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Wildfire management in Mediterranean-type regions: paradigm change needed

Francisco Moreira[1,2,24], Davide Ascoli[3], Hugh Safford[4], Mark A Adams[5], José M Moreno[6], José M C Pereira[7], Filipe X Catry[8], Juan Armesto[9], William Bond[10], Mauro E González[11], Thomas Curt[12], Nikos Koutsias[13], Lachlan McCaw[14], Owen Price[15], Juli G Pausas[16], Eric Rigolot[17], Scott Stephens[18], Cagatay Tavsanoglu[19], V Ramon Vallejo[20], Brian W Van Wilgen[21], Gavriil Xanthopoulos[22] and Paulo M Fernandes[23]

[1] CIBIO/InBIO, Universidade do Porto, Campus Agrário de Vairão, 4485-601 Vairão, Portugal
[2] CIBIO/InBIO, School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisboa, Portugal
[3] DISAFA, University of Torino, Largo Paolo Braccini 2, I-10095 Grugliasco, Italy
[4] 2931 Bellows Court, Davis, CA 95618, United States of America
[5] Faculty of Science, Engineering & Technology, Swinburne University of Technology, Victoria, Australia
[6] Department of Environmental Sciences, University of Castilla-La Mancha, Avda. Carlos III, s/n; E-45071 Toledo, Spain
[7] Forest Research Centre, School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisboa, Portugal
[8] CEABN/InBIO—Centre for Applied Ecology/Research Network in Biodiversity and Evolutionary Biology, School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisboa, Portugal
[9] Departamento Ecologia, Pontificia Universidad Catolica de Chile, Chile
[10] Department of Biological Sciences, University of Cape Town, Private Bag, Rondebosch, 7701, South Africa
[11] Universidad Austral de Chile, Facultad de Ciencias Forestales y Recursos Naturales, Instituto de Conservación, Biodiversidad y Territorio, Center for Climate and Resilience Research (CR)2, Valdivia, Chile
[12] IRSTEA-RECOVER, 3275 route Cézanne, CS4006, F-13182 Aix-en-Provence cedex, France
[13] Department of Environmental Engineering, University of Patras, G. Seferi 2, GR-30100 Agrinio, Greece
[14] Department of Biodiversity, Conservation and Attractions, Manjimup 6258 Western Australia, Australia
[15] Centre for Environmental Risk Management of Bushfire, University of Wollongong, Wollongong, NSW 2505, Australia
[16] CIDE-CSIC, Ctra. CV-315, Km 10.7, E-46113 Montcada, Valencia, Spain
[17] URFM, Ecology of Mediterranean Forests, INRA, F-84914, Avignon, France
[18] Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720, United States of America
[19] Division of Ecology, Department of Biology, Hacettepe University, Beytepe 06800 Ankara, Turkey
[20] CEAM. C. Darwin 14, 46980 Paterna, Dep. Evolutionary Biology, Ecology and Environmental Sciences. University Barcelona, E-08028 Barcelona, Spain
[21] Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, South Africa
[22] Hellenic Agricultural Organization 'Demeter', Institute of Mediterranean & Forest Ecosystems, PO Box: 14180, Terma Alkmanos, Ilisia, 11528, Athens, Greece
[23] CITAB—Centro de Investigação e Tecnologias Agroambientais e Biológicas, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, Vila Real 5000-801, Portugal
[24] Author to whom any correspondence should be addressed.

E-mail: fmoreira@cibio.up.pt, d.ascoli@unito.it, hughsafford@fs.fed.us, mark.adams@sydney.edu.au, Josem.moreno@uclm.es, jmcpereira@isa.ulisboa.pt, fcatry@isa.ulisboa.pt, jarmesto@bio.puc.cl, William.Bond@uct.ac.za, maurogonzalez@uach.cl, thomas.curt@irstea.fr, nkoutsia@upatras.gr, Lachie.Mccaw@dbca.wa.gov.au, oprice@uow.edu.au, juli.g.pausas@ext.uv.es, eric.rigolot@inra.fr, sstephens@berkeley.edu, ctavsan@hacettepe.edu.tr, ramonv@ceam.es, bvanwilgen@sun.ac.za, gxnrtc@fria.gr and pfern@utad.pt

