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Supplementary Materials for

Fire and biodiversity in the Anthropocene

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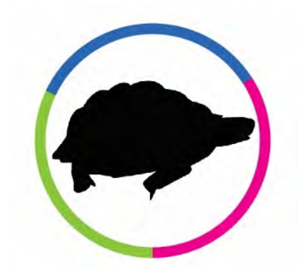
Table S1
References

Table S1.
Details of linked changes in fire regimes and biodiversity documented in Figure 2.

 **1. Saprotrophic fungi** A hotter, drier climate is projected to cause larger and more severe fires in the boreal forests of Alaska, USA. Within burned stands of Black Spruce forest and spruce-aspen forest, saprotrophic fungi decline in areas that are severely burnt *(37)*.	 **2. Whitebark Pine** Whitebark Pine populations in subalpine forests of western North America are declining through mortality caused by the Mountain Pine Beetle and White Pine Blister Rust. Yet, some individual White Pine trees are putatively pest-resistant and provide the foundation for future restoration efforts. Loss of pest-resistant trees from wildfire could reduce Whitebark Pine regeneration. Wildfires are predicted to increase in subalpine forests because of global climate change and this may place Whitebark Pine populations at further risk of decline *(84)*.	 **3. White Spruce** Extreme fire weather is increasing fire frequency in Canadian boreal forests. Short intervals between fires negatively affect recruitment of obligate seeders such as White Spruce. Global climate change is likely to increase fire activity in these forests and amplify the negative impact of drought-fire interactions on White Spruce *(11)*.
 **4. Lodgepole Pine** Subalpine forests of Greater Yellowstone, USA, have been resilient to stand-replacing fires that historically burned	 **5. Greater Sage-grouse** Invasive Cheatgrass increases fuel loads and continuity in deserts and shrublands of western USA, which alters	 **6. Chaparral** In southern California, native shrublands known as chaparral support exceptionally high plant

at intervals of 100-300 years. However, fire intervals are projected to decrease as the climate warms. Short-interval stand-replacing fires in Lodgepole Pine forests reduce tree generation and biological legacies. There will likely be marked changes in forest structure and function if short-interval fires become more common in Lodgepole Pine forests *(36)*.	regional fire regimes. In turn, an increase in fire occurrence reduces habitat for Greater Sage-grouse that prefers to forage in dense sagebrush *(53)*.	diversity. Short intervals between fires, associated with proximity to trails and roads in recreation areas, are converting chaparral into vegetation dominated largely by exotic herbaceous cover. Landscape disturbances such as trail construction and fuel breaks also provide the means for exotic herbaceous species to colonize open vegetation *(45)*.
 **7. Eastern Collared Lizard** Prior to European settlement, fires were common in the woodlands and savannas of midwestern USA. Fire suppression throughout much of the 20^{th} century shifted open woodlands and savanna to a woodland with a dense woody understory. This regime shift fragmented habitats of exposed bedrock used by the Eastern Collared Lizard, followed by local extinction of the species *(101)*.	 **8. Great Plains grasslands** The Great Plains of North America comprise extensive fire-prone grasslands. Exclusion of anthropogenic fire, including active fire suppression, has reduced the frequency of fire and led to the transition of species-rich grassland to areas dominated by woody plants such as Juniper species. Overgrazing by domestic livestock has also removed herbaceous species that contribute to grassland fires. Under global climate change, fire regimes in the Great Plains are expected to exhibit ranges of variability that have no historical analogue over millennia *(16)*.	 **9. Hylid frog** The Endangered frog *Bromeliohyla melacaena* occurs in mountain pine forests and broadleaf cloud forests of Honduras. Fire is naturally rare in these forests but intentional use of fire for agriculture is reducing habitat for this species. Government incentivization for the cultivation of coffee in protected areas is one reason for increasing alteration of primary forest habitat. In addition, a woodboring pine beetle has recently caused high tree mortality, which encourages harvesting of timber and, in turn, use of intentional fires to convert areas harvested for timber into cropland. Climate change is expected to further reduce

