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Editorial: Fire regimes in desert ecosystems: Drivers, impacts and changes

Eddie J. B. van Etten[1]*, Matthew L. Brooks[2]*, Aaron C. Greenville[3] and Glenda M. Wardle[3]

[1]Conservation and Biodiversity Research Centre, School of Science, Edith Cowan University, Perth, WA, Australia, [2]Western Ecological Research Center, US Geological Survey (USGS), Oakhurst, CA, United States, [3]School of Life and Environmental Sciences, The University of Sydney, Sydney, NSW, Australia

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EDITED AND REVIEWED BY
Peter Convey,
British Antarctic Survey (BAS),
United Kingdom

*CORRESPONDENCE
Eddie J. B. van Etten
e.van_etten@ecu.edu.au
Matthew L. Brooks
mlbrooks@usgs.gov

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Editorial on the Research Topic
Fire regimes in desert ecosystems: Drivers, impacts and changes

Introduction

Although not commonly associated with fire, many desert ecosystems across the globe do occasionally burn, and there is evidence that fire incidences are increasing, leading to altered fire regimes in this biome. The increased prevalence of megafires (wildfires >10,000 ha in size and typically damaging) in most global biomes is linked to climate change, although those occurring in deserts have received far less attention, from both a research and policy perspective, than that of forested ecosystems (Linley et al., 2022). Understanding the drivers of desert fires, from climate to landscape patterns of hydrology and soil, and how these may be changing in the face of anthropogenic pressures, such as invasive species, livestock grazing, and global climate change, is imperative. This Research Topic has published nine papers addressing these drivers, how they have changed, and their impacts on desert biodiversity.

Role of invasive grasses and ecosystem transitions

Deserts are typified by sparse, discontinuous vegetation which has resulted in historically infrequent fire and low resilience of native vegetation, particularly shrubs and trees. Invasive grasses can increase the amount, continuity, and ignitability of fuelbeds, resulting in increased occurrence of fire (D'Antonio and Vitousek, 1992). Increased fire occurrence can cause type-conversions of native desert vegetation to non-native invasive grassland (Brooks et al., 2004).

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Rodhouse et al. demonstrated this type-conversion dynamic with the invasive annual grasses *Bromus tectorum* and *Taeniatherum caput-medusae* at a North American Cold Desert site. They also reported that native perennial grasses can be more resilient than woody species to fire and used that finding to develop site-specific conservation recommendations. Wilder et al. explained how the invasive annual grass *Bromus rubens* and perennial grass *Cenchrus ciliaris* are altering fire regimes in a North American Warm Desert region. They also explain how this threatens both human communities at the wildland urban interface (WUI) and higher elevation native forest communities which are otherwise somewhat resilient to fire. Moloney et al. provides an example of how fire potential can be modeled by characterizing the matrix of patchy native perennial fuels connected across interspaces by more continuous invasive annual grass fuels.

Spatial patterns of fires and fire regimes

Remote sensing data collected by satellites and aircraft are now routinely used to detect active fires and map fire scars accurately and efficiently; analysis of these data can determine many components of the fire regime, and how these have changed over time, providing valuable insights and a sound basis for fire management, from global (Chuvieco et al., 2008) to local (e.g., Verhoeven et al., 2020) scales. Such techniques are particularly suited to arid and semi-arid lands given their general remoteness and vastness (Ruscalleda-Alvarez et al., 2021).

Clarke et al. and van Etten et al. used such mapped fire scars to effectively characterize fire regimes of two semi-arid regions of southern Australia. Periodic, intense, and stand-replacing wildfires were of over-riding importance in shaping the fire regimes in both regions, creating mosaics of different fire ages across the landscape, including many long unburnt patches. This combined with slow recovery of vegetation after burning, resulted in generally long intervals between fires. van Etten et al. demonstrated highly contrasting fire regimes across landscapes linked to soil/vegetation type, whilst Klinger et al., using remote-sensing derived maps of fire frequency and severity, also found spatially-structured fire regimes across the Mojave desert.

Climate-fire interactions

Wildfires in semi-arid and arid zones are often driven by rainfall-led increases in fuel loads, rather than droughts that increase the flammability of vegetation in more mesic regions (McLauchlan et al., 2020). Clarke et al. reviewed the role of wildfire in contemporary mallee ecosystems, with particular focus on south-eastern Australia. They found that wildfires occur in late spring and summer in both dry and wet years. Annual rainfall is sufficient to maintain vegetation and fuel connectivity within and across years. Fire return intervals are 10–20 years, but fires can return sooner after high rainfall events. In contrast van Etten et al. demonstrated that wildfire in a semi-arid region of inland south-western Australia was strongly linked with high rainfall in the year prior to fire and had longer fire return intervals from 25 and 100 years. The differences in fire regimes between the two mallee systems may be due to lower rainfall in south-western Australia. In arid regions of North America and Australia, both Brunelle and Wright et al. found a strong association between antecedent rainfall and wildfire. Brunelle examined paleoenvironmental records and found an increase in fires after the emergence of El Nino events (after ~4,500 cal yr BP), which influences winter rainfall events in North American desert southwest. Wright et al. investigated a range of different sources—from explorer diaries and remote sensed data—to show that large-scale wildfires occurred after high-rainfall events in spinifex grassland in the Western Desert of Australia, regardless of previous fuel management practices. In common across both semi-arid and arid regions investigated above, these ecosystems experience megafires and changing rainfall regimes due to climate change may have profound effects on fire regimes in these ecosystems.

Species responses to fire

Understanding species responses to fire(s) is important in predicting the fate of populations following burning; adaptations to withstand or recover following fire are generally expected to be less strongly developed in arid zones compared to more fire-prone biomes. Saguaro (*Carnegiea gigantea*), the giant columnar cactus of the Sonoran Desert, as well as many other cacti, experienced high mortality and no to minimal resprouting following a particularly severe wildfire event studied by Wilder et al., with smaller plants being more susceptible. In contrast, many other plants, including the dominant shrubs, demonstrated high resprouting capacity following fire, suggesting pre-adaptation to fire, possible as a response to other stresses, such as drought. St Clair et al. specifically studied regeneration of Joshua trees (*Yucca jaegeriana*) following wildfires in the Mojave Desert and reported variable degrees of resprouting, mostly from the base of trees, but little regeneration from seed.

Clarke et al. presented a synthesis of many studies done over several years; consequently, they were able to report responses to fire regimes, as opposed to single fire events. They found many understory plant species in semi-arid south-east Australia were obligate seeders regenerating from the soil seed bank after fire, but were vulnerable to repeated fires, whereas the dominant overstory mallees (multi-stemmed *Eucalyptus*) and many of the dominant hummock grasses (*Triodia* spp.) resprouted from below-ground structures. With change in vegetation over time, abundances of the studied animal species (including birds, reptiles and small mammals) also changed. Clarke et al. classified responses of these fauna into six categories, depending on if, and when, their abundances peaked post fire.

Conclusions and closing comments

The various papers in this Research Topic have demonstrated that shifting fire drivers are leading to altered fire regimes in many desert ecosystems, and that we need to be particularly concerned with synergistic effects of these drivers, such as climate changes interacting with invasive grasses to produce more frequent, hotter, and larger wildfires. The impending threats of changing fire regimes on biodiversity require an enhanced research agenda, particularly in desert regions outside of southwestern USA and inland Australia (where all the studies in this Research Topic were based).

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

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