis was carried out on data from the literature.

The analysis of the structural conformation and changes in the almond landscape were carried out on sample areas that were distributed as eight core areas over a total of about 4,000 Ha (Fig. 3). Within the study area, which is the part of the central Apennines where almond trees were present historically, the areas where almond was cultivated in the mid-1950s were identified. The choice of this period is because in general in Italy the number of modern landscapes and agricultural systems increased remarkably from the mid-to-late 1950s onwards (Agnoletti, 2007).

The identification of the almond orchards was carried out through an analysis of the topographic maps of Italy of the Italian Military Geographic Institute (series 25V; scale, 1:25,000). These maps were produced in 1954, and they were drawn using the photogrammetric method, which carries information about the type of crops present. Aerial photographs of the same period were also used. These flights were made by the Italian Military Geographic Institute in August 1954, at a height of 6,000 m. The aerial photographs were orthorectified and a mosaic of the study area was then created.

To facilitate and to prevent confusion in the photo-interpretation of these historical images, and as it was not possible to perform field surveys, the areas where the almond trees were in mixed cultivation with other tree species (such as olive trees) were excluded from the study. In these cases, it was not even possible to use a back-editing technique, because today there is a high prevalence of olive groves, which have a longer productive life. In these fields today, there are only a few isolated specimens of almond, and so it is not possible to include this category in this kind of analysis.

Within the study area, two structural types of almond landscape were identified. The first coincided with the almond orchards that were characterised by a regular layout, with a density of more than 50 plants per hectare. In the second type of landscape, the almond trees were distributed in a more diffuse and irregular way, with a density of less than 50 trees per hectare; they were even sometimes arranged along individual rows between estates. For simplicity, in the present study, the first category will be defined as 'regular' fields or patches, and the second as 'irregular' fields or patches. The dimensions of these fields are not relevant to this distinction, as even the regular fields were sometimes extremely small, since, as mentioned, the land was most often run under family management.

Once the historical almond cultivation areas had been identified, the morphological characteristics that were traditionally associated with these almond trees were identified through GIS spatial analysis, which was based on a 10-m digital terrain model and on the aerial photographs from 1954. The data thus collected helped to identify the most suitable sites for potential recovery projects.

The situation described for the 1950s was then compared with the current situation, using the digital colour orthophotographs of the Province of L'Aquila that were obtained by processing the frames of an October 2010 flight (equivalent scale, 1:10,000). For the entire analysis, the digitalisation lower limit was set to 1,000 m^2. Although this detail might appear excessive for operations using photo-interpretation of aerial photos of 1954, due to the poor accuracy of the images that were returned to an equivalent scale of 1:33,000, it was possible to maintain this standard for both of the time periods, as the recognition of the presence of almond trees in a non-promiscuous area is relatively straightforward.

Comparative photo-interpretations and mapping and

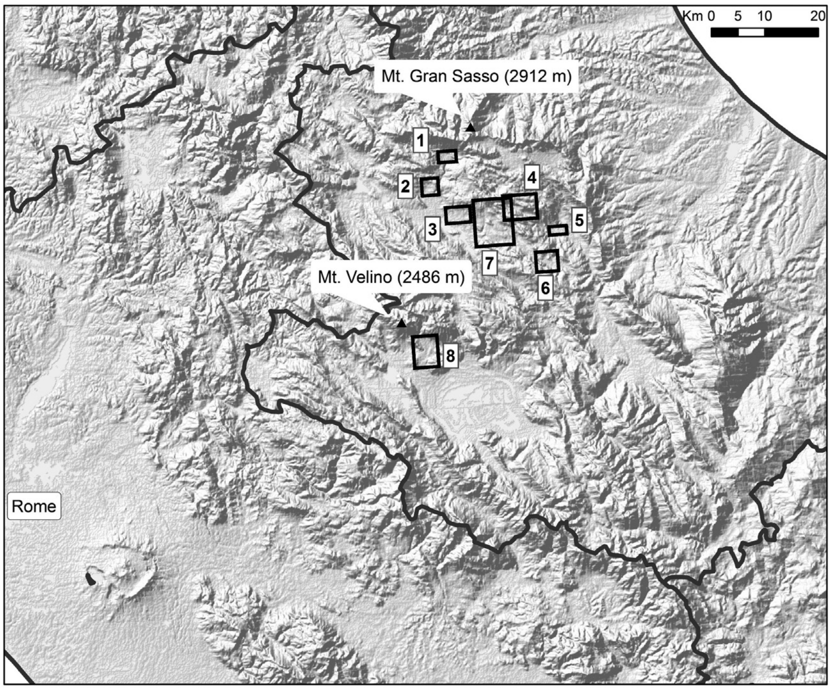

Fig. 3 - Distribution within the study area of the eight core areas, over a total of about 4,000 ha.

spatial overlaying analysis were performed in ArcGIS 10. For both of these time periods, the indices that provided information on the forms and sizes of the individual areas that made up the almond tree landscape were calculated. These indices are listed and explained in Table 1, and they are among the most simple and representative indices of landscape ecology. This reflects the desire to be sure that the data from this study are easily comparable to data from other studies that have already been carried out, and to potentially apply the present data to other and new contexts.

A structural analysis of whether and how this landscape changed from 1954 to the present highlighted the transitions in land use, where these accompanied the contraction of the almond landscape through the time interval considered. This allowed the estimation of the intensity of this trend, thus providing the essential information for the definition of any kind of strategy for the enhancement of the landscape, as well as to increase almond cultivation.

