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Relationships between understory specialist species and local management practices in coppiced forests – Evidence from the Italian Apennines

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ABSTRACT

Though the importance of coppicing for the conservation of forest biodiversity is acknowledged, little is known about flora diversity and how it may be affected by the perceptions, constraints and regulations governing how loggers choose to exploit forest resources. Building on previous research on coppiced forests in the central Italian Apennines, unstructured and structured social surveys were performed along with structural and compositional vegetation sampling to determine how the ecology of the understory flora, where most of the biodiversity is found, may be affected by direct and indirect interactions between formal rules, namely Marche Region prescriptions, and informal rules applied in coppicing management.

We identified economic/logistical and ecological variables that influence change in understory plant communities, particularly focusing on specialist forest species, and we explored how commercial, private and group property (Comunanza Agraria) loggers are influenced by these variables in deciding whether a forest is suitable for coppicing. Our insights on the relationships between the human and the ecological dimensions of the coppicing system suggest that the users prefer specific forest conditions because they facilitate efficient harvesting. These conditions also happen to be compatible with the life cycle of the specialist forest species in the ground flora.

The stand attributes considered to be indicators of productivity drive decision making almost independently from (but largely compatibly with) formal rules. This is true across the three groups of loggers. These attributes seem to act as determinants of the conservation of the functional diversity of understory plant species, at plot and forest patch scale. We conclude that economically viable coppicing can occur after the stumps have been allowed to regenerate and grow beyond a certain diameter. This enables understory conditions favorable to forest *specialist* plants to re-establish and makes the present coppicing regime compatible with conservation of the diversity of these species in the forest landscape.

1. Introduction

The importance of human action in shaping the evolution of ecological systems has led ecologists and land managers to broaden their analysis from exclusive consideration of ecological variables to exploration of the social and economic elements of coupled human and natural systems (Lele et al., 2013). This more comprehensive analysis enables better understanding of how a certain type of management might have begun and why it continues, and how the system might respond under certain pressures. With this deepened understanding, researchers can propose adjustments to management systems to maintain biodiversity, increase the resilience of ecosystems and enhance the services they afford (Chhatre et al., 2009; Persha et al., 2010; Biggs et al., 2012; Paletto et al., 2013).

Academics worldwide are devoting increased attention to forest social ecological systems and the interactions between humans and the environment, particularly forest ecosystems and their

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services (Kalaba, 2014). Some scholars have called for intensified research to explore the relationship between human livelihoods and biodiversity conservation (Liu et al., 2007 and Persha et al., 2011). To our knowledge, few studies of this kind have focused specifically on Mediterranean forest systems (Otero et al., 2013). In fact, a search of abstracts on the Web of Knowledge (https://apps.webofknowledge.com, accessed 7 April 2016), using field tags 'ts = coppice AND ts = Mediterranean,' yielded 157 studies, none of which, however dealt with flora diversity or changes in understory species community and local institutions.

This is a serious scientific gap, because these types of forests have experienced a long history of management and host a rich biodiversity (Scarascia-Mugnozza et al., 2000; Fady-Welterlen, 2005). Though the importance of Mediterranean forests has been recognized in the European Union's nature conservation policy ('Habitat' Directive 92/43/CE), there is almost no research about how institutions, intended here as 'ways of organizing activities,' (see Dietz et al., 2003), as well as the ecological knowledge local users build upon, help maintain and build the resilience of this social-ecological system (Berkes et al., 2000; Bohensky and Maru, 2011; Johnson et al., 2016; Scullion et al., 2016).

Coppicing, a forest management system that relies on the resprouting capacity of some tree species after being cut, is used worldwide (Suchomel et al., 2011) and is particularly widespread in Europe (Peterken, 1981; Rackham, 2008; Puumalainen, 2001). In the Mediterranean area, coppiced forests cover about 23 million Ha (UN/ECE-FAO, 2000), 3.9 million of which are in Italy (Ciancio et al., 2006). For centuries, this forest management system has enabled local communities to earn income and satisfy the demand for firewood (Amorini and Fabbio, 2001; Agnoletti, 2006, 2007; McGrath et al., 2015). The coppice rotation time is usually short (about 15–30 years), and yet this regime of relatively intense disturbance appears to help preserve the system's plant biodiversity (Campetella et al., 2016), including rare ground flora species of considerable conservation interest (Ash and Barkham, 1976; Hölscher et al., 2001; Decocq et al., 2004, 2005; Bartha et al., 2008; Kopecky et al., 2013). In particular, Campetella et al. (2016) demonstrated that the functional group of late successional beech forest species (beech specialist species) can largely persists in a coppiced landscape.

