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Communication

Pine afforestation, *herriza* and wildfire: a tale of soil erosion and biodiversity loss in the Mediterranean region[1]

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Abstract. From a western society's perspective, wildfires are catastrophic events that jeopardise biodiversity and cause soil erosion, not to mention risk to human lives and properties. However, many Mediterranean-type ecosystems are not only resilient to wildfires but sensitive to the lack of wildfires. This communication focuses on the Mediterranean heathland or *herriza* as a paradigmatic fire-prone ecosystem to illustrate how most negative impacts allegedly attributed to wildfires actually occur in commercial forestry plantations. They are caused by aggressive forestry practices prior to the wildfire. In natural Mediterranean habitats, such as the *herriza*, complete wildfire suppression may actually pose a serious threat to biodiversity. The large existing body of scientific knowledge on the relationships of Mediterranean ecosystems with fire should be incorporated into plans and policies dealing with wildfire and conservation to make them more appropriate and efficient. Finally, burned natural areas should not be regarded, or treated, as dead pieces of nature and destroyed ecosystems, but as a transitional stage within the dynamics of Mediterranean-type ecosystems.

Keywords: conservation policies, fire-adapted plants, floral endemism, forestry plantations, Mediterranean heathland, post-fire recovery, tree-centric conservation.

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Western society in general regards wildfires as catastrophic events that, apart from posing a risk to human life and livelihood, destroy biodiversity and trigger soil erosion, leading to a loss of natural habitats. This negative view of wildfires is fuelled every summer by mass and social media campaigns (Fabra-Crespo and Rojas-Briales 2015), often citing expert sources (e.g. Servicio de Información y Noticias Científicas (SINC) 2019; Evans 2020). However, despite the undeniable risk to people's lives and properties, the negative social perception of the impact of wildfires on natural ecosystems contrasts sharply with the scientific discourse and published evidence (Doerr and Santín 2016; Moreira *et al.* 2020). In the case of Mediterranean ecosystems, many are not only resilient to wildfires, but depend on them for their maintenance, as recurrent fire has been part of their evolutionary history (Keeley *et al.* 2012; Rundel *et al.* 2016, 2018).

Although, in several instances, mass media have echoed the role of fire as a natural disturbance agent in Mediterranean ecosystems (e.g. Sahuquillo and de Benito 2012; Asher 2016), this view does not seem to percolate into society. In the case of Spain – but this can likely be extrapolated to other Mediterranean countries – one of the reasons for such a stubbornly negative appreciation is that, presently, most wildfires are human-caused, either intentionally or accidentally, while less than 4% have a natural origin (e.g. lightning-caused; Martínez *et al.* 2009). Yet, despite the overwhelming figures, that mere 4% of naturally ignited wildfires should not be ignored. It must be borne in mind that humans, responsible for the ignition of most wildfires, are also active in extinguishing wildfires by increasingly sophisticated and effective means. If we removed humans from the natural landscape or minimised their fire-extinguishing capacity, a wildfire in a given area might well have been caused by a lightning strike tens or even hundreds of kilometres away (Viegas 1998; Koo *et al.* 2010). In other words, the occurrence of natural wildfires in the past, before the development of fire-extinguishing methods by humans, was probably more prevalent than current figures indicate. The numerous examples of fire-adapted traits described in Mediterranean plants and ecosystems (e.g. Ojeda 2001; Keeley *et al.* 2012) provide empirical support for this assertion.

Here, I focus on the Mediterranean heathland from the western Mediterranean region, a fire-adapted habitat (Ojeda *et al.* 2010) with a rich endemic flora (Gil-López *et al.* 2018), to illustrate why and how wildfires are misperceived by society as

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ecological disasters that destroy natural habitats and threaten biodiversity. To do so, I show that most negative ecological impacts attributed to wildfire are actually caused by previous anthropogenic habitat alterations, particularly commercial pine afforestation. I seek to convince society that wildfire, although certainly posing a risk to human lives and properties, is a natural element in Mediterranean ecosystems (e.g. Keeley *et al.* 2012; Moreira *et al.* 2020). The ultimate goal of this commentary is to persuade nature conservation managers and policy-makers of the need to integrate scientific knowledge in post-fire management decisions and actions in order to make them more appropriate and efficient.