Results

The results of the analysis of the characteristics of the almond landscape are organised into four sections: the first describes the plant landscape, the second reflects upon the historical point of view, the third shows the data on the structure of the traditional almond field patches, and the fourth highlights the changes in almond cultivation from1954 to 2010.

The plant landscape

The almond trees are incorporated into the landscape of the intermontane basins in which there are two different aspects of morphology and land use. In flat areas, the native vegetation has been almost totally replaced by crops, and along the slopes there is a mosaic of plant communities, with nuclei of woods and dynamic stages of substitution (shrubs, garrigues, pastures, and others).

Referring to the dynamic series of vegetation (Biondi, 2011), along the slopes, the present-day vegetation can be summarised as follows:

HILLY, CALCAREOUS, SUBCONTINENTAL SERIES OF DOWNY OAK (*Cytiso sessilifolii-Querco pubescentis* sigmetum)

- Forests of downy oak: *Cytiso sessilifolii-Quercetum pubescentis* (*Cytiso-Quercenion pubescentis, Carpinion orientalis*);
- Mantle communities: *Spartio juncei-Cytisetum sessilifolii* (*Cytision sessilifolii*);
- Shrubs: *Chamaecytiso spinescentis-Juniperetum oxycedri* (*Cytision sessilifolii*);
- Garrigues: *Sideritido italicae-Globularietum meridionalis* (*Chamaecytiso spinescentis-Saturejion montanae*);
- Xerophilous meadows: associations of the alliance *Phleo ambigui-Bromion erecti*;
- Therophytic meadows: association of *Trachynion distachyae*;

Tab. 1 - Landscape ecology indices used in this study (Farina, 2000; Forman & Godron, 1986; Rutledge, 2003).

Index	**Calculation**	**Importance**
Number of patches (NP)	NP = n_i	This is a simple measure of the extent of the subdivision or fragmentation of the field type.
Patch density (PD)	$(NP/A_{tot})100$	The patch density has the same basic use as the number of patches as an index, except that it expresses the number of patches as per unit area, which allows more direct comparisons across landscapes of varying sizes.
Mean patch size (MPS)	$\sum_{i=1}^{NP} A_i/NP$	The area of each patch that comprises a landscape mosaic unit is perhaps the single most important and useful piece of information contained in the landscape. Not only is this information the basis for many of the patch, class, and landscape indices, but the patch area has a great deal of ecological use in its own right.
Largest patch size (LPS)	LPS = A_{max}	
Compactness (γ)	$\gamma = \frac{2\sqrt{\pi A}}{P}$	The compactness measures the distance of the form of the patch from the isodiametric form of a circle.

- Vegetation in the abandoned fields: *Agropyro repentis-Dactyletum glomeratae* (*Inulo viscosae-Agropyrion repentis*);
- Weed vegetation: *Caucalidion lappulae, Fumario-Euphorbion*.

HILLY, CALCAREOUS, MESOPHILOUS SERIES OF HORNBEAM (*Scutellario-Ostryo carpinifoliae sigmetum*)
- Woods of hornbeam: *Scutellario-Ostryetum carpinifoliae* (*Laburno-Ostryenion; Carpinion orientalis*);
- Pre-wood formations of *Populus tremula: Fraxino orni-Populetum tremulae* (*Corylo-Populion tremulae*);
- Mantle communities: *Spartio juncei-Cytisetum sessilifolii* (*Cytision sessilifolii*);
- Shrubs: *Chamaecytiso spinescentis-Juniperetum oxycedri* (*Cytision sessilifolii*);
- Garrigues: *Sideritido italicae-Globularietum meridionalis* (*Chamaecytiso spinescentis-Saturejion montanae*);
- Mesophilous meadows: association of *Bromion erecti*;
- Xerophilous meadows: association of *Phleo ambigui-Bromion erecti*.
- Vegetation in the abandoned fields: *Agropyro repentis-Dactyletum glomeratae* (*Inulo viscosae-Agropyretum repentis*);
- Weed vegetation: *Caucalidion lappulae, Fumario-Euphorbion*.

DOWNY OAK EDAPHO-XEROPHILOUS SERIES (*Cytiso sessilifolii-Querco pubescentis*, var. *Quercus ilex*, sigmetum)
- Scrublands of downy oak and holm oak: *Cytiso sessilifolii-Quercetum pubescentis*, variant *Quercus ilex* (*Carpinion orientalis*);
- Shrubs: *Chamaecytiso spinescentis-Juniperetum oxycedri*, var. *Quercus ilex* (*Cytision sessilifolii*);
- Garrigues: *Sideritido italicae-Globularietum meridionalis* (*Chamaecytiso spinescentis-Saturejion montanae*);
- Therophytic meadows: association of *Trachynion distachyae*.

