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Forgetting fire: Traditional fire knowledge in two chestnut forest ecosystems of the Iberian Peninsula and its implications for European fire management policy

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ABSTRACT

Human beings have used fire as an ecosystem management tool for thousands of years. In the context of the scientific and policy debate surrounding potential climate change adaptation and mitigation strategies, the importance of the impact of relatively recent state fire-exclusion policies on fire regimes has been debated. To provide empirical evidence to this ongoing debate we examine the impacts of state fire-exclusion policies in the chestnut forest ecosystems of two geographically neighbouring municipalities in central Spain, Casillas and Rozas de Puerto Real. Extending the concept of 'Traditional Ecological Knowledge' to include the use of fire as a management tool as 'Traditional Fire Knowledge' (TFK), we take a mixed-methods and interdisciplinary approach to argue that currently observed differences between the municipalities are useful for considering the characteristics of "pre-industrial anthropogenic fire regimes" and their impact on chestnut forest ecosystems. We do this by examining how responses from interviews and questionnaire surveys of local inhabitants about TFK in the past and present correspond to the current biophysical landscape state and recent fire activity (based on data from dendrochronological analysis, aerial photography and official fire statistics). We then discuss the broader implications of TFK decline for future fire management policies across Europe particularly in light of the published results of the EU sponsored Fire Paradox research project. In locations where TFK-based "pre-industrial anthropogenic fire regimes" still exist, ecosystem management strategies for adaptation and mitigation to climate change could be conceivably implemented at a minimal economic and political cost to the state by local communities that have both the TFK and the adequate social, economic and cultural incentives to use it.

> "This universe, which is the same for all, has not been made by any god or man, but it always has been, is, and will be an ever-living fire, kindling itself by regular measures and going out by regular measures".
>
> Heraclitus

Introduction

Contemporary ecology understands that many ecosystems can be considered "fire adapted", their structure and function being partly determined by the fire regimes with which they have co-evolved (Gill, 2002; Pausas and Keeley, 2009). Humans have often played a long-standing role in such fire-adapted ecosystems. Anthropogenic landscape burning is believed to have had a significant ecological impact on the Earth system for thousands of years and in many flammable ecosystems worldwide it has become a key ecological process conditioning present biodiversity and climate

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(Stewart, 1957; Ruddiman, 2003; Bowman et al., 2010). However, biomass burning has also been recently determined to be an important contributor to the global greenhouse gas emissions causing climate change, though the impact of anthropogenic fires on net emission outputs is highly uncertain and remains widely debated within the scientific community (Hurteau et al., 2008; Fule, 2008; Pausas and Fernández-Muñoz, 2012; Moritz et al., 2013; IPCC AR5, 2014; Gill et al., 2014).

In the context of the scientific and policy debate surrounding potential climate change adaptation and mitigation strategies, researchers continue to discuss the importance of the impact of state fire exclusion policies on fire regimes. Fire exclusion policies have been defined as the attempt to exclude all types of landscape fires from a specified area (Scott, 2015). One of the first contemporary large-scale attempts at implementing a statewide fire exclusion policy was carried out by the United States throughout the 20th century prompting other countries receiving its technical advice and forestry aid funds, such as Spain, to follow suit (Donovan and Brown, 2007; Seijo and Gray, 2012). At the end of the 20th century it has become apparent that the effects of fire exclusion policies on fire regimes may be provoking what some researchers have termed a "firefighting trap" (Collins et al., 2013). By altering historical fire regimes and landscape fuel structures, state fire exclusion policies may well be contributing to contemporary "megafires" that seem to positively feedback with anthropogenic climate change as well as spiralling fire suppression costs in many countries (Millar et al., 2007; Seijo and Gray, 2012; Pezzatti et al., 2013; Stephens et al., 2014; Fernandes et al., 2014). In this volatile and uncertain scenario, theoretical concepts such as "applied historical ecology" and "pre-industrial anthropogenic fire regimes" have been advanced in an attempt to come to terms with the role that historical fire patterns (in general) and traditional anthropogenic fire practices (in particular) should or should not play as a baseline for informing future fire management decisions (Swetnam et al., 1999; Keane et al., 2009; Seijo and Gray, 2012; Pezzatti et al., 2013; Gill et al., 2014; Petty et al., 2015).

Traditional ecosystem management practices are reliant on "Traditional Ecological Knowledge" (TEK), defined as, "the cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down in generations by cultural transmission, about relationships of living beings [including humans] with one another and with their environment" (Berkes et al., 2000:8). A variant of TEK but with particular regard to the use of fire as a management tool, "Traditional Fire Knowledge" (TFK) has more recently been defined as, "fire-related knowledge, beliefs, and practices that have been developed and applied on specific landscapes for specific purposes by long time inhabitants" (Huffman, 2013:1).