Keywords: wildfires, management policy, Mediterranean-type regions, Australia, Chile, California, South Africa

Abstract

During the last decades, climate and land use changes led to an increased prevalence of megafires in Mediterranean-type climate regions (MCRs). Here, we argue that current wildfire management policies in MCRs are destined to fail. Focused on fire suppression, these policies largely ignore ongoing climate warming and landscape-scale buildup of fuels. The result is a 'firefighting trap' that contributes to ongoing fuel accumulation precluding suppression under extreme fire weather, and resulting in more severe and larger fires. We believe that a 'business as usual' approach to wildfire in MCRs will not solve the fire problem, and recommend that policy and expenditures be rebalanced between suppression and mitigation of the negative impacts of fire. This requires a paradigm shift: policy effectiveness should not be primarily measured as a function of area burned (as it usually is), but rather as a function of avoided socio-ecological damage and loss.

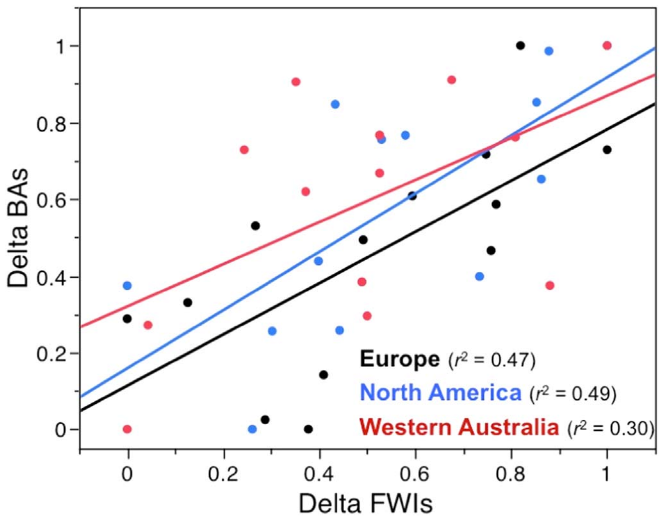

Figure 1. Burned areas and fire weather in Mediterranean-type climate regions (MCRs). A significant proportion of the inter-annual variability in total area burned in MCRs is explained by fire weather. The graph shows the mean daily fire weather during the fire season versus the total area burned during that season for years 2003–2016 in three MCRs. Burnt area (BA) was provided by the Global Fire Emission Database [27]. Fire weather was indexed using the Canadian Fire Weather Index (FWI) according to the Global fire danger re-analysis [28]. Fire season: Europe (June–September), North America (June–November), Western Australia (January–May). Calculations used the first-difference method for detrending [29]. Consequently, a change in FWI from one year to the next (Delta FWI) was matched with the corresponding change in BA (DeltaBA). Changes are standardized from 0 to 1 across the series. The graph shows that the more severe a fire season is the more area is annually burned in the three MCRs. Association between BA and the FWI is weaker in Western Australia, which suggests a fire-management mitigating effect, namely the extended prescribed burning program in place. The geographical cover of Mediterranean regions to extract BA and FWI data was set according to the Köppen–Geiger climate classification system (classes Csa, Csb, Csc).

The Mediterranean-type climate regions (MCRs) are distributed over five continents: Africa, Australia, Europe, North America, and South America. They share a strongly seasonal climate, with cool, wet winters that promote vegetation (fuel) growth, and hot, dry summers that enhance vegetation flammability. As a result, ecological and evolutionary processes, and human societies have been strongly shaped by fire in the majority of MCRs [1]. More recently, human alterations of landscapes and climate have led to strong changes in fire regimes and their socio-ecological impacts in all five MCRs. In recent decades, growing populations have brought millions of new inhabitants and homes into the wildland-urban interface (WUI), and warming and drying climates plus ignitions (most often anthropogenic) during periods of severe fire weather have led to an increased prevalence of extreme wildfire events (EWEs)—very intense fires that often result in very large burned areas and significant impacts on human lives and assets [2]. While such events have been apparent for some time, contemporary wildfire management policies in the MCRs have continued to focus almost entirely on reactive fire suppression, while failing to adequately and proactively address the underlying causes of the problem. Here, we argue that the strong focus on fire suppression is destined to fail in MCRs and recommend that policy and expenditures be rebalanced between suppression and mitigation of the negative impacts of fire. We further argue that policy effectiveness should not be primarily measured as a function of area burned, but rather as a function of avoided socio-ecological damages (and, sometimes, improved ecological outcomes). The rationale for this claim is presented below.