In the flat areas, with the integration of the phytosociological analysis of the actual vegetation with the geomorphological, pedological and bioclimatic data, it is possible to define the pattern of the potential natural vegetation in the following way. In the areas with deeper groundwater, there would be mixed mesophilous oak woods, consisting of mesophilous and semi-mesophilous deciduous species, such as hornbeam, maple, turkey oak, bay oak, and perhaps Italian oak, as can now be seen for the towns of Oricola and Tornimparte (Province of L'Aquila) (Blasi *et al*., 2002; Pirone & Manzi, 2003). The potential vegetation would thus be attributed to the endemic suballiance *Pulmonario apenninae-Carpinenion betuli*, with a northern-central Apennine distribution (Biondi *et al*., 2002). This is included in the alliance *Physospermo verticillati-Quercion cerridis*, in terms of the mesophilous woods of hornbeam, oak sp. pl., Neapolitan maple, and field maple with an Apennines distribution, the vicariant of the Balkan alliance *Erytronio-Carpinion* (Biondi *et al*., 2008). In areas with temporary stagnant water and/or that are periodically flooded, there would be the infrazonal vegetation of rich meadows, represented by alliances *Arrhenatherion elatioris, Cynosurion cristati, Ranunculion velutini* and *Agropyro-Rumicion*. The sites that are perennially flooded would have the azonal hygro-hydrophilous vegetation with thickets of willows and poplars, and hydrophytic and helophytic communities, with the alliances *Salicion albae, Salicion eleagni, Phragmition australis, Caricion elatae, Sparganio-Glycerion, Ranunculion fluitantis*.

Historic presence

In terms of the historic presence, the literature shows that in the study area the earliest sources that mentioned almond trees date back to Roman times, when Pliny the Elder described a variety of almond trees cultivated at the foothills of Mount Velino. In 1500, there was an increase in this almond cultivation in the Province of L'Aquila (Sabatini, 1996), while another increase occurred in the XIX century, in the midst of the crisis of the transhumance (the movement of sheep between the grazing grounds in the north and south of Italy) (Console & Frattaroli, 1996). The writings of the Swiss noble Carlo Ulisse De Salis Marschlins from the year 1789 demonstrate how the inhabitants of Avezzano (AQ) were occupied “mostly with agriculture, cultivating preferably almond trees and vineyards” (De Salis Marschlins, 1789). Then, an 1882 Italian survey on the conditions of the agricultural class stated that in the regions of the central and southern Adriatic, the almond tree was widespread. It was well cultivated in the Provinces of Bari and Lecce (in Puglia), and on the sunlit lands around L'Aquila and Avezzano (in Abruzzo), where this cultivation increased until the end of the 1800s (Jacini, 1882).

In Abruzzo, due to the warmer temperatures around the middle of the XIX century, land located at high altitudes was also put under cultivation. This started the really rapid ‘climb’ in farming as it was pushed to higher and higher altitudes, and also with the use of terracing (Manzi, 2012a). The plants that arrived from America (e.g., beans, corn, and especially, potatoes), were cultivated alongside the traditional crops of the high mountains, such as wheat (e.g., the variety ‘solina’), rye, barley and lentils, while fields neighbouring the temporary dwellings were surrounded by fruit trees: pears, apples, nuts, and Sorbus, and almonds too.

Until the mid-XX century, in the carbonate highlands, the almond trees were an important source of carbohydrate and fat for the mountain populations, as well as of wood. They were also one of the few money sources for the farm families, and the almond cultivation was often necessary for the dowry when a daughter wed, or represented the chance to pay for medical expenses. Culturally, there are many traces of the importance of the almond for local communities at various levels. Examples vary from the literature, from the novel “Ai piedi di un mandorlo” (“At the foot of an almond tree”) written by Ignazio Silone in 1970, to confectionery traditions where the almond has a primary role, such as in the centennial production of ‘confetti’(sugared almonds; primarily for weddings) in the city of Sulmona in the Province of L’Aquila.

From the second half of the 1960s, however, almond cultivation in the Apennine valleys was in steep decline. This was due to low production levels, irregular yields, and the widespread abandonment of upland agriculture. Today, this particular landscape with its traditional scenic and environmental values is in danger of disappearing. Figure 4 illustrates this dramatic decline in almond cultivation in the Apennine region from the end of the 1960s, in terms of the land dedicated to it and of the production in quintals. Data from 1960 on the Abruzzo Region and on the Province of L'Aquila can be approximated to the study area shown in Figure 3.

This productive crisis arose due to several factors, which included the lack of fields cultivated according to the most modern techniques, and the competition with other more profitable crops. Other causes of this

