



## A comprehensive insight into the geography of forest cover in Italy: Exploring the importance of socioeconomic local contexts



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### ARTICLE INFO

#### Article history:

Received 31 December 2015

Received in revised form 30 October 2016

Accepted 21 November 2016

Available online 30 November 2016

#### Keywords:

Forest land

Land-use change

Socioeconomic profile

Indicator

Southern Europe

### ABSTRACT

Forest cover is a key attribute of local communities and affects the spatial organization of any given region. Changes in forest cover are influenced by spatially-varying biophysical and anthropogenic factors mainly associated with urban–rural, coastal–inland and elevation gradients. The present study investigates the relationship between the socioeconomic structure of local communities and selected indicators of forest landscape in Italy, including change in forest area over time (2000–2012), using an exploratory multivariate analysis based on principal component analysis, hierarchical clustering and discriminant analysis. We assess the importance of socio-spatial structures, economic dynamics and demographic patterns in the geography of forest cover, expansion and loss, considering 149 statistical indicators that are used to evaluate the multiple dimensions of sustainable development. The results point to agriculture, income, education and labour market indicators as a key predictors of contexts with high forest cover and moderate changes in forest area (both gain and loss) from those with low forest cover and marked changes in forest area. High forest cover in rural districts was spatially associated with local communities featuring depopulation, unemployment, low educational levels and subsistence agriculture. These factors consolidate land abandonment and soil erosion. The highest rate of change in forest area was observed in economically-growing, accessible local contexts with dynamic socio-demographic profiles. Integrated environmental and socioeconomic policies for sustainable development are required to incorporate forest cover and changes in wooded area as pivotal variables and may benefit from a better understanding of the role of local communities in forest management.

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### 1. Introduction

Ecological disturbance caused by human-driven landscape transformations is the main cause of biodiversity loss, habitat fragmentation and land degradation (Foley et al., 2005; Baptista and Rudel, 2006; Blondel et al., 2010). Therefore, assessing landscape characteristics and environmental quality plays a crucial role in natural resource planning and biodiversity conservation (Sirami et al., 2010; Salvati et al., 2013a, b). High-quality natural environments (e.g. forests, shrubland, pastures, wetlands) require renewed monitoring approaches based on their joint socioeconomic and landscape value (Marchetti et al., 2014). Approaches that concentrate on the role of local socioeconomic contexts are particularly needed to ascertain the dynamic patterns underlying complex socio-ecological systems (Safriel and Adeel, 2008; Raymond et al., 2009), especially those exposed to processes of environmental degradation driven by climate and land-use changes, desertification, soil and water pollution (Hill et al., 2008; Salvati and Zitti, 2009; Imeson,

2012). Local communities reflect the long-term interplay between man and natural resources as a result of joint demographic, cultural, political and economic processes (Salvati and Carlucci, 2011), in turn promoting feedbacks, influencing thresholds and determining synergies in complex socio-environmental systems (Kelly et al., 2015).

The characteristics of local communities are important factors shaping forest landscape, from the stand level to forest compartment and landscape level (e.g. Konijnendijk et al., 2006; Zhang et al., 2010). Understanding the human-forest relationship requires consideration of the “economic behaviour in relation to social structures and processes as well as a necessary focus on the context-bounded and culturally rooted human actors' behaviour” (Schlüter and von Detten, 2011, p. 326). Regional disparities, economic marginality, rural poverty and increased anthropogenic pressure on ecologically-fragile land have been hypothesized to be decisive in the depletion of the forest resource base in both affluent and emerging countries (Blaikie and Brookfield, 1987; Boardman et al., 2003; Iosifides and Politidis, 2005). However, although an essential component in the analysis of drivers of change, the spatial distribution of forest cover and the socio-economic profile of local communities has been little studied. One exception is the work reported by

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Kelly et al. (2015) which uses a truly holistic approach based on the concept of socioeconomic resilience. Taking into account this knowledge gap, the present study contributes to the assessment of population and land-use factors shaping socio-demographic, economic and forest transitions in affluent countries. Specifically, we explore the local-scale spatial complexity of the socio-environmental systems in Italy as a case study, by focusing on the long-term nexus between local communities and forests. Italy is a suitable case study since it is characterized by territorial disparities in environmental conditions (climate, vegetation, soils, agricultural systems) and socioeconomic variables (income, labour market, demography and socio-spatial structures). A multivariate analysis of contextual indicators profiling local communities in six research dimensions (population, labour market, economy, quality of life, agriculture, environment) allowed us to investigate the changing local context at the base of complex socio-environmental systems undergoing socio-demographic and forest transitions.

We considered local communities as an element shaping forest structure and short-term changes in forest cover (Iosifides and Politidis, 2005). The spatial distribution of forest cover reflects the interplay between nature and humans, with recent landscape transformations being dependent on the (more or less rapid) evolution of local contexts. Complexity in the spatial distribution of forest cover and the unique relationship with agriculture and human settlements at the local scale make Italy an interesting case for investigating complex socio-environmental systems which reflect the long-term interaction between natural landscapes, cropping systems and rural communities (Antrop, 2005; Bajocco et al., 2012; Zitti et al., 2015). Wood resources have been traditionally utilized for millennia and forests have been managed for a long-term in Italy, the country with the largest surface area of coppiced forests in Europe (Scarascia Mugnozza et al., 2000).