Burned area and EWEs are mostly driven by fire weather

Despite extraordinary global expenditures on wildfire suppression in MCRs, most inter-annual variability in burned areas in MCRs in recent decades is still explained by fire weather (figure 1). Due to global warming, fire danger and burned areas are expected to increase in MCRs [3]—although some predictions are variable depending on whether conditions will become drier or wetter across MCRs [4]—and will be further exacerbated by ongoing changes in land use and management that increase fuel loads and continuity [5]. In many cases, EWEs and their impacts are already devastating in MCRs. For example, California has experienced the most destructive wildfires in the USA over the last 40 years. Nine of these have occurred since 2003, with six events in 2017 and 2018 destroying >30 000 homes and businesses, killing 148 people, and resulting in insured fire losses of over US $35 billion. Other recent MCRs examples of EWE outbreaks include 2009 in southern Australia, 2017 in Portugal and in Chile, 2018 in Greece and in South Africa, with summed fatalities in the hundreds and economic losses in the billions of dollars. EWEs are usually associated with extreme weather and, under such circumstances, fires spread displays little

Drivers	Med basin	North America	Chile	South Africa	Australia
Agricultural land abandonment	H	L	L	L	L
Expansion of mismanaged tree plantations	H	L	H	M	L
Expansion of the wildland-urban interface	M	H	M	H	H
Invasive species	L	L	H	H	L
Hindered use of fire	M	H	L	H	H*
Lack of adequate post-fire management	M	M	M	L	M

*Mainly in eastern Australia, as there is a strong use of fire in Western Australia.

Figure 2. Drivers of the firefighting trap: estimated relative importance (coding: H = high; M = moderate; L = low) of major drivers the 'firefighting trap' across Mediterranean-type climate regions (MCRs), as evaluated using expert-knowledge (set of authors of this paper). Relative importance for each MCR inferred from potential share of the total area of the region affected by the driver and the resulting increases in fire hazard and exposure.

sensitivity to land cover type [6], except where large-scale and sustained strategic fuel reduction activities are implemented such as in SW Australia [7]. Additionally, although there is evidence that fire suppression can limit fire size [8], under EWE conditions it is largely ineffective even in cases of massive resource deployment [9, 10]. This is due to a combination of factors including strong winds that preclude ground engagement and aerial support; long distance ember cast; simultaneity of ignitions; and fire intensity above extinction capacity [11].

Policies leading to the firefighting trap

Existing policies in MCRs—that have largely ignored climate warming and landscape-scale buildup of fuels—have led to the so-called 'firefighting trap' [12]. In brief, the trap results from allocating to fire suppression most of the investment in fire management. Paradoxically, this exacerbates the problem, as it contributes to ongoing fuel accumulation and landscape-level fuel continuity, which then precludes suppression under extreme fire weather, and results in more severe and usually larger fires.