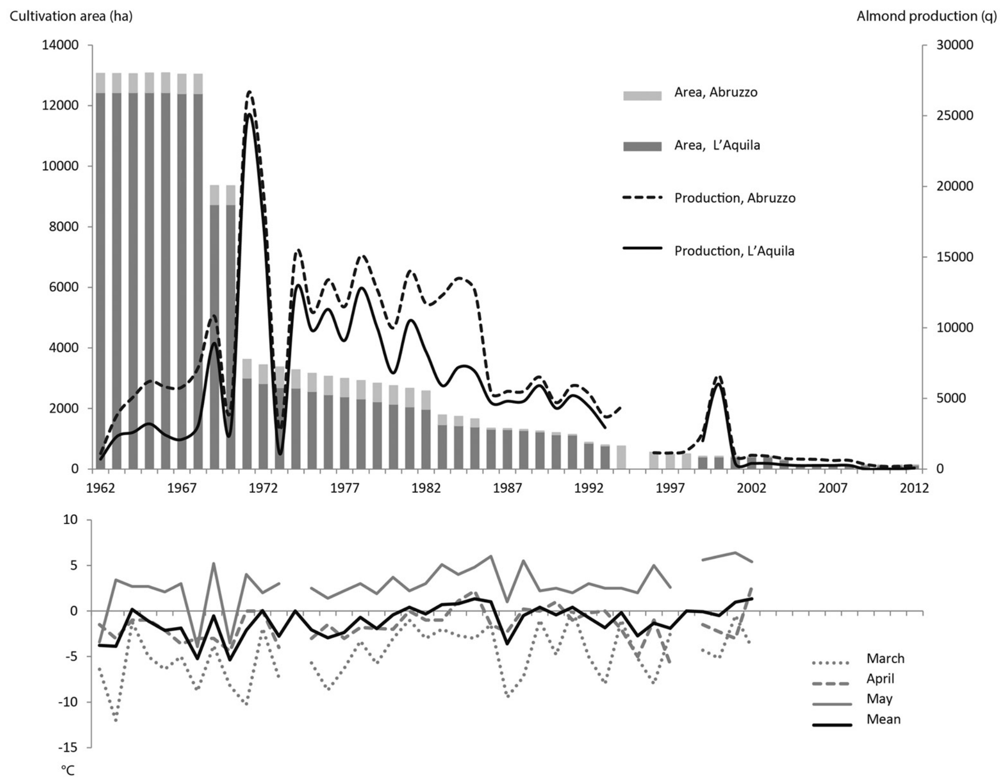

Fig. 4 - Almond production and temperature trends. Top: Almond production in the Abruzzo and L’Aquila Provinces, as area and yield. Bottom: Absolute monthly minimum temperatures and mean minimum temperatures in spring, from 1962 to 2002. Temperature data are from the thermo-pluviometric station of Barisciano (AQ) (source: Abruzzo Region).

decrease included the abandonment of cultivation in unfavourable areas (Biondi *et al*., 2000). In particular, this was because in the high and medium-high hilly areas there was a reduction in the average annual crop yield due to the aging of the trees, the reduced plantation density, and the lack of almond cultivation management. In addition, the higher production costs needed to be considered, as well as the variable production from year to year, which depended primarily on the climatic conditions that affect the success of the pollination, and on disease and insect damage (Socias *et al*., 2012).

In contrast to the decline in almond cultivation, recently some cultural associations and folklore initiatives dedicated to its recovery and to traditional almond products have been appearing (Frattaroli *et al*., 2010). These indicate the contrasting attitudes of the local populations, and show that the 'insiders' (the local communities) can perceive the historical presence of these almond orchards, even beyond their economic return (Turri, 2000). Locally, it is still recognised that almond cultivation represented an important element in the local cultural identity, and this is a potential key towards the revitalisation of these marginal areas. However, the same does not apply to 'outsiders' and to the authorities. A lack of knowledge of this landscape by those who are not part of the local community was also reflected, for example, in the official cartography: the Corine Land Cover level 4 and the Land Use cartography for the Abruzzo region (1:25,000) did not mention the almond orchards, because they were generally misclassified as olive groves. This error had serious consequences for the enhancement of almond cultivation, as land-use cartography was the basis for the identification of most of the traditional landscapes processes.

Characterisation of the structure of the almond landscape

The physiography of the almond landscape is conditioned by the use of the almond trees to sustain individual families. This landscape was therefore characterised by the widespread presence of almond trees that were planted relatively distant from each other, to allow cattle grazing or cultivation of cereals and legumes. These almond trees were often arranged in single rows between estates, or placed on hillocks or on slopes that were not suited for other crops, or next to the seasonal dwellings to which the farmers used to move during the summer to cultivate their small plots of land and to graze their cattle (Manzi, 2012b).

Even where the almond trees had a higher density, they respected the parameters of traditional tree crops. Some have set this limit to 75 trees per hectare (Pointereau & Paracchini, 2007), and others to 100 (Ramos & Santos, 2010). In the study area here, the almond orchards with a regular arrangement had densities from 50 plants per hectare to 85 plants per hectare. This was determined over 30 sample areas in the present study (over about 25 ha) that were randomly selected from both of these time periods.

For the patch sizes and their arrangement in the field mosaics, these were small even in the times of their development, which reflected the fragmentation of the landholdings. In the mid-1950s, the average size of the almond fields was around 2.5 ha, and they were located on the steepest of the slopes and along the sides of the open fields. This probably dates back to pre-Roman times, when these fields were characterised by their ribbon shape (Sereni, 1961). Such fields were typical of the southern slopes of Gran Sasso, with cereals, legumes and fodder crops grown in rotation, and with the fields left for free grazing after the harvest. In some areas, almond fields were juxtaposed with other crops; in others, the almond trees punctuated pastures or cereal crops, thus enriching the diversity of the landscape mosaic with a variety of features (e.g., points, lines, polygons).

GIS analysis conducted on the field layout in the 1950s showed that these almond orchards were mainly located at altitudes between 800 m and 900 m a.s.l., but also from 900 m to 1,000 m a.s.l., especially for the regular and denser fields (Fig. 5). The average altitudes confirm this: 908.87 m a.s.l. for the regular patches, versus 825.25 m a.s.l. for the irregular patches (Tab. 2). The open fields were instead located at lower

Tab. 2 - Mean values for altitude, slope and exposure of the regular, irregular, and total almond fields in the 1950s. Data are arithmetic means, with standard deviations and standard errors given.

