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The role of topography, stand and habitat features for management and biodiversity of a prominent forest hotspot of the Mediterranean Basin: Saproxylic beetles as possible indicators

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ABSTRACT

The maintenance of biodiversity in forestlands has become one of the major concerns of global forestry. Regarding the situation of Italy, the Mediterranean forests belong to the less studied in Europe. There is an urgent need to individuate reliable indicators that help to assess forest features important for their future management and biodiversity. We focused our study on the largest forest hotspot of Southern Italy, the Sila National Park in Calabria, an upland covered by 130,000 ha of forest dominated by Calabrian black pine (*Pinus nigra calabrica*).

We chose to test saproxylic beetle species as possible indicators of biodiversity and management. The main condition was the use of method and species useful also for forest managers. Data on the occurrence of 75 wood-inhabiting beetle species of body size approx. 1 cm and larger have been collected in 2010–2015 at 96 forest sites by multiple methods finally simplified in standardized visual census.

For the suitability of individual species for indication, we used a novel hierarchical approach: starting from a model for the whole community. Target species were selected if they occupied more than 20% of the sites and non-obligate saproxylics were eliminated. These species' responses were compared with that of the whole community and only concordant species were maintained as possible indicators. Species whose presence marked significantly species-rich habitats have evaluated as biodiversity indicators. Finally, conservation value model was used for validation.

Two saproxylics met all the stepwise criteria used: *Cucujus cinnaberinus* and *Clinidium canaliculatum*. They provide a simple and useful tool for periodic diversity monitoring in nature reserve networks. Choosing easily identifiable species, rapidly detectable in a visual census as biodiversity indicators may greatly facilitate less expensive forest monitoring also by unspecialized forest managers.

1. Introduction

In southern Italy a long history of human land use has led to profound changes within forest ecosystems (Ciancio et al., 2006). The Sila mountain plateau is the largest forested area of Calabria (Fig. 1) and is acknowledged today as a biodiversity hotspot for its floral and faunal composition (Brandmayr et al., 2013). It has elected Man and Biosphere Reserve in 2014 and this makes urgent the need to fix operational procedures to ensure sustainable management of the Sila forest landscape, possibly by integrating forest exploitation with forest restoration and maintenance. The maintenance of biodiversity in forestlands (i.e., maintenance of species richness and threatened species) has become one of the major concerns of forestry in the European Union (EU) as well as globally. The EU and its member states implement it through the Forest Europe process (Forest Europe, 2010), promoting sustainable forest management, and the EU Council 92/43 "Habitats Directive" (Kovač et al., 2016).

The Sila forest is a mosaic of strongly varying small parcels, often covering a few hectares and intermingled with pasturelands, cropland and other habitats that may differ extremely in their biodiversity. All this results in a scattered pattern of disparate habitats considered highly important for deadwood-dependent organisms (Horák et al., 2014; Šebek et al., 2015). On the other hand, the structure itself is often not directly recognizable for foresters and landscape managers. Thus, there is a strong need to find a suitable method that can be timely repeated in nature reserve networks, with species able to indicate a high value for

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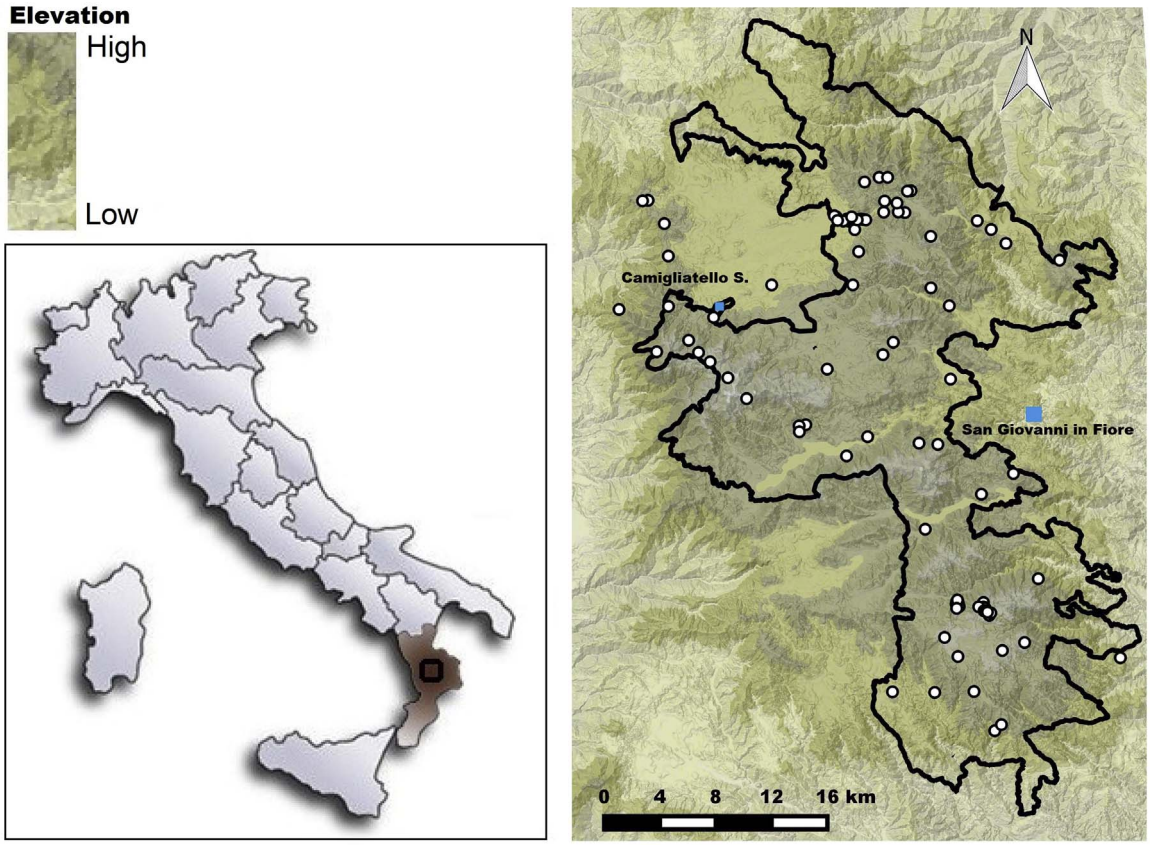