		suitable habitat for this hylid frog, and make populations more vulnerable to fire *(24)*.
 **10. Ant communities** In the cerrado ecosystems of Brazil, fire suppression is practiced in most nature reserves and protected areas because of the perception that fire is damaging to biodiversity. Reduction in fire occurrence is exacerbated by crops, pasture and forest plantations that fragment savanna landscapes. Fire suppression has transformed some savanna vegetation into forests, through woody encroachment, causing biodiversity losses and marked changes in ecological processes. Ant communities are less diverse when fire is excluded *(43)*.	 **11. 'Pineapples'** Natural fire ignitions are rare in the shrubland ecosystem of central Chile called matorral. Since the 19th century, human-driven ignitions associated with agriculture and transportation have significantly increased fire frequency in matorral and are driving evolutionary changes in seed traits of the native herbaceous plant 'pineapples' *(76)*.	 **12. Forest butterflies** Until recent decades, tropical broadleaf forests of the Amazon rarely experienced large fires. Extensive fires in the Amazon rainforest are a result of deforestation, habitat fragmentation and climate change, underpinned by social, political and economic changes. Forest specialists such as Leaf Wing Butterfly decline in areas burnt recurrently *(41)*.
 **13. Dartford Warbler** In northern Spain, land abandonment continues to shift mosaics of farmland and	 **14. Common Heather** Common heather occurs across Europe in a variety of temperate, boreal and	 **15. Spur-thighed Tortoise** Fire frequency and extent is expected to increase in the Mediterranean woodlands

open forest to dense, fire-prone forests. A hotter and drier climate exacerbates the risk of very large fires. Higher tree cover has increased populations of some forest bird species, while causing declines in open-country species. Threatened bird species that prefer open habitat, such as Dartford Warbler, will benefit from open spaces created by wildfires *(47)*.	montane ecosystems. In Norway, coastal populations of this shrub species have experienced higher fire frequency than other ecosystems, under millenia of traditional burning for agriculture. Smoke-induced germination, which helps plants exploit frequent fire, is found in populations from traditionally burnt shrublands but is lacking in ecosystems where fire is rare. Thus, anthropogenic fire has likely shaped the evolution of this species and conservation management will be enhanced by considering these adaptations *(102)*.	and shrublands of northwest Africa because of global climate change, rural land abandonment and dense plantations of trees for timber production. Spur-thighed Tortoise can be killed by fires and areas recently burnt by wildfires do not provide suitable food and shelter resources. Short intervals between fires are expected to cause regional population crashes *(103)*.
 **16. Savanna trees** Humans are the main source of fires in the savannas of west and central Africa. In the savannas of Gabon's Bateke Plateaux there has been a change from annual to semi-annual fires over the past 40 years as governance has become less centralized. Fire are now lit several times a year by individual hunters to create pasture. Semi-annual fire regimes in the savannas of Gabon are increasing the survival and density of the dominant tree	 **17. Wild herbivores** Reduction in fuel loads through increased livestock grazing has virtually excluded fire in savannah ecosystems of the Serengeti-Mara, Tanzania. Fire plays an important role in the function of this region and its exclusion could lead to an increase in bush encroachment and the displacement of wild herbivores such as wildebeest *(18)*.	 **18. Cyprinid fish** The fish *Enteromius seymouri* occurs in river systems in Malawi. The freshwater habitat of *E. seymouri* is declining due to sedimentation caused by agriculture. Fires used to clear land, or as part of agriculture, threaten wetlands in the northern tributaries of the species geographic range, through siltation from soil erosion (*24*).

Hymenocardia acida. With less fuel to burn, semi-annual fires are patchier and cooler than the previous annual fires *(104)***.**		
		
19. Red-fronted Brown Lemur The lemur *Eulemur rufifrons* occurs in moist lowland forests, montane forests and dry tropical forests in Madagascar. Populations of this species have declined due to habitat loss and fragmentation caused by deforestation fires, land clearing, and illegal logging. Hunting is also a threat. Uncontrolled fires are an ongoing threat, particularly in dry tropical forests in the western part of the species geographic range (*24*).	**20. Clanwilliam Cypress** Conifers are disproportionately threatened by changes in fire regimes. In South Africa, Clanwilliam Cypress has declined in shrubland ecosystems called fynbos that, in some areas, are subject to high fire frequency. Increases in temperature and more frequent anthropogenic fires are projected to cause further declines of this species and highlight the need for conservation interventions *(105)*.	**21. Eurasian steppe** After the collapse of the Soviet Union, 12 million ha of cropland were abandoned in the steppe zone of Kazakhstan and livestock grazing ceased across large areas of fields and grasslands. In the absence of grazing, tall grasses dominate the recovering steppe grassland and increase fire frequency and severity. Dwarf shrubs, such as *Artemisia*, are tolerant of grazing but decline when fires are too frequent or intense *(62)*.
		