Field characteristic	Field type	Mean	SD	SE
Altitude (m a.s.l.)	Regular	908.87	173.67	0.47
	Irregular	825.25	126.03	0.25
	Total	854.20	149.70	0.24
Slope gradient	Regular	8.36° (18.5%)	6.73°	0.01°
	Irregular	8.47° (18.8%)	7.75°	0.02°
	Total	8.40° (18.6%)	7.10°	0.01°
exposure gradient (Prevalent aspect)	Regular	179° (S)	75.53°	0.15°
	Irregular	185° (S)	75.87°	0.20°
	Total	181° (S)	75.71°	0.12°

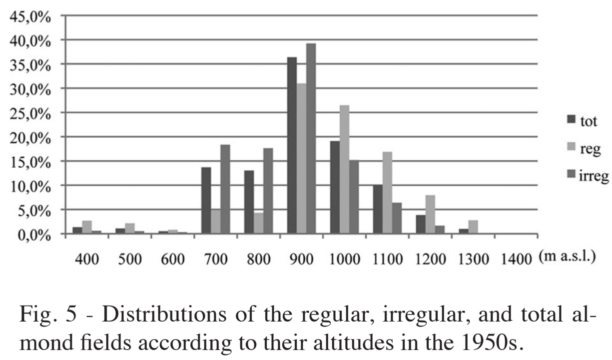

Fig. 5 - Distributions of the regular, irregular, and total almond fields according to their altitudes in the 1950s.

altitudes, thus corresponding to the low-lying areas that were more suitable for agriculture. Of note, the areas historically dedicated to almond cultivation had precise physiographic features, although these did not necessarily correspond to the areas with the best suitability for almond, although these were the lands that were traditionally assigned to almond cultivation.

This emerges also in the analysis of the almond orchard distribution according to the different classes of the steepness of the land. The group values in Figure 6 also define the different slope classes according to their suitability for forestry and agricultural activities (Sorbini *et al*., 2008). The almond fields were localised mainly along the contours of valleys, in areas with a slope between 10% and 25% (Fig. 6), and with an average slope of 18.5% to 18.8% (Tab. 2). These areas were generally compatible with rural activities, but they usually required appropriate tillage and hydraulic techniques for their sustainable management of productive activities, especially in the case of crops that needed annual tillage.

The climatic requirements of the almond trees emerged strongly in the analysis of the exposure: the majority of the fields were located on south-facing slopes, with a prevalence of south-west facing slopes (Fig. 7). This is due to the particular climatic conditions of the area, which were characterised by late frosts that also occurred in May. In Figure 4, the annual almond production in the Province of L'Aquila can be more directly compared to the absolute minimum temperature trends during spring (March, April, May; and their averages) from 1962 to the present (Fig. 4, bottom panel). These temperature data came from the thermo-pluviometric station in Barisciano (AQ) (source, Abruzzo Region). As can be seen in Figure 4, many of the dips in the production of almonds corresponded to years in which there were late frosts. To test this hypothesis, the trends of the average minimum temperatures were related to the annual yields in the Province of L'Aquila. For the period of 1962 to 1991, the Spearman index is 0.5; there is therefore a positive correlation between the production of almonds and these temperatures.

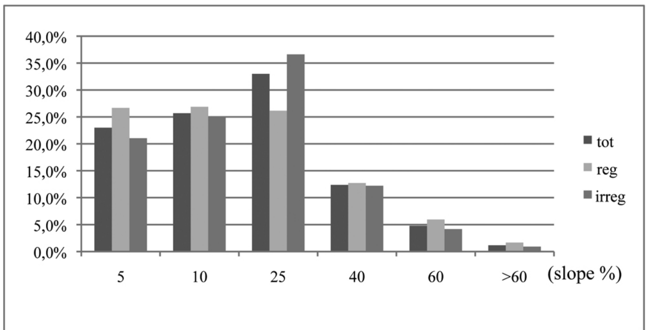

Fig. 6 - Distributions of the regular, irregular, and total almond fields according to their slopes in the 1950s.

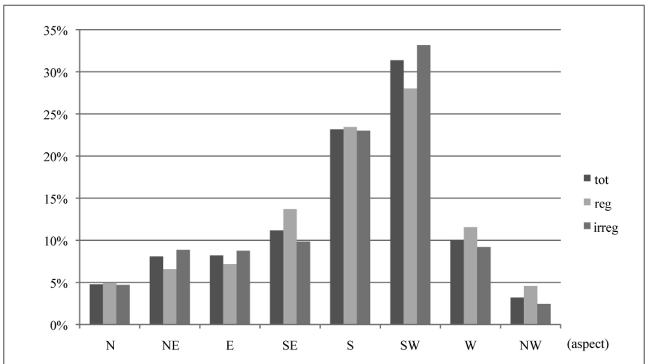

Fig. 7 - Distributions of the regular, irregular, and total almond fields according to their prevalent aspects in the 1950s.

The main features and characteristics of this landscape are easily recognisable even today. While on the one hand, the dispersion and localisation in the more tricky areas has led to abandonment of almond cultivation, on the other hand, this has enabled many specimens to survive until today, as these were not in areas that were attractive for alternative crops.

The first analytical study here concerns the structure of the patches that made up the almond landscape. Table 3 shows that in 1954, the almond trees covered 3,964 ha, 1,229 ha of which were cultivated with regular fields, and 2,735 ha with irregular fields. This distribution reflected the fragmentation of the land and the absence of any intensive farming systems. Indeed, the almond cultivation was divided into 596 patches with a mean patch size (MPS) of 6.65 ha, which is a relatively small size. The mosaic was composed of many small patches of regular fields (545; 91% of the total) and by a few large polygons of irregular fields (51; 9% of the total). The MPS of the regular patches was 2.52 ha, and the largest patch size (LPS) was 161 ha. The irregular patches had a MPS of 53.62 ha and a LPS of 592.77 ha.

