

Chapter 44

The Langhe Landscape Changes

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Abstract Agricultural policies and socioeconomic constraints are strong drivers of change in human-dominated rural landscapes of Mediterranean Europe. Changes in rural landscapes can have a strong influence on the perspectives of protection and improvement of the natural and cultural heritage. A shift towards quality production, favoured by institutional financial support, has been recently observed in hilly productive Mediterranean sites. An example of this situation is the Langhe region (NW Italy), where woody plantations such as vineyards and orchards have been cultivated on hillslopes for centuries. In this chapter, we assess the landscape evolution occurred in this study site. Land use changes in the 1954–2000 period were assessed by object-oriented analysis of aerial photographs and quantified by spatial statistics capturing and measuring different elements of landscape change. The expansion of orchards from 1954 to 2000 caused an increase of landscape heterogeneity and the fragmentation of field crops. Orchards expansion has reduced other land uses occupying up to 55 % of former field crops, 24 % of vineyards and 15 % of forests. Changes in rural landscapes, traditionally dominated by vineyards, field crops and forests, were so observed in the Langhe region.

Keywords EU-CAP • Historical aerial photographs • Land use change

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44.1 Introduction

In this contribution, land use change in a hilly region of southern Piemonte (northwestern Italy), called Langhe, is studied. This landscape is a traditional complex mosaic of forests, vineyards, orchards and other cultivated fields. The entire Langhe region is also famous for the quality of its wine and food and is candidate to be included in the UNESCO World Heritage List.

Land use changes observed in the area are particularly strong and seem influenced by local and European rural policies. A rigorous photogrammetric processing of historical aerial images was performed thanks to the availability of rare historical camera calibration certificates. The goal of the contribution is the quantification of the landscape changes occurred in the area between 1954 and 2000 and, in particular, the determination of transition paths and transition rates of the main land use categories of this ecosystem. Finally, the effects of the EU-CAP and local policies on the rural landscape of Langhe region are discussed (Godone et al. 2014).

44.2 Materials and Methods

Study area. The study area is part of Langhe hilly region (NW Italy – 44°40' N, 07°59' E), which is characterised by strong agricultural tradition and is widely renowned for its high-quality wine production like Barolo and Barbaresco (Delmastro 2005). Study site elevation ranges from 190 to 634 m a.s.l. and the climate is characterised by humid summer and dry winter seasons; annual precipitation ranges from 800 to 1,100 mm with a main minimum in July, a secondary one in winter, and a peak in autumn. Total annual rainfall reaches 730.4 mm while mean annual temperature averages 11.9 °C.

A set of four historical aerial photographs, taken by the Gruppo Aeronautico Italiano (GAI) flight, which represents the first available flight covering almost the entire Italian territory after the Second World War, was employed in the analyses. They were stored in the archive of Italian National Research Council (CNR-IRPI, Torino), where historical and recent aerial images concerning hydrogeological phenomena are stored. GAI flight was carried out in 1954–1955 with a flight height ranging from 10,000 to 5,000 m a.s.l. having a medium scale of 1:33,000 (Acosta et al. 2005).

In the Italian Military Geographic Institute (IGMI) historical archive, the camera calibration certificates of the investigated flight were retrieved, thus allowing a rigorous image orientation. Photograms were oriented, in Z-Map software, by Automatic Aerial Triangulation assuring an overall accuracy of 2.22 m. The oriented images were then orthorectified and mosaicked at 1-m resolution. A recent, 1:1,000 RGB, orthoimage (Terraitaly – IT2000™, Blom C.G.R. S.p.A) having a ground resolution of 1 m, was employed in the diachronic analysis.

