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Wildfires as collateral effects of wildlife electrocution: An economic approach to the situation in Spain in recent years

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HIGHLIGHTS

- Fauna electrocution can be a cause of wildfire ignition Bird species that caused wildfires were similar to species killed by electrocution.
- For the period 2000–2012 fauna mediated wildfires has an economic cost of €7.6–12.4 M with an estimate of direct CO_2 emissions of 1.8×10^4 tons.
- Corrections of dangerous power lines would reduce the wildfire by electrocution.

GRAPHICAL ABSTRACT

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ABSTRACT

The interaction between wildlife and power lines has collateral effects that include wildfires and Carbon Dioxide (CO_2) emissions. However, currently available information is scarce and so new approaches are needed to increase our understanding of this issue. Here, we present the first analysis of wildfires and their incidence as a result of this interaction in Spain during the period 2000–2012. Amongst the 2788 Power-Line Mediated Wildfires (PLMW recorded) during this period, 30 records of Fauna Mediated Wildfires (FMW) were found, with an average affected vegetation cover of 9.06 ha. Our findings suggest that no significant differences were observed between the amount of affected surface area due to fauna mediated wildfires and power-line mediated wildfires. In both cases, a space-grouping trend was observed. In terms of changing trends over time, after the first incident detected in 2005, the number of incidents increased until 2008, year in which the percentage of wildfires caused by wildlife stabilized at approximately 2.4% of all power-line-induced wildfires. Population density and road abundance were variables that better explained PLMW whereas for FMW, the models that included land use and raptor abundance. In the multivariate model, FMW emergence was positively related with population density, percentage of grazing areas and Natura 2000 cover, and predatory abundance; and negatively with the percentage of forested area. No significant differences were observed between the species of birds that caused wildfires and the species of ringed birds killed by electrocution. The economic and environmental impact due to necessary repairs, the loss of biodiversity and CO_2 emissions represent an estimated net value of €7.6–12.4 M for the period 2000–2012, which indicates the importance of the economic and environmental costs associated with wildfires.

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1. Introduction

The interaction between wildlife and power lines has been extensively researched (Bevanger, 1998; Lehman et al., 2007; Jenkins et al., 2010). The most thoroughly studied aspect of this interaction are the negative impacts on bird population such as mortality due to collisions (Loss et al., 2014), electrocution (Lehman et al., 2007) and, to a lesser degree, forest fragmentation due to power-line corridors (e.g. Kroodsma, 1982; Andrews, 1990). Other affected animals include reindeer, whose migration patterns are disrupted by power lines (Reimers et al., 2007). On the other hand, the most studied positive effect of power lines is the use of pylons by birds as nesting sites (Infante and Peris, 2003; Mainwaring, 2015; Tryjanowski et al., 2014).

Other negative effects of power lines including their electromagnetic fields (Fernie and Reynolds, 2005; Balmori and Hallberg, 2007), changes in species interactions including increases in predator presence and/or prey visibility (Lammers and Collopy, 2007; Dinkins et al., 2012), and bird mortality due to entanglement (Gangoso and Palacios, 2002) have not been comprehensively studied.

Another negative effect that has only ever been poorly studied is the impact of the wildfires caused by electrocuted animals. Although power lines usually cause wildfires when there is electrical contact with nearby trees (Mitchell, 2013), wildfires can also occur when an electrocuted animal begins to burn and falls to the ground (Kagan, 2016). Despite significant negative consequences including the loss of human life in cases such as the 2014 Valparaíso wildfire in Chile (Vargas, 2016), fauna-mediated wildfires are very poorly documented in the literature.

Fire is a natural phenomenon that plays a major role in shaping the environment and maintaining worldwide biodiversity (Shlisky et al., 2007; Kelly and Brotons, 2017). The benefits and impacts of wildfires are far-reaching as the majority of the world's terrestrial habitats depend on fire for their ecological sustainability. Fire determines the distribution of habitats, carbon and nutrient fluxes, and soils properties (DeBano et al., 1998). However, >20% of all terrestrial ecoregions experience altered fire regimes due to direct fire suppression or human-caused ignitions that lie outside the range of natural variation (Shlisky et al., 2007). The human alteration of fire regimes can contribute to provide a pathway for harmful invasive species, change regional hydrology, accelerate ecosystem transformations caused by long-term climate change (Kershaw et al., 2002; Shlisky et al., 2007), and directly threaten biodiversity and human habitation and security (Bardsley et al., 2015).

