

HISTORICAL MAPS PROCESSED INTO A GIS FOR THE ASSESSMENT OF FOREST LANDSCAPE DYNAMICS

Giuseppe Cillis, Dina Statuto, Pietro Picuno

School of Agricultural, Forest, Food and Environmental Sciences, University of Basilicata, 85100, Potenza, Italy

Abstract

During the last decades, changes in land use and management led to the degradation of traditional rural landscapes, mostly in Mediterranean areas, with relevant consequences for local populations, landscape functionality and the maintenance of ecosystem services. The analysis of modifications occurred in rural land, as well as in mountain areas of some internal Regions - like the Basilicata Region (Southern Italy), in which the continuous abandonment of agriculture is relentlessly reshaping the landscape patterns - is crucial to understand their profound transformations, and to reconstruct their landscape original structure, so as to avoid negative impacts (e.g., loss of biodiversity, land degradation, hydrogeological instability, etc.). One of the observed connected phenomena is the continuous increase in the forest surface. In this work, data from the official Italian dataset and “Land Copernicus” program have been implemented into a GIS environment, together with some historical thematic cartographies (the 1936 Italian Kingdom Forest Map and the National Research Council Map of Land Cover 1960) and ancillary data, to evaluate the main dynamics of landscape and forest environment transformation in the last century. After this general assessment, the changes that affected the forest areas have been then analysed in terms of surfaces and vegetation types.

Key words: forest landscape, historical cartography, Geographic Information System, Basilicata region, landscape pattern

Introduction

GIS techniques implementing historical cartography are increasingly used to reconstruct the multi-chronological patterns and relevant ecological dynamics of a landscape, thanks to the possibility of integrating several types of temporal geodata and enabling multidisciplinary analysis methodologies (Statuto et al., 2016). This approach is essential to understand the transformations that are taking place in rural settlements (Olišarová et al., 2018) and agroforestry landscapes of the Mediterranean area, where the continuous abandonment of agriculture is reshaping the landscape patterns (Statuto et al., 2017). In fact, in the last century, a particular land configuration has taken place in the Mediterranean Europe region: internal mountain areas were abandoned and then naturally reforesting, while settlements were quickly increasing around the city and along the coastline, and the flat areas almost totally turned to arable lands (Falcucci et al. 2007). The effects of these land use changes have been studied by many authors (Lambin et al., 2001; Malandra et al., 2018; Statuto et al., 2018/b) but it is necessary to investigate in detail, at different scales, what positive or negative impacts they could determine. This phenomenon has also been detected in the Basilicata region (Southern Italy) where, in some areas, an increase in the forest area that is reshaping the forest landscape was registered (Statuto et al., 2013; Mancino et al., 2014). However, there are no studies at the level of the entire region that retrace the transformations of the forest area occurred in the last century. Furthermore, assessing the dynamics of the forest landscape can reveal useful in particular contexts, where there is the double need both to environmentally protect and to socio-economically enhance the territory (Cillis et al., 2018). The objective of the present study is therefore to implement a methodology finalized to reconstruct the dynamics occurred in the forest landscape by using an open-source GIS environment, in which some different multi-temporal cartographic data have been implemented.

Material and methods

The study area, consisting of the entire Basilicata region (Fig. 1), covers a total surface of 10,073 km², 90% of the whole territory being mountainous. The territory has a strong agricultural vocation; indeed almost 50% of the regional area is cultivated. Forests are an important heritage thanks to their high biodiversity. More than 20% of land is covered by different protected areas.

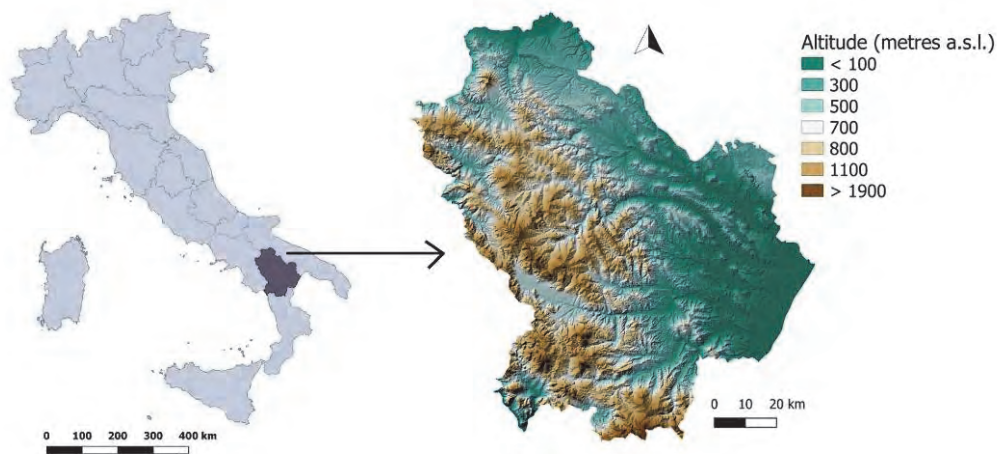


Fig. 1: The study area (Basilicata Region – Southern Italy)