For the shape of the patches, the metric compactness (γ) indicates by how much the patches deviate from the isodiametric shape of a circle: for a square, γ is 0.88;

Tab. 3 - Changes in the landscape indices of the almond landscape mosaic between 1954 and 2010.

Landscape index	Field type	1954	2010	Δ (net gain/loss)	Δ (%)
Patch area (ha)	Regular	1228.78	228	-1000.78	-81.4
	Irregular	2734.85	1463.09	-1271.76	-46.5
	Total	3963.62	1691.09	-2272.53	-57.3
Patch number	Regular	545	146	-399	-73.2
	Irregular	51	158	107	209.8
	Total	596	304	-292	-49.0
Mean patch size (ha)	Regular	2.25	1.56	-0.69	-30.7
	Irregular	53.62	9.26	-44.36	-82.7
	Total	6.65	5.56	-1.09	-16.4
Largest patch size (ha)	Regular	161.24	56.29	-104.95	-65.1
	Irregular	592.77	386.83	-205.94	-34.7
Compactness	Regular	0.54	0.67	0.13	24.1
	Irregular	0.75	0.75	0.00	0.0
	Total	0.73	0.71	-0.02	-2.7

for a rectangle with the ratio between the sides of 1:2, γ is 0.83; while, for a stretched rectangle with a ratio of 1:100, γ is 0.17 (Graci *et al*., 2009). The compactness for the regular almond orchards in 1954 corresponded to smooth-edged shapes, like almost natural patches, and not to excessively regular shapes, as for those of modern agricultural landscapes. When combined with the number and size of patches, this compactness characteristic provides an image of a heterogeneous landscape in which almond orchards were not uniformly distributed, but were sometimes dispersed, sometimes clumped. This irregularity is typical of traditional cultural landscapes (Cullotta & Barbera, 2011).

Since the 1950s, the almond landscape has undergone a conspicuous rarefaction, which hit all of the studied area relatively evenly. This also had an impact on the structure of the landscape patches, and in particular on the irregular field patches, which have suffered remarkable fragmentation, as shown by the 82.7% decrease in MPS between 1954 and 2010. This structural change is less appreciable for the regular patches, where the MPS has decreased by only 30.7%. The regular patches have always been characterised by their very small size, and their decrease results more from the loss of entire units, rather than from their erosion or segmentation. Here, it should be noted that the compactness of the regular patches in 1954 remained the same for 2010 (γ = 0.75). The regular almond orchards, therefore, maintained the same characteristics as in the 1950s, in terms of their sizes and shapes.

Thus, in 2010, despite the overall decrease in the land dedicated to almond cultivation, the characteristics in terms of the patch shapes and configurations were maintained, as seen in the definition of traditional agricultural landscapes.

Land-use transitions

From the 1950s to date, the almond cultivation suffered an overall decrease of about 57% in the total area (Tab. 3). This contraction was much more evident in soils that were characterised by the regular distribution of the almond trees, which has dropped from 1,229 ha to 228 ha, thus showing a decrease of 81.4%, although new fields were developed. The irregular almond orchards decreased from 2,735 ha to 1,463 ha, which represents a loss of 46.5%.

Figures 8 and 9 illustrate all of the categories of land use that replaced the almond orchards from 1954 to 2010. The most common transition for regular almond orchards was to irregular almond orchards (55%), which could overlap with arable land (44%), pasture (9%), and natural recolonisation (1%). This also partially explains the lower decrease for the patches classified as irregular compared to those of the regular ones (Fig. 10). Natural recolonisation was the next most frequent transition (16%), where as a result of abandonment, there are now the serial stages of *Quercus pubescens* forest and bushes of *Juniperus oxycedrus* subsp. *Oxycedrus, Cornus sanguinea, Crataegus monogyna, Euonymus europaeus, Rosa canina* and *Prunus spinosa* (Pirone *et al*., 2001, 2010; Cutini *et al*., 2002; Pirone & Cutini, 2002; Corbetta *et al*., 2004). Over the same period, 14% of the regular almond orchards was replaced by herbaceous crops, such as cereals, legumes and forage, 6% was converted into pasture, and 5% was maintained for the original use. The urbanisation of soils took place in 3% of the patches analysed. Added to this, there was 1% of the surface that was designed for mining, dumping and construction sites, with another 1% attributable to other unspecified categories of land use.

The transformations that occurred to the irregular almond fields are summarised in Figures 9 and 10. These irregular fields were converted for the most part into areas with natural recolonisation (24%) and to arable land (22%), and to a lesser extent, they became pastures (8%) and urban areas (5%). Compared to the regular patches, there was also the conversion of the irregular patches into woods (1% of their total area). Woods developed in the areas where the almond was present in an irregular manner in the matrix, in which the ecological succession was already somehow triggered; e.g., in uncultivated patches of pasture.

From this synthetic description of the transitions of

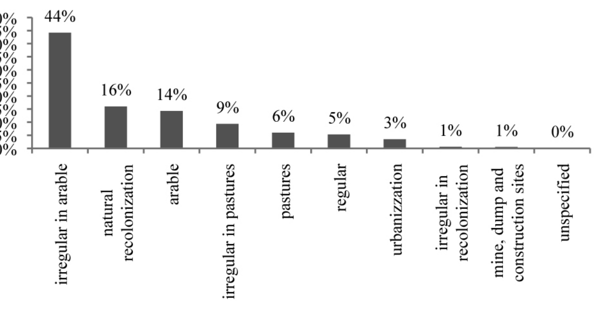

Fig. 8 - Land use changes from 1954 to 2010 for the regular almond orchards.