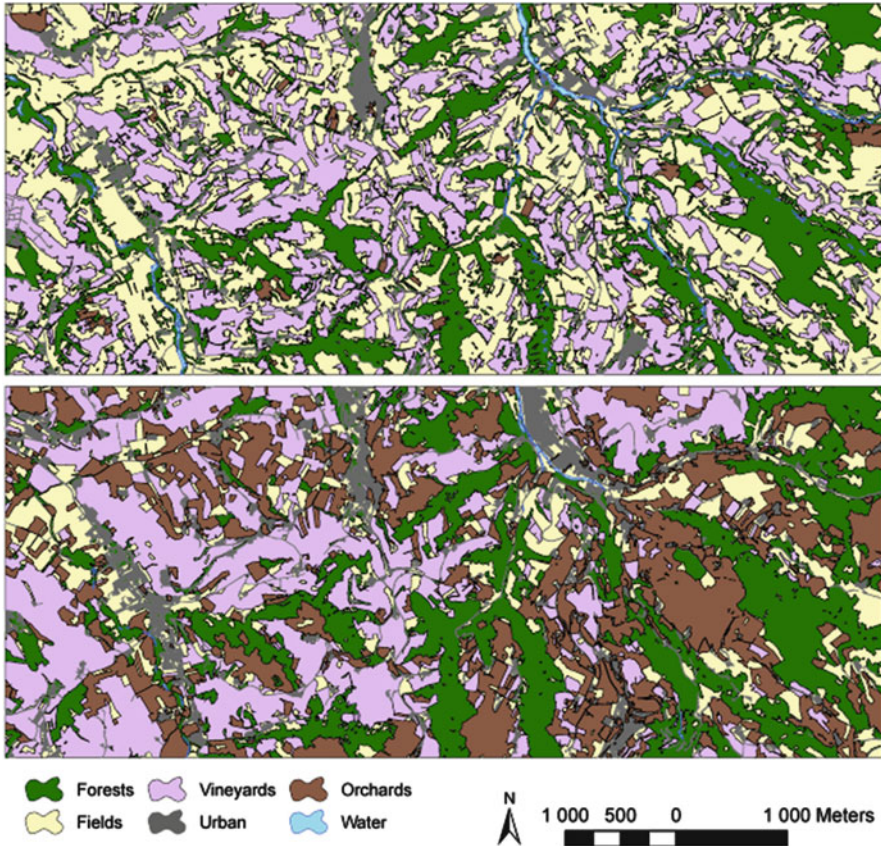


Fig. 44.1 Land use classifications of 1954 (*upper map*) and 2000 (*lower map*) orthoimages

In order to delineate land use classes in the investigated orthoimages (1954–2000), automated segmentation with the eCognition software (scale parameter, 100; shape factor, 0.5) was used to draw polygons in the test area. The segmented images were manually classified into six categories of land cover (Fig. 44.1). An accuracy assessment was performed on each map resulting in the K statistic ranging from 0.86 (90.2 % overall accuracy) for the 1954 image to 0.87 (90 % overall accuracy) for the 2000 image.

Landscape analysis. The analysis was performed by using the “change detection” free extension in ArcView environment (Chandrasekhar 1999), which allowed the computation of a matrix describing the transition between each pair of land cover categories by quantifying its extent per unit time. The permanence of a certain land cover category in the studied period was also calculated by the kappa (K) statistic (Romero-Calcerrada and Perry 2004) that ranges from 0 (category’s surface unchanged) to 1 (all categories’ surface changed).

Then, to analyse changes in landscape pattern, Fragstats software (McGarigal and Marks 1995) was used to calculate, by applying an 8-cell neighbourhood definition, key metrics representative for landscape configuration and composition: patch size and density, edge, contagion, connectivity and diversity (Cushman et al. 2008). Since many metrics are closely related at the landscape level and describe similar aspects of landscape structure (Neel et al. 2004), ten landscape-level metrics were selected excluding those that were highly correlated ($r > 0.8$) (Tischendorf 2001).

Landscape structure was also analysed at the class level by computing 13 metrics for the 6 land cover classes, for the two time periods. Indirect ordination analysis (PCA) was used to reduce the redundancy of landscape metrics into uncorrelated components (McCune and Grace 2002), allowing comparison of land cover classes from all time periods (Tinker et al. 1998).

44.3 Results

In the study site, remarkable changes have been observed during the 1954–2000 period, e.g. a general increase in landscape heterogeneity. The total surface of *Orchards* showed an increase of 24.6 %, to the detriment of *Fields* category (−26.9 %). A slight increase (3.6 %) was observed in the *Urban* class too. *Forests* and *Vineyard* categories experienced an increase and a reduction, respectively.

The kappa statistic indicated that forests and vineyards categories were the most stable components of the landscape, while fields category was the least stable. The noteworthy variation experienced by the *Orchards* category pushed us to deepen our analysis on class level transitions. Only 3 % of the total surface of *Orchards* category remained unchanged, while 55 % of it was former fields, 24 % vineyards, 15 % forests and 3 % other categories.

Principal component analysis provided an ordination scatterplot of land cover changes. The first principal component accounted for 35 % of the total variation and reflected variations of aggregation, core area, mean patch area and shape complexity. The second component explained an additional 30 % of the total variation and was correlated to connectivity, Euclidean nearest neighbour and patch density. The scatterplot confirmed that *Orchards* category experienced the strongest change in the landscape (Fig. 44.2). This category increased both in patch density and patch size mainly at the expenses of the *Fields* category that resulted more fragmented and reduced its mean patch size. *Forests* and *Vineyards* categories showed a similar pattern of change where they increased the aggregation, the connectivity and the size of their patches. A different pattern was observed for *Urban* areas that increased in patch/edge density and shape complexity.

