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Resin-tapped pine forests in Spain: Ecological diversity and economic valuation

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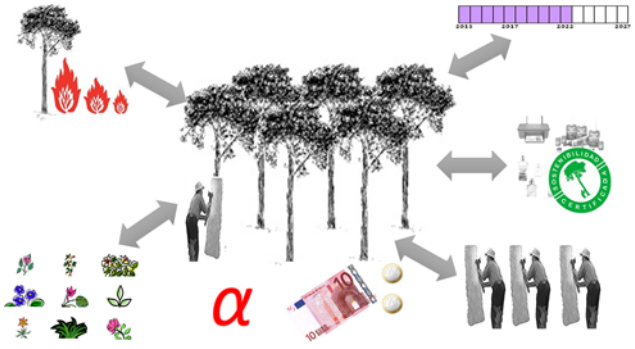
HIGHLIGHTS

- Resin tapped pine forests do not differ in α richness from other pine forests.
- A growing non-linear WTP was found towards higher levels of biodiversity.
- People play special attention to the reduction of the risk of forest fires.
- Welfare loss of the abandonment of resin tapping sum up 204 million euros.

GRAPHICAL ABSTRACT



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ABSTRACT

Since ancient times, Mediterranean pine forests have been habitat for human activity, providing a wide range of goods such as timber, seeds, resin and derived products. Among them, tar and resin have played an historical role on the interaction between human activity and forests. In Spain, the resin played an important role in the economic and social development in rural areas during 20th century. But after 1980, resin production plummeted and the virtual disappearance of resin tapping caused the abandonment of traditional forest activities and the subsequently losses of ecosystem forest services (provision, regulation and cultural). This paper deals with some of the ecosystem services provided by resin tapped pine forests and shows how the abandonment of this traditional forestry activity would lead to a loss of social welfare beyond the economic activity. Among these ecosystem services, special attention is paid to the biodiversity of the pine forests. For that purpose, a stratified vegetation sampling was conducted in the leading resin-tapping Spanish region. Ecological analysis was therefore compared with the social preferences for several attributes associated to resin-tapped pine forests in Spain, including the biodiversity of flora.

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1. Introduction

Pinus spp. are the most economically and ecologically significant forest tree species in Mediterranean basin (M'Hirit, 1999; Moussouris and Regato, 1996; Richardson and Rundel, 1999; Tapias et al., 2004). Mediterranean pine forests have been scenario of human activity for millennia (Malagnoux and Lanly, 1999; Moussouris and Regato, 1996; Mutke et al., 2012). Pine forests have provided not only a wide range of marketed goods (timber, firewood, resin and derived products, pine nuts, barks, mushrooms, etc.), but also non-marketed goods and services such as soil protection and water regulation, landscape, biodiversity, leisure and recreation, all of them relevant for rural development (LeMaitre, 1999; Leone and Lovreglio, 2004; Ortuño et al., 2013). Among the marketed goods, resin and tar was exploited since Antiquity (Moussouris and Regato, 1996; Alía et al., 1996) and played an historical role on the interaction between human activity and forests (Leone and Lovreglio, 2004; Kohlross, 2011; Pinillos et al., 2009). For example, the use of pitch for caulking vessels and for waterproofing is one of the long-term relationships between humans and pines (LeMaitre, 1999; Kohlross, 2006).

In Spain, when extensive forest clearing took place during economic liberalism in the 19th century in the central Douro basin, fossil dunes were reactivated after losing their forest cover and started to move and to cover farmlands, roads and even houses of some village, before they were immobilized again by afforestation (Romero, 1886). In this sense, resin tapping had taken an important role for the economic and social development in rural areas, including creating jobs and providing a natural, renewable raw material for the chemical industry (Mutke et al., 2013; Rodríguez et al., 2015). Moreover, resin tapping gave economic sustainability for managing the large natural Mediterranean pine forests that cover several hundred thousand hectares of Quaternary sand deposits and rocky slopes of mountain ranges in inner Spain. However, the profitability of extractive activities from forests largely depends on the social and economic context. With increasing economic and human development and increasing geographic mobility, other more profitable economic or occupational activities, or under less harsh working conditions, lead to an abandonment of most of these traditional forestry practices. This is stressed by the highly cyclic component of the international prices of natural products, despite their strategic value at the local level.