The *herriza* or Mediterranean heathland: floral uniqueness forged by fire

The western Mediterranean region, including most of the Iberian Peninsula (Spain and Portugal) and NW Africa, is characterised by a Mediterranean climate with a strong seasonality: cool, wet winters and warm, dry summers. Dominant soils are fine-textured with a neutral to basic pH and fairly high fertility levels (di Castri 1991). The most representative habitat in the Mediterranean region of the Iberian Peninsula is a *garrigue*-like shrubland (Dallman 1998), composed of sclerophyllous shrub species, such as kermes oak (*Quercus coccifera*), wild olive (*Olea europaea*) and mastic shrub (*Pistacia lentiscus*), and non-sclerophyllous species, such as rock roses (*Cistus* spp.), sage and thyme scrubs (e.g. *Phlomis purpurea*, *Thymus* spp.) and gorses (e.g. *Genista* spp.). However, in the west Iberian Peninsula and northwesternmost tip of Africa, another shrubby habitat is also quite abundant: the *herriza* or Mediterranean heathland. It is the most diverse subtype of European dry heathland (Habitat 4030 of the European Natura 2000 network; Ojeda 2009), associated with coarse-textured, infertile acid soils and a mild Mediterranean climate regime due to oceanic influence (Loidi *et al.* 2007). Unlike other European Atlantic heathlands, the *herriza* is highly diverse and, despite being Mediterranean, is floristically different from the garrigue shrubland (Gil-López *et al.* 2018). Apart from the heather *Calluna vulgaris*, it is distinguished by the abundant presence of truly Mediterranean heath species (e.g. *Erica australis*, *E. scoparia*, *E. umbellata*) and other shrub species strongly associated with Mediterranean heathland, such as the gorse *Pterospartum tridentatum* and the rock rose *Cistus populifolius*.

In the Strait of Gibraltar area (Gaditanian peninsula, in southwesternmost Spain, and the Tingitanian peninsula, in northwesternmost Africa), the *herriza* is one of the dominant natural habitats, covering peaks and ridges of siliceous sandstone mountains. It stands out from the rest of the Mediterranean heathlands of the western Iberian Peninsula by its high floral endemic richness and uniqueness (Gil-López *et al.* 2018). In addition to the species referred to above, the *herriza* from the Strait of Gibraltar includes interesting species, such as the prostrate oak *Quercus lusitanica* and the rare carnivorous subshrub *Drosophyllum lusitanicum*, the epitome of floral uniqueness of the *herriza* (Paniw *et al.* 2017*a*). Finally, it also harbours narrow endemics restricted to *herriza* patches from both sides of the Strait, such as the gorse *Genista tridens*, the thyme *Argantoniella salzmannii*, the dwarf oleander *Bupleurum foliosum* and the annual herb *Silene gaditana*.

Fire has played a preponderant role in the evolutionary history of the *herriza*, most of whose species are pyrogenic (i.e. their seeds depend on the occurrence of fire to germinate; Ojeda *et al.* 2010). The *herriza* is not only fire-resilient (Ojeda *et al.* 1996), like other Mediterranean habitats, but it is likely sensitive to the lack of fire (Ojeda *et al.* 2010; Gil-López *et al.* 2014). In fact, many of the *herriza* endemics, such as *Drosophyllum lusitanicum* or *Silene gaditana*, are found in the *herriza* only within the first 4–5 years after a wildfire (Ojeda *et al.* 1996). They then disappear from the aboveground vegetation and persist only as dormant seeds in the soil seed bank (Paniw *et al.* 2017*b*). This means that they are not only species endemic to the *herriza*, but are restricted to a short post-fire window. Therefore, a policy of fire suppression would eliminate those post-fire windows, threatening many species, mostly narrow endemics, and the very persistence of the *herriza* as a unique habitat. How can we then explain the general perception of wildfires as agents of biodiversity loss and habitat degradation in the *herriza*?

The curse of the *herriza*: being noticeable for what it lacks

The notion that tree-less habitats are, in most instances, degraded stages of a forest habitat is the paradigm of the Sigmatist Phytosociology School (Braun-Blanquet 1965) and it has been devotedly applied to nature management and conservation in Spain and Portugal until quite recently (e.g. Loidi 1994; Quinto-Canas *et al.* 2012). That idea of the forest as a 'climax' in opposition to the scrub vegetation as a 'degraded' stage has been repeated almost as a mantra by nature managers and policy-makers in Spain during the last two decades of the 20th century (e.g. Alcanda-Vergara and Ortuño-Pérez 2006). Until the onset of the 21st century, nature conservation in Spain was strongly tree-centred, and its management was often conducted according to forestry principles and techniques rather than to ecological knowledge (Vadell *et al.* 2016).

Despite the high plant biodiversity value and uniqueness of the *herriza* (Gil-López *et al.* 2018), the feature for which it has been has been most frequently noted is its virtual lack of trees, determined by scarce, nutrient-poor soils, exposure to strong winds and, particularly, wildfire recurrence (Ojeda 2018). Then, as a consequence of an obstinate tree-centric view of conservation, the *herriza* was systematically ignored or considered as a mere 'pre-forestal', regressive stage of 'climax' forests of cork-oak (*Quercus suber*) or semideciduous oak (*Q. canariensis*, *Q. pyrenaica*) trees (Pérez-Latorre *et al.* 1999; Quinto-Canas *et al.* 2012). That explains why, until recently, conservation policies in Spain allocated resources to the afforestation – not reforestation – of *herriza* patches with cork-oak trees and, in particular, with pine trees (Andrés and Ojeda 2002).