Causes of this firefighting trap are variable across MCRs (figure 2), but can be broadly divided into (a) land use changes leading to increased fire hazard and risk, and (b) the persistence of reactive and shortsighted fire management policies. Contributory land use changes in the MCRs include: expansion of human settlements into fire-prone areas; introduction of and invasion by fire-promoting exotic species; establishment of large, poorly managed tree plantations of highly flammable species; and agricultural land abandonment as a consequence of rural depopulation, resulting in replacement by unmanaged vegetation [5, 6, 13, 14]. Together, these trends lead to an increase in the amount and connectivity of fuel at the landscape-level, as well as the expansion of WUI and intermix areas. The main flaw in fire management policies derives from the prevalence of a shortsighted wildfire suppression approach, which seeks to minimize burned area in the short-term, treats fire as delivering only negative impacts, and tends to react to public opinion with ever-greater investment in firefighting capacity. In many MCR countries, repressing of traditional burning practices and cultural uses of fire, including legislative and other constraints that prevent use of prescribed fire, also hinders the use of cost-effective tools for reducing fire hazard and risk [15]. Lastly, post-fire management, when implemented, is not always oriented to fire hazard mitigation in the medium/long-term. These land use and policy settings will likely result, in the long run, in larger burned areas and/or a greater share of total burned area being accounted for by the largest, and most intense fires [6, 12], exacerbating both ecological and socio-economic impacts.

Aim at reducing damage, rather than area burned

We believe that a 'business as usual' approach to wildfire in MCRs will not solve the fire problem under current climate and land use trends. Indeed, evidence is that this approach will make it worse. No amount of investment in suppression will prevent EWEs [11], in particular if the climate of MCRs is to become warmer and wetter, driving productivity and thus flammable biomass [4]. 'Success'—if it is measured as reduced area of land burned in any given year—will actually be failure in the long term, as EWEs are merely postponed [16]. Eventually, there will be an inevitable confluence of extreme fire weather and landscape-scale fuel hazard, generating fires of extraordinary intensity, seriously threatening lives, property and ecosystems. Acknowledging this inevitability, the only alternative is to aim for reduced fire severity across large areas and in key locations, to minimize negative impacts to society, ecosystems and their services. Accordingly, we argue that measures of policy success must be changed in most cases, from targets emphasizing reductions in area burned to targets more closely related to reducing fire negative impacts. Multi-dimensional metrics including socio-ecological components (e.g. human lives lost, direct economic losses, soil erosion (e.g. [17], water and air quality (e.g. [18], carbon emissions, and biodiversity impacts) would provide a more realistic and useful assessment of fire impact than a single and misleading statistic like burned area. It is out of the scope of the current paper to derive these metrics, including if they should be all expressed as a common currency (e.g. monetary value) or as a series of topical metrics for different parameters (e.g. human lives lost, damage to assets, estimated soil losses, GHG emissions, smoke emissions, suspended sediments in water), without creating an overall impact indicator for each wildfire. Focusing on reducing negative fire impacts may well require a multi-sectorial vision and implementation of novel solutions, such as adoption of 'coexistence strategies' as used by plants, animals and indigenous cultures in order to avoid, adapt to, and depend on fire [19, 20]. Consequently, we propose that governments develop and implement an integrated policy package based on two key elements: (i) promoting less vulnerable and more fire-resilient landscapes; and (ii) minimizing risk for humans and infrastructure.

Targeting the reduction of the amount and connectivity (landscape design) of fuels would reduce fire growth rate, increase the potential for fire suppression, and mitigate fire damage. Afforestation, reforestation and forest management should incorporate these aims, including species selection considering flammability, fire resistance and resilience and the adoption of silvicultural practices that decrease fire hazard. Agricultural policies should be better aligned with forest and fire policy, particularly in the Mediterranean Basin where maintaining farmland areas surrounding villages can help avoid vegetation encroachment around assets. Further advantages in terms of mitigation (reduced risk to lives and property) are offered by encouraging livestock grazing and promoting agroforestry [14]. Under controlled conditions, deliberate use of fire (prescribed burning or fuel reduction burning) is a very cost-effective fuel treatment, with proven effectiveness in: hazard reduction; fire suppression; meeting ecological and conservation objectives; and rangeland management [15]. Enhanced provisioning of some ecosystem services can even result from wildfires, particularly under non-extreme conditions, including e.g. improved natural disease and pest control, enhanced pollinator activity, or alleviation of water shortages [15, 21]. However, barriers associated with bureaucracy, cultural resistance, perceived risk, ecological issues, and availability of resources have hindered fire use. The use of biomass for energy, as well as prescribed grazing, should be implemented and fostered where feasible. Other possible strategies include the involvement of suppression forces on fuel treatments, or setting programs to promote the removal of fuels by local communities (e.g. gathering wood for biomass burning). Finally, post-fire management provides a window of opportunity to implement large-scale and socially acceptable changes in forest and landscape planning [22] that can create more fire-resilient and less flammable landscapes. Key here is avoiding imposition of costs on individuals with limited capacity to pay, especially in the aftermath of EWEs when economic losses are already large.