In the last three decades, European resin production had plummeted due to increasing labor costs and international competiveness of Chinese natural resins tapped from *Pinus massoniana*. This situation was similar to previous ones during the 19th and 20th century, first in United States and later in France and the rest of Europe, conducting to the virtual disappearance of resin tapping as forest activity in developed countries, translocating it to third countries such as China, Brazil, or Indonesia (Pinillos et al., 2009; Picardo and Pinillos, 2013). The virtual disappearance of resin tapping in Spain caused the abandonment of traditional forest activities and the subsequently losses of ecosystem forest services (provision, regulation and cultural). Most of these ecosystem services lack an associated market, and no economic total value is available for a traditional forest activity such as the resin tapping.

In the last five years, resin production from Spanish forests has started to recover, thanks to a drop in Chinese exportation triggered by the prevalence of Pine Wilt Disease that has caused Masson pine mortality (Gao et al., 2015; Wei et al., 2016), to the resulting increasing world market prices, and to new business models based in sourcing of high-quality secondary products for cosmetics, pharmacy, healthcare and food industries (Pinillos et al., 2009; Picardo and Pinillos, 2013). Nevertheless, a quite important paradox is nowadays present: forests that had been secularity managed for coproduction of timber and resin, providing a wide range of additional ecosystem services, could be abandoned if those ecosystem services are not considered in the decision making process (Mutke et al., 2013; Rodríguez et al., 2015).

Economic valuation methods based on stated preferences can be applied to incorporate the non-marketed goods and services to decision making (Bateman et al., 2002). These methods allow estimating an economic measure for different ecosystem services provided by the pine forests. In this sense, special attention is paid to the biodiversity (Nunes and van den Bergh, 2001), since indicators of biodiversity constitute the basic prior information for the development of conservation programs. There are multiple indicators of biodiversity in pine forests (Martínez-Jauregui et al., 2016). The richness of herbaceous species has been shown as good indicator of ecological diversity in forest ecosystems (Noss, 1990), agricultural landscapes (Billeter et al., 2008) and agricultural landscapes with more or less extended forest patches inside (Varela et al., 2017). Among these indicators, the ecological diversity of vascular plants is a good guide for the overall conservation status in pine forests.

What is relevant for biodiversity is not the tapping per se, but the presence of managed pine forests with human activities within. In this sense, the abandonment of the resin tapping activities could imply in public forest, and has actually already implied in private ones, less management as well as less investment in tending and silvicultural treatments essential for maintenance of these traditional forest systems: the absence of human activity (actors) from forests and the lack of pruning an clearing imply an incremented risk of natural hazards, especially of wildfires affecting hundreds of hectares due to increased fuel accumulation and late detection. There might be also risks of land use changes especially in private forests, i.e., to agriculture or urban. Nevertheless, the most evident loss of current ecosystem services related directly with resin-tapping of pine forest are those of social, cultural, and economic (sustainable provision of renewable bioproducts, local rural employment, among others) ecosystem services. This paper deals with some of the ecosystem services provided by resin-tapped pine forests and shows how the abandonment of this traditional forestry activity would lead to a loss of social welfare beyond the economic activity. Some of these ecosystem services were estimated in order to provide a useful guidelines to the policymakers in order to guide forest policy and prevent from the highly cyclic change in resin prices (for example, designing payments for ecosystem services), as a mean to preserve resin tapping activities. If both the social and ecological indicators are in the same direction, conservation programs can be urged to policymakers. Therefore, this paper constitutes a novel approach combining ecological and social sciences to guide policymaking on resin-tapped multifunctional pine forests.

2. Material & methods

2.1. Study area

The study area focuses on Castilla y León, a Spanish autonomous region located in the northern centre of the Iberian Peninsula (Fig. 1). It is the largest Spanish region, covering an area of 9.4 million of hectares (19% of the national territory), within which more than 50% of the territory is classified as forest land use (including forests, rangelands, scrublands, heathlands, etc.), 23% as forests. Resin tapping is a traditional activity in Castilla y León and most (95%) of the production of natural resin in Spain is obtained from maritime pine *Pinus pinaster* Ait. forests in this region (Pinillos et al., 2009).

Excluding those pine forests associated to mountain ranges surrounding the central plain (or "*meseta*") of the region, we have centred the study on the pine forests of the flat central Douro river basin (700–1000 m a.s.l.). *Pinus pinaster* forms together with *Pinus pinea* a singular landscape called "*Tierra de Pinares*" (Land of the Pinewood) that is dominated by extended pine forests on deep Quaternary sand deposits (up to 80 m in some places). Recognized legally as Spanish provenance region 8 ('*Meseta Castellana*') for forest seed production and transfer of *P. pinaster*, this Provenance Region (Fig. 1) includes 223,000 ha (21%) of maritime pine forests out of 1.05 million hectares in 271 municipalities