The Mediterranean Basin is one of the world's richest places in terms of animal and plant biodiversity (Cuttelod et al., 2009) and fire has been one of the major drivers shaping its landscape for millennia (Blondel and Aronson, 1999; Fernandes et al., 2013; Moreno et al., 2014). Nevertheless, in the previous century the fire regime changed sharply and it is now regarded as one of the main threats to environmental conservation by some authors (Moreira and Russo, 2007; Syphard et al., 2009). Accordingly, major efforts have been devoted to prevention, management and extinction (Vélez, 2000; Parente et al., 2016). Over the past 35 years, >15.8 million ha have burned in the EU Mediterranean Member States (European Commission, 2015); in Spain alone, 2.3 million ha of forestlands burned in 1981–2013. This is particularly worrying given this country's populations of endemic species such as the Spanish imperial eagle (*Aquila adalberti*) and the Iberian lynx (*Lynx pardinus*), and of highly threatened species at global level such as the cinereous vulture (*Aegypius monachus*) and Bonelli's eagle (*Aquila fasciata*), all of which are affected directly or indirectly by power lines and wildfires (not necessarily in a negative way, i.e. López-López et al., 2006; Rollan and Real, 2011). At the same time, Spain is one of the countries where most studies of bird deaths due to electrocution (Lehman et al., 2007) and the causes of wildfires (ADCIF, 2002, 2012a) have been performed. This country is thus a good case study for investigating the interaction between wildfires caused by wildlife and power lines.

This study addresses the principal issues arising from the occurrence of wildfires caused by the interaction between wildlife and power lines in Spain (hereafter referred to as fauna-mediated wildfires; FMW). Our main goals are i) to explore this phenomenon by analyzing the characteristics of FMW, ii) to characterise the location of wildfires by type and the presence or absence of a space-grouping scheme; iii) to analyse the factors affecting the occurrence of wildfire types and address the timing of wildfires during the year; iv) to identify the species that cause these events; and v) to examine the economic impact in terms of both the costs of recovery and Carbon dioxide (CO_2) emissions.

2. Material and methods

The study was carried out in Spain (~500,000 km^2) using data for the period 2000–2012 obtained from *Defense Area Against Wildfires* (ADCIF) database, managed by the Spanish Ministry of the Environment (ADCIF, 2014) This database compiles wildfire statistics since 1968 (ADCIF, 2002). This dataset contains the causes of wildfires gathered in broad categories, including wildfires caused by power lines – belongs to the group *Negligence and accidental causes* (ADCIF, 2002). The database of the government administration does not specifically distinguish between fires provoked by electrocuted fauna within the fires caused by power lines. To determine which PLMWs are FMWs, we reviewed all additional information of PLMW considering as FMW those events which included any comment or reference to a bird/animal as the cause of the fire.

Finally, for this study, data from the Canary Islands were not included due to the low number of wildfires ($n = 10$) and absence of FMW in this archipelago.

2.1. Description of FMW and PLMW

We compared the characteristics of FMW and PLMW by taking into account two essential aspects: the total affected forest surface area and the potential for self-regeneration. These data were calculated on a regional basis by technical staff using a standardized methodology and then stored the database. For areas <50 ha, a palmtop GPS was used in the field to measure the affected surface area; for areas >50 ha PNOA orthoimages were used (Spanish National Orthoimage Plan). The potential for self-regeneration was assessed following the method described by ADCIF (2012b), which consists of a qualitative evaluation of the affected surface area capable of self-regeneration without any specific treatment. This assessment considers three levels depending on the recoverable surface area (without treatment): level 1: <30%of the affected surface area; level 2: 30–59%: and level 3: >60%.

2.2. Locations of wildfires by type

We used spatial UTM coordinates to study the spatial distribution of FMW and PLMW. First of all, the spatial coordinates corresponding to the fieldwork conducted regionally and incorporated into the database were checked to detect events (i) with incorrectly entered coordinates, (ii) that took place over 1 km from the Spanish border, or (iii) with multiple coordinates from different years; all such events were deleted.

Additionally, we analysed the percentage of wildfires caused by electrocution in Special Protection Areas (SPA hereafter) and drew an external buffer of 5 km around each such area (Pérez-García et al., 2011).

We investigated the spatial distribution of the FMW and PLMW and assessed their regularity and randomness. We used the G function at 96% (Baddeley et al., 2015) that measures the distance between a given point and the next nearest. If these distances are given by $d_i = \min_j\{d_{ij}, \forall j \neq i\}, i = 1, \ldots n$ then the G function can be estimated as $\hat{G}(r) = \frac{\#\{d_i : d_i \leq r, \forall i\}}{n}$. Using Complete Spatial Randomness (CSR), the value of the G function is $G(r) = 1 - \exp(-\lambda \pi r^2)$ where λ is the strength or average of the number of dots by surface unit. To determine the randomness of the FMW distribution in the PLMW, a complementary analysis was conducted for both FMW and PLMW. The goal of this analysis is to