Much attention must also be paid to the WUI, including considerations related to land use planning (location, infrastructure design), landscape management (land use surrounding the WUI, asset protection zones), and structure hardening to promote self-protection. Serious efforts should be made to regulate existing WUI and its expansion by introducing fire hazard and risk into urban planning. Possible approaches include curtailment of rights to build, creating financial incentives to fire-safe development, imposing regulations on fuel management surrounding infrastructure or on construction materials (quite different across MCRs [23]), increase insurance premiums, and providing low interest loans to homeowners to improve structure hardening in existing homes. In areas undergoing agricultural land abandonment, encroachment of highly flammable vegetation and tree plantations around rural settlements ought to be contained. For residents in the WUI, community preparedness is also a key component of a policy targeting reduced damage. This includes the definition of 'stay-or-go' policies, safe egress, and the engagement of local communities in the design and planning of mitigation actions [24]. In Australia the policy of prepare, stay, defend, or leave early continues to be successfully used, albeit with the caveat that under extreme conditions the only safe course of action is to leave.

Reducing anthropogenic fire ignitions remains an important component of all fire management strategies [22] although, if not matched with the management of fuels, it will contribute to the firefighting trap.

Conclusion: a policy shift from suppression to mitigation and adaptation

Fire suppression must continue to play a key role in the protection of human lives and assets in MCRs. However, given current and projected climatic, ecological, socioeconomic and land use trends, the frequency of EWEs is likely to increase even in the face of escalating fire suppression expenditures. Shifting focus from fire suppression to mitigation, prevention, and preparation [12, 22] is both logical and pragmatic, and more likely to reduce the negative socioeconomic and ecological effects of fire than the current, largely one-dimensional, focus on fire exclusion. This could be done through both redirecting existing investment in fire policies and using additional investment coming from other sources (e.g. agriculture, forest, energy policies). Of course, there are several barriers to this policy shift, a major one being the immediacy of fire suppression, its immediate effect (when it works) and visibility to the media (e.g. [25]), which contrasts with the long term effectiveness of fuel management, much less visible and out of synchrony with electoral cycles. Depending on context, this policy change does not necessarily equate to a decrease in fire suppression effort but rather to more focus and investment in the alternatives, which are expected to enable lower firefighting expenditures in the future as landscapes, structures and people become more fire-resilient. But replying to each catastrophic fire season with ever increasing fire suppression expenditure, while disregarding mitigation and adaptation, will continue to be a major political mistake.

Adoption of best practices in fire management, even when supported by policy, is constrained by a number of factors, including strong risk aversion motivated by social and political expectations and pressures [26], including societal unacceptance of prescribed fire, pressure to establish forest plantations, or perceived benefits (e.g. aesthetics, privacy, sound reduction, shade and temperature moderation) of having vegetation surrounding houses in WUIs, making residents unwilling to treat fuels around their homes. These barriers have different importance across MCRs and need to be tackled accordingly.

EWEs in the MCRs may be best treated as unavoidable episodic events like hurricanes and earthquakes [1], where the inevitability of their occurrence frees us to focus more on minimizing the damage they do. We propose moving beyond the simplistic and often self-defeating use of burned area to measure fire impacts on complex socio-ecological systems, and embracing a more detailed multifactorial vision of fire impacts.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID iDs

Francisco Moreira https://orcid.org/0000-0003-4393-8018
Mauro E González https://orcid.org/0000-0002-3729-9523
Juli G Pausas https://orcid.org/0000-0003-3533-5786
Brian W Van Wilgen https://orcid.org/0000-0002-1536-7521
Paulo M Fernandes https://orcid.org/0000-0003-0336-4398

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