Fig. 1. Study area of the Sila high plateau. Black line: boundaries of the Sila National Park. White circles: sampling sites. Blue squares indicate the largest town (San Giovanni in Fiore) and the main touristic village. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

guild diversity and easily to identify by non-specialist operators. For this reason, we chose to test the biodiversity indicator method (McGeoch, 1998) searching for single/few species that could be good predictors of the saproxylic beetles diversity. A recent review by Gao et al. (2015) shows that saproxylic beetles are strongly or at least significantly related to deadwood volume (Blasi et al., 2010; Müller et al., 2010; Brin et al., 2011; Lassauce et al., 2011; Lachat et al., 2012). Other studies revealed the surrogate capacity of both dead wood amount and/or dead wood diversity (Juutinen et al., 2006; Brin et al., 2009; Djupström et al., 2010; Bouget et al., 2013). Thus, Gao et al. (2015) stated a correlation with "strong evidence", well supported by recent studies, between the structural indicators deadwood volume, deadwood diversity and the species richness of saproxylic beetles. In our study we need first to specify the exact nature of the indicator and of the indicandum, because, as already suggested by Duelli and Obrist (2003), "there is no single indicator for biodiversity". The aim of this paper is to individuate single species indicators that show the best correlation with the macro-saproxylics of a Mediterranean mixed forest (the indicandum), a component that reflects the conservation status of the forest habitat and its animal community. Together with fungi and other organisms, saproxylic beetles are important agents in the process of wood recycling (Speight 1989; Schmidl and Bußler, 2004; Nieto and Alexander, 2010; Carpaneto et al., 2015). The choice of saproxylic beetles satisfies at least two fundamental indicator values for ecosystem biodiversity pointed out by Duelli and Obrist (2003): the conservation value, because many species have enclosed in national red lists, and a focus on ecosystem resilience and functioning.

A possible alternative in our definitions was the use of the "umbrella species", as firstly hypothesized in Mazzei et al. (2011). An umbrella species is a species whose conservation has expected to confer protection to a large number of naturally co-occurring species (Roberge and Angelstam, 2004). These authors provide an interesting summary of the use of this concept in several case studies. Primarily it is proposed, for example, as a tool to determine the minimum size for conservation areas by selecting sites to be included in reserve networks. However, the concept has used to facilitate site selection in reserve networks at a larger geographical scale (Wilcox, 1984). This umbrella concept for site selection refers to single species (or also multi-species sets) and sometimes to the species richness as a higher umbrella taxon. In a more comprehensive version of the concept (Roberge and Angelstam, 2004), the idea includes further attributes of the landscape such as connectivity, ecosystem processes and resources. An interesting variation of the extended concept was proposed by Lambeck (1997) through the use of focal species. It is a sort of multi-species umbrella in which all taxa considered at risk have grouped and the most threat-sensitive species is used to define the minimum acceptable level at which that threat can occur.

The concept seems anyway less fitting our aims, because we conducted the samplings at stand level, at which minimum area problems are less relevant. Second, we avoided any a-priori choice of indicators, by selecting a "bottom-up" analysis that starts with a robust set of samplings in all possible kinds of forest, more or less proportional to their relative importance in the landscape, and a hierarchical approach that progressively individuates the most representative species with the highest co-occurrence of other threatened ones. Dealing with a mosaic of variably managed forest types composed of about ten species of trees and with all stages of forest dynamics in close proximity, we chose beetles as the indicator set. Indeed, obligate saproxylic organisms (in the sense of Speight, 1989), whose development is dependent on deadwood microhabitats are presently used as indicators of conditions in forests (Horák et al., 2014). Another problem for such evaluations is that many practitioners might not be able to use them or easily