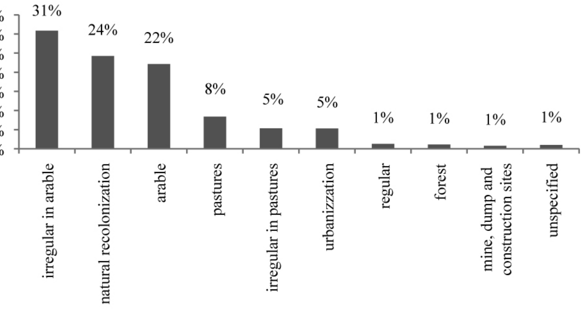

Figure 9. Land use changes from 1954 to 2010 for the irregular almond orchards.

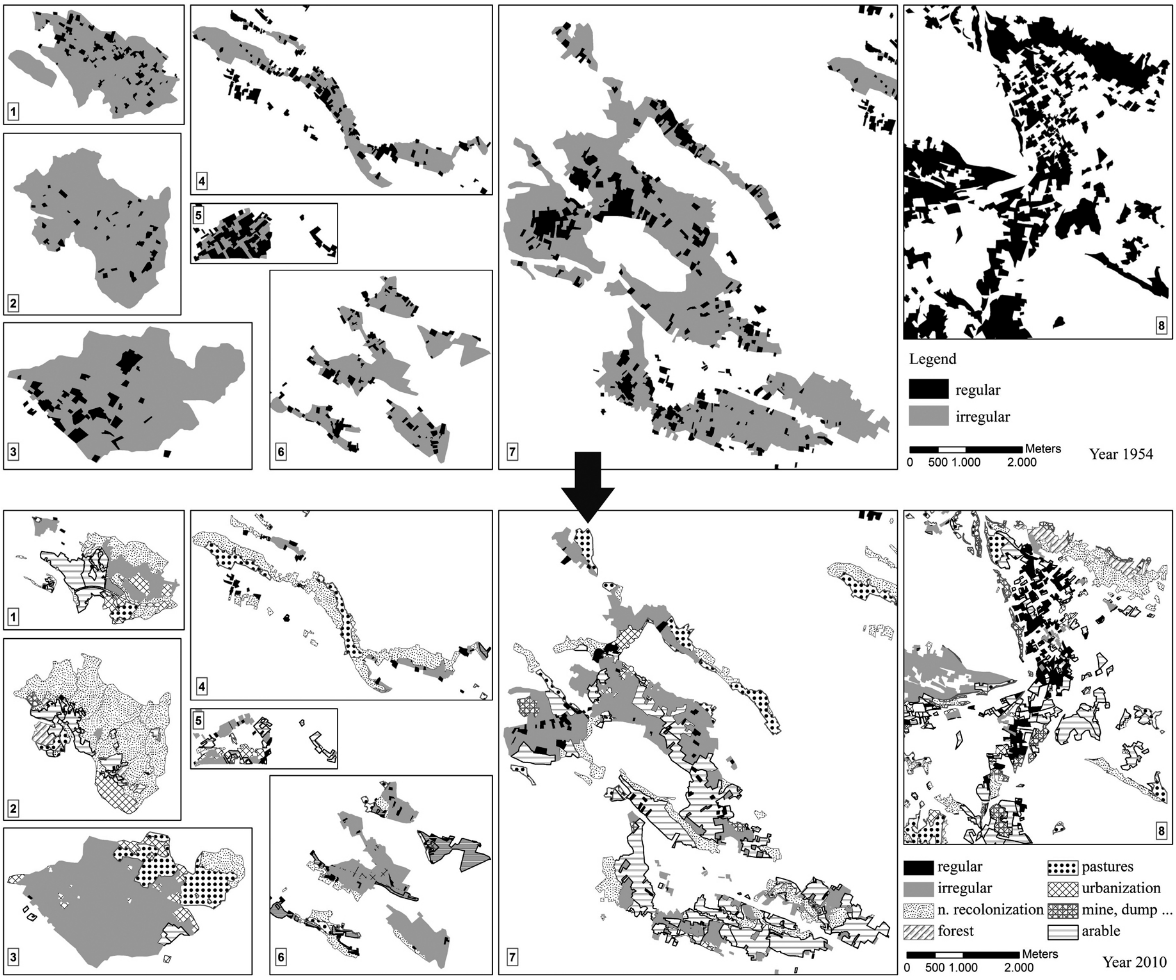

Fig. 10 - Land use changes from 1954 (top) to 2010 (bottom) for the regular and irregular almond orchards in the different areas studied (as indicated).

the land-use categories, it emerges that as for other European traditional and rural contexts, these almond tree crops have generally been replaced by arable crops or by the early stages of the ecological successions that have taken over as a result of the abandonment of the land (Nainggolan *et al*., 2012). It can be seen that compared to other situations, urbanisation has only had a secondary role in the Apennines. This has replaced only 3% of the almond orchards, and it is relevant only in the areas closest to the city of L'Aquila, where this construction development in the agricultural context was mainly due to an exceptional event: i.e., it formed part of the reconstruction process that followed the destructive earthquake in 2009 (Fig. 11). This emergency drive led to the construction of new urban areas as 'new towns', which were often in contrast to the planning conditions and the landscape protection plans. Indeed, this even affected areas with many known landscape values.