Land use change study requires careful approaches and should be carried out by employing trustworthy data sources in order to correctly reconstruct historical landscape dynamics (Burgi and Russell 2001; Garnero 2013; Minucciani and Garnero 2013). For this reason, the adopted rigorous photogrammetric approach

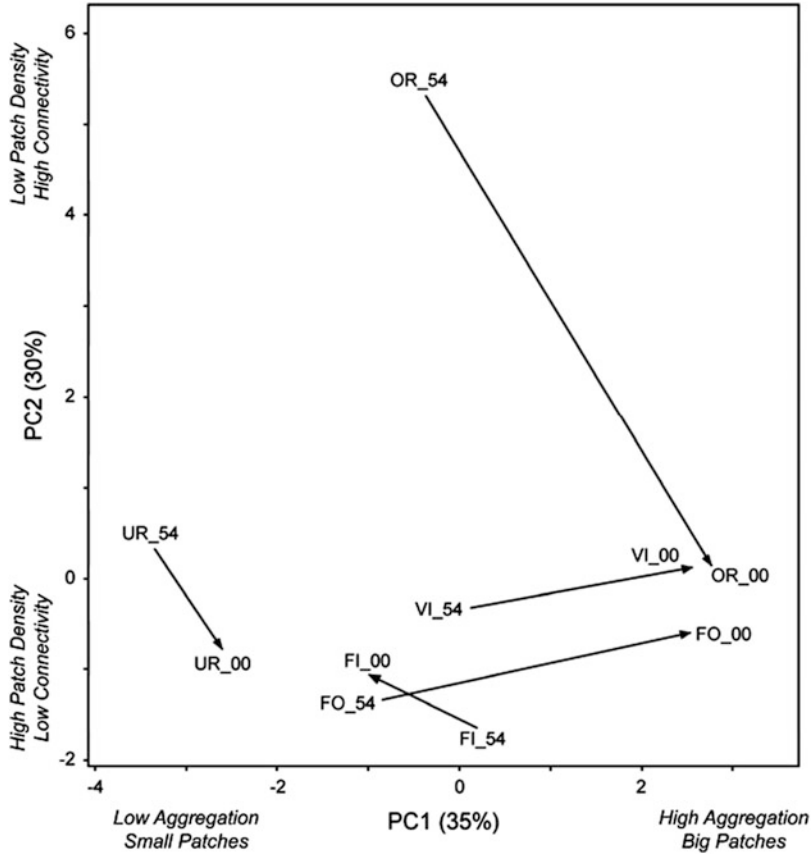


Fig. 44.2 Principal component analysis of five land cover classes (*FO* forests, *OR* orchards, *VI* vineyards, *FI* fields, *UR* urban areas) for 1954 and 2000 periods

assures accurate processing results (Rocchini et al. 2012). The described image processing together with the high classification accuracy assured a reliable land use change investigation.

Among the six land use categories, *Orchards* increased from 1954 to 2000, replacing other agricultural areas, like *Fields* and *Vineyards* and *Forests*. The expansion of *Orchards*, coupled with the increase of *Urban* areas transformed the traditional landscape featured by vineyards, crops and forests in a more fragmented mosaic of various land use categories.

Forests remained almost unchanged; the reforestation pattern observed in the study area is in agreement with other Italian and European (Sitzia et al. 2010; Cocca et al. 2012) mountainous and hilly areas. The non-marginal, productive, vocation of the investigated area is also proved by a notable increase of inhabitants recorded in the last decades, in contrast with Italy and other European countries (Peroni et al. 2000). Vineyards slightly expanded in the most accessible and productive

sites, limiting orchards expansion. However, a general reduction of their surfaces in marginal and less accessible sites in favour of orchards is confirmed by other studies in the Mediterranean territory (Corti et al. 2011).

The land use category defined as *Orchards* was almost entirely represented by hazelnut (*Corylus avellana* L.) orchards. In accordance to the explained results, in Piemonte region the hazelnut cultivated surface increased by 20 % in the last 1990–2000, with the highest increment peak during the 1990–1995 period (Valentini and Me 2002). Furthermore, in the 1981–2000 period, the surface expansion triggered an increase of hazelnut production, nearly doubling the output tons, and of its price from 1.66 to 1.96 €/Kg. A cultivation shift from vineyard towards hazelnut is detectable from the historical records, concerning Cuneo province, on cultivated surfaces (ISTAT 1971–2001). In the last twenty years of the study period (1980–2000), hazelnut orchards have nearly doubled their surfaces, while vineyards have shown a remarkable decrease. These records confirmed the results observed in our study area through change detection analysis.

The strong increase of hazelnut surfaces occurred in Piedmont at the beginning of the 1990s was probably favoured by several European Council regulations and national rural policies. A key policy measure concerning hazelnut cultivation in Italy was a decree (DM 2/12/93) of the Italian Ministry of Agricultural and Forestry Policies which recognised hazelnut's Protected Geographical Indication (PGI) under the appellation *Nocciola Piemonte*. Likewise, in 1996, the European Union registered, with a regulation, the "Piedmont hazelnut" as a PGI (EC 1107/96), and, more recently, in 2007 the Langhe hazelnut was registered within the Community Plant Variety Office (CPVO) with a new name: *Tonda Gentile Trilobata*, for an efficient preservation. The rapid expansion of hazelnut plantations is radically transforming the rural landscape of Langhe region questioning the role of the EU common policy as a driver of land use change.

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