The first operation has been to collect some different cartographic datasets. The Italian Kingdom Forest Map (1936) has been implemented as proposed by Ferretti et al. (2018), together with the Map of Land Cover of the Italian CNR (National Research Council) of the 1960s, which has been digitized according to the techniques established in other studies (Pindoizzi et al., 2016; Statuto et al., 2018/a). Finally, the more recent “*Land Copernicus*” dataset (2000) and the ISPRA dataset (2017), retrieved online as free vector and raster files, have been implemented as well. After the scanning and georeferencing process, the land use vector file was created. With a first simple mapping operation (Fig. 2) the forest surfaces have been obtained - in terms of hectares and percentages, with respect to the entire region - for each one of the four years of analysis.

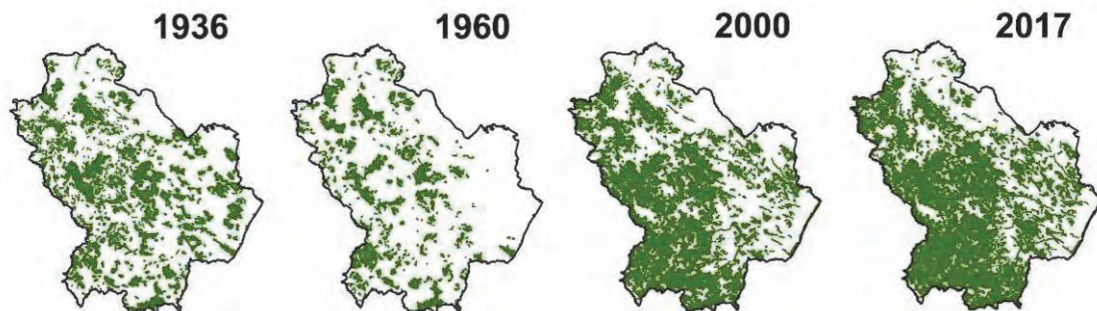


Fig. 2: Forestry area during the four different analysed time levels

Then, thanks to a geospatial analysis (intersection of polygons) between the different datasets, it has been possible to derive the main dynamics that occurred in the different time intervals: 1936-1960; 1960-2000 and 2000-2017. This allowed to highlight the *Conservation areas*, in which the persistence of forests was conserved, and the *Deforestation areas* (Fig. 3). The *Afforestation areas* have not been considered, because they need more detailed investigations. All operations were carried out with an open-source approach thanks to the use of QGIS 3.4.

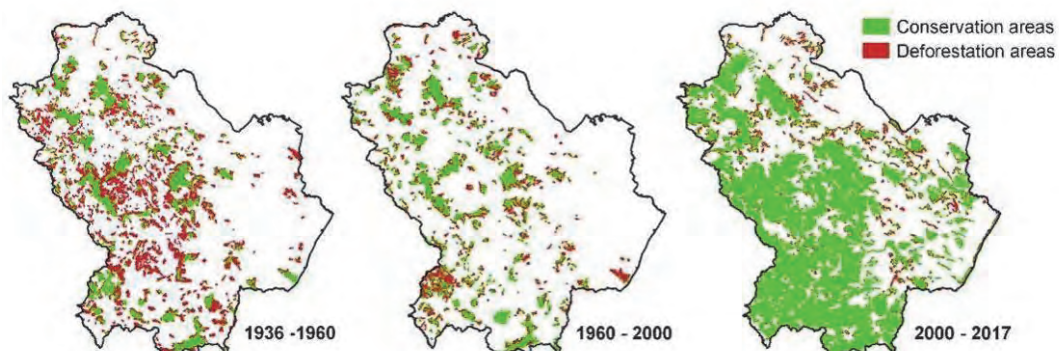


Fig. 3: Conservation and deforestation areas for each time interval

Finally, the data of the 1936 forest map were compared to the data of the year 2006 – obtained through the official forest map of Basilicata Region - by aggregating them on the basis of information on the various forest species. In this way, it has been possible to highlight the transformations that occurred to the most representative forests of the Basilicata Region, that are the oak-forests (considering *Quercus cerris* L. and *Quercus pubescens* Willd.) and beech-forests (*Fagus sylvatica* L.) (Fig. 4).

