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Landscape changes, traditional ecological knowledge and future scenarios in the Alps: A holistic ecological approach

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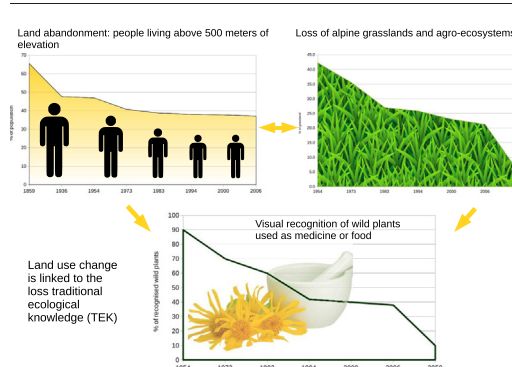
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HIGHLIGHTS

- An Alpine community participated in a study on Traditional Ecological Knowledge (TEK).
- We calculated trends of Land Use Change (LUC) in an Alpine region for 150 years.
- We mixed TEK questionnaires, statistics, historical data, GIS, and future scenarios.
- We found that a clear trend of forest cover expansion and open areas loss is in place.
- LUC, in particular open areas loss is a suitable proxy for TEK loss in the Alps.

GRAPHICAL ABSTRACT



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ABSTRACT

In recent decades, a dramatic landscape change has occurred in the European alpine region: open areas have been naturally recolonized by forests as traditional agricultural and forest activities were reduced and reorganized. Land use changes (LUC) are generally measured through GIS and photo interpretation techniques, but despite many studies focused on this phenomenon and its effects on biodiversity and on the environment in general, there is a lack of information about the transformation of the human–environment connection. The study of Traditional Ecological Knowledge (TEK), such as the ability to recognize wild plants used as medicine or food, can suggest how this connection evolved through time and generations. This work investigates the relationship between the natural forest cover expansion that influences the loss of open areas and the loss of TEK. Different data sources and approaches were used to address the topic in all its complexity: a mix of questionnaire investigations, historical maps, GIS techniques and modelling were used to analyse past land use changes and predict future scenarios. The study area, Trentino, Italy, is paradigmatic of the alpine situation, and the land use change in the region is well documented by different studies, which were reviewed and compared in this paper. Our findings suggest that open area loss can be used as a good proxy to highlight the present state and to produce future scenarios of Traditional Ecological Knowledge. This could increase awareness of the loss of TEK in other Alpine regions, where data on TEK are lacking, but where environmental trends are comparable.

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1. Introduction

In recent decades, a dramatic landscape change has occurred in the European alpine region: open areas have been naturally recolonized by forests. Many studies have documented and quantified forest cover expansion in European Alpine areas (Sitzia et al., 2010). Less attention has been paid to understanding the dynamics and the consequences of this dramatic change from both an environmental (Scarascia-Mugnozza et al., 2000; Schulp et al., 2008; Valle et al., 2009) and social perspective (Grêt-Regamey et al., 2013). The loss of open areas is linked with human migration; changes in lifestyles, languages and traditions; loss of economic dynamism in mountain areas; and increasing disconnection between people and natural areas (Ianni et al., 2015). Within the scope of the relation between Land Use Change (hereafter, LUC) and its associated social processes, this study addresses the particular relationship between the loss of open areas and the decreasing intergenerational transmission of Traditional Ecological Knowledge (hereafter, TEK).

It is important to emphasize that the monitoring of TEK is an extremely complex and time consuming issue because it requires hard work by committed researchers and the involvement of the interested local communities, who must be convinced to actively contribute to questionnaires and meetings. Therefore, very few studies of Alpine TEK loss are available in the literature.

The use of the word open area “loss” should not necessarily imply a negative outcome of the ongoing processes that can be considered pathways of transformation. The Alpine environment is the result of a complex and millennia-long interaction between man and the original alpine biomes. The anthropic intervention has irreversibly changed the natural environment (for example, by driving animal or plant species to extinction) and has created a different equilibrium in which man has replaced, at least partially, the role or the habitat of the absent fauna or flora (Diamond, 2005). The alteration of the original environment included high deforestation rates and massive LUC that stressed mountain areas and generated important phenomena of soil erosion and surface flow sediment.