Beyond this particular condition, very few of the areas of almond landscape were altered permanently, and this should represent a positive factor for projects that are aimed at the recovery of this ancient cultivation.

Discussion

Almond landscapes appear to be characterised by elements of a traditional landscape and elements that show its decline and that put it into the forgotten landscapes category at the same time. Almond cultivation had an important role in local rural traditions, but it is currently undergoing a rapid decline in terms of production yield and hectares dedicated to its production. However, the transformations that have occurred are not irreversible, and the traditional structure of fields still remains at a local scale. A lack of attention to the presence of this landscape is extremely dangerous, as even the traces of its presence are being lost, as seen by the lack of its representation in the thematic cartography.

Many initiatives are appearing locally to cope with this situation of landscape degradation, and to reco-

Fig. 11 - The role of the urbanisation in the Apennines. Example of the transitions in the land use of almond orchards in the L'Aquila basin, seen for three time periods: 1954 (a), 2000 (b), 2010 (c). The urbanisation took place mainly after the 2009 earthquake, with the 'new town' development (c).

Table 4 - Components of traditional and forgotten landscapes, indicating aspects relevant to the almond. (X, aspect relevant to the almond; TCL, traditional cultural landscapes).

TRADITIONAL		FORGOTTEN	
Presece in literature	X	Absence in literature	
Folkloristic events dedicated to the cultivation	X	No folkloristic events dedicated to the cultivation	
Ties with the culinary tradition	X	Exclusion from the culinary tradition	
Local communities involvement. eg: presence of cultural associations linked to the cultivation	X	Indifference of local communities	
Permanence of the originary structural characteristics at the local level (shape and size of the patches)	X	Loss of the originary structural characteristics at the local level. (shape and size of the patches)	
Extensive presence of animal and plant species related to agro-ecosystems	X	Extensive presence of "interior" plant and animal species, typical of natural areas or anthropophilic species	
Presence in the official map (Corine, Regional Land use etc.) on which the first identification of TCL is based		Absence in the official map (Corine, Regional Land use etc.) on which the first identification of TCL is based	X
Stability of cultivation surfaces		Reduction in cultivation surfaces	X
Stability of production yield (crop quintals)		Reduction in production yield (crop quintals)	
Economic value		Loss of economic value	X

ver the abandoned almond orchards, so as to create new cultivation in areas that used to be dedicated to almond. In recent years, through the Rural Development Plans linked to the Natura 2000 network, the EU Common Agricultural Policy has been creating more opportunities for the recovery of traditional agricultural landscapes.

The almond trees are in part the subject of studies in Special Protection Areas like the "Parco Nazionale del Gran Sasso-Monti della Laga" (National Park of Gran Sasso-Monti della Laga) and "Parco Regionale Sirente" (Sirente Regional Park), whereby companies and local businesses have access to forms of subsidised financing (Biondi, 2012; 2013; Biondi *et al*., 2012).

Projects in progress for the restoration of the almond landscape also involve the participation of research institutions (e.g., The Consortium for Applied Research in Biotechnology, Universities), local communities (e.g., cultural associations, farmers), entrepreneurs engaged in confectionery (with particular reference to confetti), and institutions (e.g., regions, municipalities). The idea is to recover the almond landscape to enhance the local supply chain, while focusing not on quantity but on product quality, and promoting the use of traditional and eco-friendly cultivation techniques, with particular reference to organic cultivation. The results should be the creation of a high quality niche product that is deeply attached to the land. The initial financial boost needs to come from specific programmes, such as the Rural Development Programmes of the regions that will implement the guidelines of the Common Agricultural Policy.

With regard to these financing channels, according to recent Italian studies, there has been reasonable demand for the preservation of traditional landscapes in the hills and mountains in Italy (Tempesta, 2014). Future developments for almond landscape research will focus on the identification of the varieties that are more resistant to spring frosts, and that are characterised by late flowering. Parallel studies will have to be carried out on the genetics and the plant phenology at different altitudes, to select the varieties that will be best adapted to the local climatic and physiographic characteristics.

A second area of research concerns the extension of the analytical techniques used in the present study to other contexts related to traditional agricultural landscapes, and to other areas where almond trees have been traditionally cultivated (e.g., Spain, Greece, Malta, and other Mediterranean countries) (Delplancke *et al*., 2013). This will increase the available data on the structure and trends of almond cultivation, and will provide additional information that will be useful to plan protection and revitalisation actions for the traditional almond landscape.

In conclusion, almond landscape analysis helps to identify the characteristics of both landscape classes: the traditional landscape and the forgotten landscape, with the almond landscape falling between these two definitions. These elements and how they apply to the almond are summarized in Table 4, and they can also be used in other contexts of analysis. These provide the basis for a first rapid examination of the level of conservation of a landscape, with the listing of which features should be explored in analyses aimed at identifying strategies for the recovery and enhancement of the quality of these forgotten landscapes.

Following this approach, it is expected to continue this line of research to extend the case studies. This will help to standardise as best as possible the elements that need to be considered in the evaluation of traditional agricultural landscapes, and will thus provide policy makers who are developing recovery projects with some easy-to-use instruments to better understand landscapes.

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