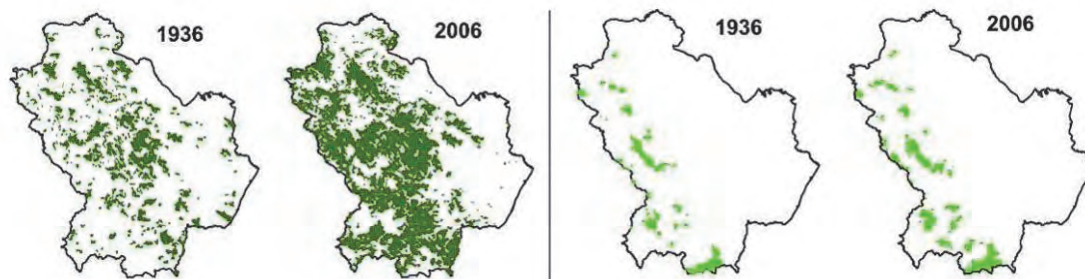


Fig. 4: Changes in the time interval 1936-2006 of oak-forests (left) and beech-forests (right)

Results and Discussion

From the analysis which has been here conducted, it emerges in the last few decades a strong increase in forest cover, with progressive fewer conversions in other land use categories. The results (Tab. 1) show in fact that the Basilicata regional land is currently covered by 33.8% of forested areas, which in the year 1960 were representing only 12.6% (about 127000 ha) of the whole territory. The economic growth occurred at that time has pushed indeed towards an intensive use for agricultural purposes of these territories, with a reduction (-2.4% between 1936 and 1960) of the forested surfaces.

Tab. 1: Forest surface (in hectares and percentage compared to Basilicata Region extension) for each years of analysis

Forest surface	Year			
	1936	1960	2000	2017
ha	150,864	127,032	292,910.	340,742
%	15.0	12.6	29.1	33.8

In subsequent periods, even characterized by a progressive abandonment of agricultural activities in these mountainous marginal areas, there was a considerable increase in forested surfaces, more than doubled in 2000 (almost 293000 ha), followed by a further increase of 4.7% over the last 17 years (Tab. 2). This table shows the consistency of areas characterized by forest persistence (conservation areas) and deforested areas. In the time interval 1936-1960 it emerges that only the half of the forest cover present in 1936 has been preserved, while the 47.5% has been deforested, *i.e.*, transformed into other types of land use. On the contrary, in the time interval 1960-2000, and even more in 2000-2017, an increase in the percentage of conservation area has been occurred, until almost reaching 100% in the last period.

Tab. 2: Variation of forest and conservation/deforestation areas (in ha and percentage compared with forest area) for each time interval of the analysis

	1936-1960		1960-2000		2000-2017	
	ha	%	ha	%	ha	%
Forest variation	-23831.72	-2.4	165878.10	16.5	47831.91	4.7
Conservation areas	79175.20	52.5	94828.73	74.6	284571.78	97.2
Deforestation areas	71689.23	47.5	32203.95	25.4	8339.01	2.8

Instead, from the last analysis on forest types (Tab. 3), it is noticed that the surface represented by oak forests has more than doubled from 1936 to 2006. In percentage terms, oak woods are both in 1936 and in 2006 more than 50% of the whole forest area. Therefore, this forest typology still continues to be the most representative. On the other hand, beech forests are only relegated to some

mountain areas of Basilicata, showing an increase limited to 570 ha between the values recorded in 1936 and 2006.

Tab. 3: Surface (in hectares and percentage compared with forest area) of oak-forests and beech-forests for years 1936 and 2006

	1936		2006	
	ha	%	ha	%
Oak-forests	89,275.9	59.2	183,704.3	51.8
Beech-forests	29,229.2	19.4	29,776.3	8.4

All the above-reported trends are currently investigated regarding the impacts they produce on the rural landscape, in terms of loss of biodiversity, land degradation, hydrogeological instability, etc. The relevant results are giving useful indications for the implementation of suitable policies, able to assess and preserve naturalness, bio-diversity and visual quality of rural landscapes.

Conclusion

The integration of new open data with historical cartography which has been experimented in this study allowed to understand the transformation of a forest landscape, which took place in an internal area. This method could be used in similar context, where comparable datasets are available. The consequences of this process is going to be evaluated in more detailed studies, aimed to assess the characterization and spatialization of dynamics of land use transformation.

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Souhrn

Historické techniky GIS jsou stále více využívány k rekonstrukci ploch a ekologické dynamiky krajiny, protože díky možnosti integrace několika typů časových geodat zaručují zavedení metod multidisciplinárních analýz. Analýza modifikací proběhla jak na venkově, tak v horských oblastech některých vnitřních regionů, ve kterých je neustálé opouštění zemědělství přetvářením krajinných vzorů, je klíčové pro pochopení jejich hlubokých změn a rekonstrukce původní krajinné struktury, vyhýbání se následkům negativních vlivů. Studie zjistila, že po poklesu v roce 1960 lesy stále více rostou, přičemž hodnota (v roce 2017) přesahuje 30% celého regionu. Navíc, zejména v posledním období, vzrostla vytrvalost lesů ve stejných oblastech. Nakonec, dubové lesy, kromě toho, že se zvětšují z hlediska rozlohy, jsou stále dominantní v typologii lesů. Metodika použitá v této studii umožňuje prohloubit problematiku transformace lesní krajiny, která se odehrává ve vnitřních oblastech Středozemního moře, a mohla by být využita v podobném kontextu v oblastech, ve kterých jsou srovnatelné soubory údajů.

Contact:

Giuseppe Cillis

E-mail: giuseppe.cillis@unibas.it