Understanding the factors that drive their dynamics is therefore important from both an ecological and a socio-economic perspective.

In this paper, we studied a socio-ecological system of beech forests in the Marche Region of Italy, in the central Apennines. In the study area, beech forests cover about 10,000 ha, and in fully 90% of these forests coppicing was or still is practiced (Ipla, 2001). Some ecological studies report a remarkable level of plant diversity in coppiced forests (15% of the Marche Region flora, according to Bartha et al., 2008, or 10%, according to Campetella et al., 2016) including beech forest specialist species of considerable conservation interest, and point to a certain relationship between plant diversity and management. While these studies indicate that the main factor influencing diversity seems to be the number of years since the last coppicing (Bartha et al., 2008; Canullo et al., 2011; Campetella et al., 2016; Mattioli et al., 2016), there is no clear understanding of how other management factors affect plant diversity, and in particular the contingent of beech specialist species which have been shown to be a good indicator of the functional state of the forest (Bartha et al., 2008; Garadnai et al., 2010; Campetella et al., 2016). There is also a lack of information on how other management factors relate to this critical rotational timeframe.

This study builds on previous research conducted on the ecological dimension of the coppicing system in the Marche Region (Bartha et al., 2008; Garadnai et al., 2010; Campetella et al., 2011; Canullo et al., 2011; Campetella et al., 2016; Canullo et al., in press) by adding a follow up survey of 57 plots to characterize temporal changes in vegetation and forest structure, a review of the administrative prescriptions regulating logging in the region and the way they are applied and enforced, as well as a semi-structured social survey focusing on the economic/logistical and ecological variables affecting this system.

Three main types of loggers act in this coppice system: (i) commercial, (ii) private and (iii) group property users (Comunanza Agraria); the latter is defined as a group of users of extended forest plots that has the right to exclude other parties from exploiting the resources in these lands (Ostrom et al., 1999). Our main hypothesis is that the institutional context evolved to incorporate critical ecological elements to support long-term use of the forest resources.

In this sense, we explore the 'problem of fit', namely whether environmental institutions (users, formal rules and rules in use) are adequate to preserve ecosystem functions (Galaz et al., 2008) on a sufficient scale and for a sufficient length of time to ensure the long term biodiversity of the system.

2. Materials and methods

2.1. Ecological dimension

2.1.1. Biological and physical context

The study area is located in the central section of Italy's Apennine Mountains, in the southern part of the Marche Region, including most of the Monti Sibillini National Park (Fig. 1). The area belongs to a meso-temperate climatic zone of the low and high mountain belts, with mean annual rainfall ranging from 1100 to 1400 mm and mean annual temperatures of 8–12 °C (Biondi and Baldoni, 1995; Pesaresi et al., 2014). The bedrock is mainly Mesozoic and Tertiary limestone, with a smaller area of Tertiary arenaceous marly flysch sandstone in the southernmost part.

The coppicing cycle has been in practice for at least 100 years (Bartha et al., 2008). Felling is followed by the agamic growth of suckers and their self-thinning due to intra- and inter-specific competition. A certain number of trees are chosen to be 'standards' and are left uncut in order to ensure soil protection and reproduction by seeds. This results in non-linear regeneration of the canopy-cover from the initial open habitat, and eventually, a dense and patchy shrub layer. With time, a complex tree stand with vertical and horizontal heterogeneity is created, formed of the standards and the new shoots that have grown from stumps through agamic propagation (Bartha et al., 2008).

2.1.2. Vegetation surveys

The original dataset consists of 2225 logging permission requests from the registers of the Italian Forest Service. We then selected the forest stands by cross-validation or which have been verified by the National Forest Service; this allowed to define the stand age since the last coppice event. The validated 1248 forest stands have been sampled by using a stratified design based on the following criteria: age since last coppicing (the 'official age' from the above registers), geological setting (limestone and sandstone) and elevation classes (Bartha et al., 2008). A proportional, affordable, subsample was selected to provide 57 forest plot.

The officially recorded age of each forest plot was used to construct a chronosequence (Space-for-time substitution system; Pickett, 1989) starting at the time of the last coppicing (ranging from 0 to 95 years). According to Canullo et al. (2011) and Campetella et al. (2011) three age groups have been distinguished in the same chronosequence, namely:

1. Post-logged (PL) stands coppiced within the last 16 years and encompassing all the stands where the canopy closure provided by sucker growth is still incomplete;