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Towards Fire Resilient Landscapes: Strategies For Reducing Exposure To Extreme Wildfires

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In the last decade, extreme wildfire events (EWE) have left severe economic, environmental, and social impacts worldwide. Notable instances in 2023 occurred in Canada, Greece, and Maui in the U.S. Canada and Greece set records for the worst fire season, with the largest burned area in both regions. Meanwhile, Maui witnessed the deadliest wildfire in U.S. history, claiming over 100 lives. The societal consequences have reached unprecedented levels, highlighting the insufficient capacity to respond to this new fire regime, even with intensified suppression efforts (Bowman et al., 2017). The evolution of the new wildfire regime stems from complex interactions of biological, meteorological, physical, and social factors. The convergence of weather patterns and fuel conditions are the factors that most influence wildfire behavior. Weather patterns influence fuel conditions such as moisture and the formation of the physical conditions necessary for wildfire spread, such as unstable atmospheres, pyro convection, or the new interaction between drought, high air temperatures, low relative humidity, and wind variations. Besides, fuel conditions such as continuity, quantity, flammability, and vegetation management directly influence wildfire behavior (Rogers et al., 2020). Consequently, climate change and human-related factors compound the challenges of EWE. Human-related factors encompass social aspects such as rural depopulation, cultural elements such as neglect and arson, and political dimensions, namely, land management, afforestation, and forest restoration. Current actions to reverse climate change may not be sufficient (IPCC, 2022). In this sense, specific measures addressing human-related factors, particularly in land management, can enhance wildfire resilience against these phenomena' increasing occurrence and intensity.

Human intervention has modified the natural environment, increasing susceptibility to wildfires. For instance, the severity of recent fires in Maui (2023) is linked to the proliferation of invasive grasses covering significant portions of the islands. In Portugal, extensive and highly flammable eucalyptus plantations have reduced the country's resilience to wildfires (Weston, 2023). In addition, Portugal has extensive areas of undermanaged forests and shrublands that facilitate the occurrence of frequent, huge, and uncontrolled wildfires (Fernandes et al., 2016). This evidence the importance of effective landscape management as a key strategy for reducing landscape flammability and fuel continuity. Preparedness and adaptation activities become imperative for promoting wildfire resilience in the medium and long term, potentially mitigating the consequences of the new wildfire regimen (Loepfe, Martinez-Vilalta, and Piñol, 2012).

Therefore, one of the main challenges for wildland fire scientists and managers is to promote more resilient landscapes and consequently, there is an eminent need for tools to support decision-making in this domain. Various frameworks exist for modelling fuel connectivity and assessing the spatial influence on fire spread, e.g., (Loehman, Keane and Holsinger, 2020; Sá et al., 2022; Aparício et al., 2022). However, these models are intrinsically attached to propagation models that primarily aim to predict wildfire occurrence, specifically fire ignition points. This connection introduces high uncertainty, especially considering that a significant portion of forest fires, particularly in the European Union, result from arson. In Portugal, for instance, 98% of fires are attributed to arson. Existing models fail to capture this high level of uncertainty adequately. Moreover, current methods are increasingly specialized, focusing on specific scenarios. Nevertheless, their limited ability to extrapolate and apply to diverse situations or conditions raises concerns about the conclusiveness of decision-making based on the analysis of a restricted number of fire events (Arango et al, 2023).

To address these issues, this study proposes the use of a Geographic Information System (GIS)-based methodology for fire analysis, serving as a more effective tool for landscape fuel management. This tool evaluates exposure by considering various fuels, encompassing both built and natural environments. Unlike other models, this tool does not require the definition of the wildfire conditions and the location of the fire ignition, thereby eliminating associated uncertainties. Instead, the tool focuses on the system's ability to cope with such events, incorporates different intensities of wildfires including EWE, and conducts analyses at the system level. It has previously demonstrated its effectiveness in assessing various adaptation measures, capturing the influence of different fuels (sources or barriers) in exposure assessment. This study shows the tool's efficacy in landscape management by applying different fuel treatment strategies to reduce exposure to wildfires. For this, the exposure level of a case study in the Leiria region of Portugal is compared to the conditions that led to the devastating fire in 2017 and future conditions. Future scenarios involve two cases: one without implementing fuel treatment strategies and another using treatment strategies. This approach provides stakeholders with pertinent information to support necessary changes in forest management and the development of fire-resilient landscapes. The results suggest that the tool can significantly contribute to achieving certain goals outlined in the European Green Deal.

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