Decline of the use of TEK and TFK can lead to significant changes in ecosystems. Some of the first descriptions of these impacts appear in Omer C. Stewart's collection of essays "Forgotten Fires" (Stewart, 1957), which has inspired this article's title. In his 1950s pioneering work, Stewart identified diverse TFK-based fire uses by native Americans for ecosystem management and described some of the ecological consequences that emerged when these practices were "forgotten". Today, the gradual abandonment of traditional land use – resulting in a loss of both TEK and TFK – has been recognized as one of the main structural factors leading to the emergence of so-called "Large Wildland Fires" across Mediterranean Type Ecosystems in Europe (Seijo and Gray, 2012; Galiana et al., 2013; Pezzatti et al., 2013; Montiel, 2013; Stephens et al., 2014; Fernandes et al., 2014). Much of the literature now acknowledges that socio-economic and political drivers are at the core of this change (Seijo, 2005; Seijo and Gray, 2012; Pezzatti et al., 2013; Fernandes et al., 2014). However, little attention has been paid to the exact mechanisms by which state fire exclusion policies – which have been shown to be ecologically, economically and politically undesirable (Seijo and Gray, 2012; Montiel, 2013) – and rural development policies have impacted TEK and TFK. For example, in the Iberian Peninsula these policies often set the stage to the enclosure of large tracts of land for new industrial era uses (e.g. afforestations, conservation areas, recreational hunting estates, etc.) and the prohibition of traditional land use practices such as extensive animal husbandry and swidden agriculture (Fernandes et al., 2014) These changes shifted rural economies away from approaches that required the use of TFK-based practices and therefore contributed to rural abandonment (Seijo and Gray, 2012; Stephens et al., 2014). It is important, therefore, to re-evaluate the fire management potential of TFK-based practices, particularly since continent-wide European Union funded research projects such as Fire Paradox are calling for a reform of present fire suppression based management strategies and advocating for the promulgation of new European legislation on the matter in the form of a "Fire Framework Directive" (Montiel, 2013).

As an evidence-based contribution to this ongoing debate, in this study we examine the current biophysical attributes of two adjacent sweet chestnut forest ecosystems of the Iberian Peninsula and local inhabitants' perspectives on pre-industrial anthropogenic burning within them. The present existence of chestnut forest ecosystems throughout Europe was only made possible by centuries of intense management by local communities (Conedera et al., 2004; Conedera and Krebs, 2009). In fact, the chestnut forest ecosystems of the study sites we consider in this paper – the municipalities of Casillas and Rozas de Puerto Real in the foothills of the mountains of Gredos, central Spain – can be theoretically described as coupled human–natural systems because of the historically verified, prolonged and intense interaction between human and natural system variables in them (Liu et al., 2007). Communities in this region have managed their chestnut forests with a sophisticated ecosystem management toolkit that exemplifies TEK and TFK. Through time these communities actively participated in the design of their chestnut forest ecosystems through terracing, grafting, pruning, careful tree species selection and burning in what can be most aptly described as a pre-industrial effort at large-scale environmental engineering (Martin et al., 2010).

Changes in the use of TEK in coupled human–natural chestnut forest ecosystem management have been known to result in substantial transformations in both their structure and function as natural succession processes resume unaltered (e.g. Mazzoleni et al., 2004; Romero-Calcerrada and Perry, 2004; Millington et al., 2007; Millington et al., 2009). Such change in forest stands formerly dominated by chestnut trees has been observed in Corsica, for example, with the encroachment of mixed and closed-canopy stands dominated by Holm oak (*Quercus ilex* L.) and Cluster pine (*Pinus pinaster* Ait.) following abandonment (San Roman et al., 2013). In Bulgaria, in the absence of traditional management, chestnut forests have apparently become increasingly vulnerable to pest disturbances such as chestnut blight (Zlatanov et al., 2013), and in Switzerland the loss of ecologically valuable old growth "giant" chestnut trees is feared – as well as the emergence of significant fire regime changes – as the anthropogenic silvicultural practices of the past fade away (Krebs et al., 2012; Pezzatti et al., 2013).

In an effort to restore ecosystem structure and process in abandoned chestnut forest ecosystems a debate is thereby emerging concerning the appropriate role of traditional pre-industrial era burning in the ecological restoration of these ecosystems. Some researchers advocate for continued use of TFK-based practices or surrogate prescribed burning (Grove and Rackham, 2003; Seijo and Gray, 2012; Fernandes et al., 2013) in contrast to others who argue it should be limited to certain specific sites where the goal is the conservation of locally endangered species associated via coppiced (or abandoned) chestnut stand communities (Grund et al., 2005; Moretti et al., 2006, 2008; Pezzatti et al., 2013).