We implemented a data mining approach (Section 4) with the aim to identify the socioeconomic traits that characterise Italian local communities in relation to indicators assessing selected characteristics of forest landscapes. Our approach is based on the multidimensional analysis of 19 forest indicators and 149 biophysical and socioeconomic indicators at the municipal level. Salvati and Carlucci (2011) demonstrate that a comprehensive socioeconomic profile of local communities can be derived using statistical indicators available at spatially-detailed administrative domains. As concerns forest cover dynamics, we have applied the approach by Hansen et al. (2013) which provides indicators assessing forest area and its short-term loss and gain. The present article is organized into seven sections. To suitably frame the questions at hand the following Sections 2 and 3 report, respectively, an outline of previous investigations on the considered research subject and a short presentation about the state of the art of forest area evolution in Italy. After materials and methods (Section 4), Section 5 presents the results, that are then discussed in Section 6. Finally, Section 7 proposes some overall conclusions.

## 2. Previous investigations

The long-term impact of local socioeconomic structures on forest cover and more recent changes in forest area have been widely analyzed and discussed in previous studies (Rudel et al., 2005), proposing original interpretations of complex socio-environmental systems, among which the Forest Transition (FT) theory is one of the most consolidated approaches. The FT theory describes a long-term process with variable trends in forest cover (from loss to expansion of forest areas, and vice-versa) depending on place-specific socio-environmental conditions (Mather, 1992, 2004; Klooster, 2003; Meyfroidt and Lambin, 2008; DeFries and Pandey, 2010; Yackulic et al., 2011; Redo et al., 2012; Gutiérrez Rodríguez and Ruiz Pérez, 2013). Changes from net deforestation to net reforestation reflect the impact of economic factors at the regional scale, such as urbanization, population growth, crop intensification, learning and education level, governance quality and the level of environmental awareness (Mather et al., 1998; Perz,

2007; Barbier et al., 2009; de Jong, 2009; Pagnutti et al., 2013). The FT theory contributes to the understanding of land-use change drivers, e.g. in terms of land abandonment or biodiversity conservation, and informs policies with the aim to promote a sustainable management of forest land (Mather and Needle, 1998; Mather et al., 1999; Mather and Fairbairn, 2000; Hecht et al., 2006; Rudel, 2009; Salvati et al., 2012; Ferrara et al., 2014; Otero et al., 2015).

The intimate connections between demographic transitions and forest transitions, particularly well studied in some developing regions of the world (e.g. Rudel et al., 2002; Mather, 2007), are also relevant in developed countries, since they involve multiple dimensions that should be considered as synergistic drivers of change (Chesnais, 1993). In wealthier regions, demographic changes impact forest management schemes influencing the provision of ecosystem services (Bajocco et al., 2012). Only a comprehensive understanding of forest management general context (Hajjar et al., 2014) may indicate how changes in the use of forest resources from productive aims to non-economic landscape or environmental functions (e.g. aesthetic, recreational, conservation) can be adapted to the specific local context. This requires the design of sustainable forest planning strategies that take into account the evolution of landscape and local communities (Corona et al., 2008).

The loss in forest area is associated with a broad spectrum of social processes driven by industrialization and agricultural intensification (Meyfroidt and Lambin, 2011; Raghavan and Shriali, 2015). By contrast, more variable patterns have been associated with the increase in forest area. Wealthier countries have generally shown turning points from loss to expansion of forest area in a time period encompassing the two World Wars and coinciding with rapid demographic changes (Rudel et al., 2002; Klooster, 2003; Bray and Klepeis, 2005). However, these evidences are still mixed and need further investigation to shed light on the latent relationship between socio-demographic changes and forest transition in affluent countries, and especially in the European continent (Antrop, 2005).

Extensive land-use transformations impacting natural ecosystems have been observed during the last century in Europe (European Environment Agency, 2006a, 2006b; Hill et al., 2008; Lazarus, 2014) with multiple environmental and socioeconomic factors being implicated in this process and sometimes representing the most relevant drivers of change (Santos et al., 2014). On the one hand, land-use changes determined the fragmentation, simplification and deterioration of natural landscapes, rather than deforestation per se (Zheng et al., 2013). On the other hand, urban expansion in metropolitan regions has determined a polarization in areas with high and low population density (Salvati and Zitti, 2007), relegating rural regions to poverty and economic marginality as a result of unbalanced demographic structures, social deprivation and a locked production base (Salvati and Carlucci, 2011). Natural forest expansion has been observed in such districts since the 1980s (Mancino et al., 2014). Although the (natural or human-driven) increase in forest area is generally considered a signal of improvements in environmental quality, it may actually have a critical (either positive or negative) role for biodiversity and landscape conservation (Corona et al., 2008), depending upon local environmental conditions (e.g. pasture encroachment is usually negatively considered from a recreational point of view). Thus, the process of forest area expansion requires land planning especially in peri-urban areas and rural landscapes with medium population density, high accessibility and a dynamic economic system (Sabbì and Salvati, 2014). Knowledge of the socioeconomic factors most closely associated with forest dynamics is also strategic to identify correct policy interventions and economically-viable solutions for the sustainable management of forests in marginal contexts vulnerable to depopulation, land abandonment and soil erosion (Canadas and Novais, 2014). Empirical studies confirm the importance of multiple sources of data to assess changes in spatial structures and characteristics of forests heavily impacted by human activities (Motta and Edouard, 2005; European Environment Agency, 2010, 2016).

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