Afforestation with pines: biodiversity loss, soil erosion and fire

Owing to the skeletal, nutrient-poor soils, the afforestation of *herriza* patches with cork-oak trees seldom succeeds. By contrast, afforestation trials with pine trees (mainly *Pinus pinaster* and *P. pinea*), which peaked in southern Spain during the second half of the 20th century, were very successful (Andrés and Ojeda 2002). The initial purpose of those pine plantations was to

restore 'degraded' landscapes while providing a sustainable natural resource to improve the welfare of local communities (Simón-Navarrete 1993). However, most of them have been abandoned owing to their poor economic returns, particularly those of *P. pinaster*. And, despite good intentions, those pine plantations are responsible for a dramatic loss of plant biodiversity (Andrés and Ojeda 2002).

Pine afforestations have been also justified in southern Spain as a management practice against water and soil loss in natural habitats (Simón-Navarrete 1993). However, studies in other regions of the world under similar Mediterranean-type climate conditions have shown that pine afforestation, in fact, reduces water availability (Farrington and Bartle 1991; Scott *et al.* 1998; Stock *et al.* 2012). Regarding soil loss, however paradoxical it may seem, pine plantations in heathland habitats do not protect from but contribute to soil erosion. Land preparation methods carried out before tree planting, such as subsoiling and terracing, increase soil erodibility (Romero-Díaz *et al.* 2010). A study performed in northern Portugal showed that runoff and soil erosion levels in pine (*P. pinaster*) plantations were much higher than those of adjacent shrublands and nearly as high as in arable land (Nunes *et al.* 2011). High soil erodibility beneath pine plantations becomes even higher after a wildfire (Martins *et al.* 2013), because the scorching and consumption of pine crowns exposes already disturbed soils to eroding rainfall events. By contrast, soils of Mediterranean heathlands seem to be resistant to erosion (Nunes *et al.* 2011) even after wildfire (Jordán *et al.* 2010). Like in a pine plantation, fire consumes the aboveground biomass of the *herriza* – or of any other Mediterranean shrubland – in a more or less fierce way depending on fire intensity. However, unlike in pine plantations, a complex system of shrub roots and rhizomes helps protect the soil against erosion as a kind of natural, belowground mesh.

Concluding remarks and management implications

Most negative ecological impacts attributed to wildfire in the western Mediterranean region, such as biodiversity loss and soil erosion, are reported after the burning of pine plantations with at least some degree of commercial management (Gómez-González *et al.* 2018). There, wildfire would impact on an already impoverished flora (Andrés and Ojeda 2002) and a soil previously damaged by afforestation techniques (Romero-Díaz *et al.* 2010), thus dramatically increasing soil erosion levels (Martins *et al.* 2013). In such instances, wildfire does indeed pose a significant ecological threat because it intensifies the environmental deterioration caused by pine plantations (Pausas *et al.* 2008). However, a total fire suppression policy in Mediterranean ecosystems, the desire of numerous well-intentioned naturalists, resource managers and politicians (Moreira *et al.* 2020), may cause unintended negative consequences to many of these ecosystems, such as the Mediterranean heathland or *herriza*.

I do not mean that fire should necessarily and straightforwardly be considered as a generalised management tool in western Mediterranean countries (e.g. Spain, Portugal, Morocco), although prescribed fires are being successfully used in Portugal as a management tool to prevent intense pine forest wildfires (Fernandes and Botelho 2004; Fernandes 2018). In many cases, there are economic risks, such as the escape of prescribed fire to commercial forest plantations – not so much of pines and eucalypts (Fernandes 2018), but of cork-oak trees – that discourage their use, apart from the inherent risk of wildfire to human lives. Nonetheless, I strongly suggest that the large body of scientific knowledge on the relationships of natural ecosystems with fire must be integrated into management practices and conservation strategies of burnt areas to make them more rational and efficient (e.g. Calvo *et al.* 2012; Fernandes 2013; Moreira *et al.* 2020). In the *herriza* and, most likely, in other Mediterranean shrubland habitats, the most effective (and economic) way of post-fire management is permitting natural regeneration with no intervention (Calvo *et al.* 2012), just limiting the density of large herbivores, which may compromise post-fire recovery (Silva *et al.* 2014). In the case of wildfires in pine plantations, which can be truly dangerous to people's lives and properties owing to fire intensity and size (e.g. 2017 mega-fires in Portugal and Chile; Gómez-González *et al.* 2018), an active management plan of soil protection against erosion and vegetation restoration should be implemented (e.g. Fernández and Vega 2016). This is particularly desirable for abandoned plantations and if public interest in the site has moved from commercial plantation to nature conservation (e.g. Safford and Vallejo 2019). All the same, burned natural habitats should not be envisaged or managed as 'damaged' or 'destroyed', but rather as interesting and important transitional stages in the spatial and temporal dynamics of Mediterranean ecosystems (Keeley *et al.* 2012).

Conflicts of interest

The author declares no conflicts of interest.

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