22. Scots Pine Fire is expected to become more frequent and more severe under a hotter and drier climate in the boreal	**23. Dragonfly** *Asiagomphus coreanus* is a dragonfly known from a single geographic location on the Korean Peninsula. The	**24. Grasshopper communities** In high-altitude grasslands of the Western Ghats, India, planned burning is used to

forests of Siberia, which will alter species composition, forest area and carbon storage. In particular, shifts from boreal forest, dominated by Scots pine, to grass-dominated vegetation are expected *(12)*.	population occurs in a freshwater stream inside the demilitarized zone (DMZ) between South Korea and North Korea. Military forces of both countries use fire to reduce vegetation for increased visibility. Forest fires negatively impact the preferred stream habitat of *A. coreanus*, but fires cannot be extinguished due to administrative restrictions. Forest reduction is ongoing and is particularly severe around this species' habitat (*24*).	create habitat for an endangered ungulate. But uniform burning has negative effects on grasshopper communities, which prefer patchier fires that facilitate rapid population recovery. 'Patchy' burning could be used to promote both the flagship ungulate species as well as species-rich grasshopper communities *(106)*.
 **25. Orangutan** Large fires in tropical forest of Indonesia are primarily associated with land clearing for agriculture, particularly oil-palm and paper-pulp plantations, and threaten one of the world's most biodiverse ecosystems and endangered species including orangutan *(8)*.	 **26. Obligate seeding conifer** The invasive grass, Gamba *Andropogon gayanus*, was introduced to the savannas of northern Australia as food for cattle. The high biomass of this invasive grass led to a switch from low-intensity surface fires to more intense fires that burn midstorey vegetation. Successive fires of high intensity have led to the decline of the obligate seeder *Callitris intratropica* through tree mortality. In turn, the reduction in canopy cover facilitates further invasion by grass. (*107*).	 **27. Banksias** Up to 90% of native vegetation has been cleared for cereal cropping and sheep grazing in a southwest Australian biodiversity hotspot. Consequently, shrubland ecosystems comprised of *Banksia* species occur in fragmented landscapes dominated by small patches. Interactions between fragmentation, fire and a drying climate are projected to increase local extinctions of *Banksia* species, especially in small, isolated patches that cannot be colonized post-fire through dispersal. Intervals between

		fires that are either too short or too long can place *Banksia* species at risk of local extinction *(73)*.
 **28. Leadbeater's possum** Temperate Mountain Ash forests of southeastern Australia provide habitat for species-rich animal and plant assemblages. The cumulative impacts of logging and extensive wildfires have removed large trees, placing populations of arboreal mammals that nest in old trees with hollows, such as Leadbeater's Possum (*Gymnobelideus leadbeateri*), at increased risk of extinction. In addition, high temperatures and droughts associated with climate change can directly increase mortality of large, hollow-bearing Mountain Ash trees and amplify the size and frequency of wildfires *(48)*.	 **29. Southern temperate forests** Invasive plant and animal species interact with fire to slow forest regeneration and cause shifts in vegetation types in New Zealand. Humans introduced fire to temperate forests that previously experienced low fire frequency, while seed predation by invasive mammals and the reduction of avian pollination and seed dispersal halted post-fire vegetation succession. Highly-flammable invasive plants can also contribute to regime shifts via higher fire frequency and by altering plant-soil feedbacks. Temperate forest is gradually replaced by more fire-prone shrubland *(55)*.	 **30. Endemic Tasmanian pine** Populations of the pine *Athrotaxis selaginoides* collapsed following the transition from Indigenous to European fire management in temperate forests of Tasmania, Australia. The species is now restricted to topographic refugia that offer protection from more severe fires *(64)*. More recently, large fires associated with global climate change are impacting these refugia and targeted fire management is required to protect the species (*64*).

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