If examined from another point of view, natural reforestation could seem to be the best response to global concern over the rapid loss of the world's biodiversity. In fact, at a global level, in the last decades, afforestation practices and landscape restoration projects have been trying to stop or reverse the massive deforestation rates that affect the tropical regions in particular (Williams-Linera and Alvarez-Aquino, 2010). Reversing the loss of environmental resources is, in fact, a global priority and one of the targets of the millennium development goals. It has been widely documented that deforestation (and LUC) affects the distribution and richness of local biodiversity (Orlandi et al., 2016), the resilience of ecosystems to climate change (Brambilla et al., 2015), water availability (Glavan et al., 2013) and carbon sequestration (Achard et al., 2014; Schulp et al., 2008). Nevertheless, what is currently occurring in the Alpine mountain environment – the recovery of forests at the expense of open areas and the associated impressive change in biodiversity patterns – should not be viewed only as a renaturalization process with positive consequences. This is not only because of the above-mentioned TEK loss but also because of the short- and long-term effects on fauna and flora biodiversity, which are debated and sometimes considered negative or uncertain, at least for some groups or species (Gilardelli et al., 2013; Pornaro et al., 2013; Strebel and Bühler, 2015; Tattoni et al., 2011).

Unlike TEK, the monitoring of LUC in the Alps has been extensively performed using GIS and modelling techniques (Sitzia and Trentanovi, 2011; Tappeiner et al., 2007). The majority of these studies rely on GIS analysis of cartographic material (historical maps, ortho-rectified aerial photographs, technical maps) processed by combining manual and automatic techniques to extract LUC for each temporal step (Sitzia and Trentanovi, 2011; Tattoni et al., 2010). Although the techniques used in different studies may vary, there is general agreement in the way in

which data are extracted, analysed and processed (Kozak et al., 2007; Wulf et al., 2009; Tattoni et al., 2011). The process of data preparation and analysis is especially time consuming and requires specific expertise and background. Unfortunately, the description of this process is sometimes incomplete in the scientific literature (Tattoni et al., 2010), and this makes cross-study comparisons more difficult. Additionally, it is possible to use past LUC rates to generate future scenarios based on assumptions about key drivers such as environmental pressures and management choices. Although the literature has debated the suitability of different methods of scenario generation based on past LUC and the associated uncertainty levels, these approaches are presently well accepted and widely used in the scientific community (Cabral and Zamyatin, 2009; Ciolli et al., 2012; Tappeiner et al., 2008). The same limitation mentioned above, regarding the importance of transparency in describing methods, also applies to scenario generation affecting cross-study comparison.

The aim of this work is to clarify the relation between LUC and its associated social processes, in particular, this work aims to show a relationship between the loss of open areas and the decreasing intergenerational transmission of ecological knowledge in a rural community. Highlighting the “inextricable link” between cultural and environmental processes can generate new creative and innovative actions for the management of mountain areas that are suffering from depopulation and ageing.

To achieve these goals, this work calculates past LUC trends in the forest and open areas of an Alpine region (Trentino, Italy) during the last 150 years; future scenarios are calculated using GIS (Geographic Information System) aerial photographs and historical cartography; these scenarios are described and then combined with statistical data on migration and on traditional mountain activities that had an impact on forest patches, such as grazing. Second, the study is focused on a small community at 1000 m altitude. It tries to combine LUC with field data that describe intergenerational TEK transmission using information about past TEK trends and forest LUC trends to produce future scenarios and to investigate the possible fate of LUC and TEK.

2. Study area

The study area is the Province of Trento, a mountain region of approximately 6212 km² (located in the northeastern Italian Alps (Fig. 1)).

The Trentino region was selected because forests cover >60% of the territory and they are expanding at the expense of open areas (Agnoletti, 1998; Sitzia, 2009; Tattoni et al., 2010); also, the region has undergone massive migration and social changes during the last century and is an important hotspot for biodiversity. In fact, the area hosts a large number of floristic endemic species (Prosser, 2001), and approximately 19% of its surface is covered by natural parks and protected areas (ISTAT, Italian National Institute of Statistics website (<http://www.istat.it/en>)). The Dolomites are considered a world natural heritage site, and the Val di Ledro valley is to be declared a biosphere reserve. With its networks, the region is a corridor for macrofauna; it is the only Italian Alpine area from which the brown bear never disappeared (Mustoni et al., 2003; Tattoni et al., 2015).

The forest varies from Mediterranean vegetation, where forests of *Quercus ilex* occur, up to alpine areas where *Pinus mugo* and alpine herbaceous vegetation represent the principal forest cover. Trentino has a long tradition of forest management, and the vast majority of its forests are public (Paletto et al., 2013). Forest and agricultural activities still constitute an important part of Trentino's economy; winter and summer tourism is the main source of income for the region. In Trentino, the central valleys located along its main communication routes have experienced a positive population trend, while the centres located at altitudes over 600 m have experienced a clear negative trend, unless they are located in touristic areas (Sitzia, 2009; Turri and De Ros, 2006). In 1921, 17.9% of the total population lived in the 750–1000 m altitude

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