Department of Climate Change, Energy, the Environment and Water

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NSW GOVERNMENT

The impacts of bushfires on freshwater ecosystems

Summary of findings

January 2024

Acknowledgement of Country

The Department of Climate Change, Energy, the Environment and Water acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Introduction

Australian summers are becoming hotter and drier, and the fire season longer; with bushfires predicted to become more frequent and more intense in many parts of the country (Tran et al., 2020; IPCC, 2021). It is unlikely that widespread and severe burning similar to the 2019–2020 bushfires has occurred before, with areas that have never, or have very rarely burned, experiencing significant bushfires during this period (Black and Mooney, 2006; Mooney et al., 2011; Graves et al., 2019). The increasing occurrence of bushfires in Australia is threatening the integrity of freshwater ecosystems and the sustainability of the services they provide. Developing strategies to aid the resilience and recovery of aquatic ecosystems during and after fires is becoming increasingly important for effective river management.

As the intensity of a bushfire increases, so does the severity of its ecological impacts. Fires often occur during droughts when the moisture content of fuel loads and soils are already low, compounding the impacts on an already stressed aquatic system. Typically, high intensity fires followed by heavy rainfall events cause the most severe effects on aquatic ecosystems. These effects occur over a range of spatial (local habitat to entire catchments) and temporal (hours to decades) scales. Often the most acute impacts of fires occur within the first few weeks post-fire. The effects of bushfires may alter the water quantity, geomorphology, water quality and biodiversity of waterways.

The information from this summary has been taken from the technical report “Impacts of bushfires on aquatic ecosystems and potential management options” published by NSW DCCEEW-Surface Water Science.

Photo credit: John Lugg DCCEEW

Fire effects on water quantity

Initially following fires, the quantity of rainfall run-off into rivers is increased. This is caused by a combination of processes:

1. the fires impact on soils (for example making soils repel water rather than absorb it)
2. the loss of catchment roughness increasing the rate of runoff
3. reduced forest drawdown

This increased run-off may result in significant short-term increases (months to years) in flow (Baldwin, 2022). In the long-term (years to decades) annual streamflow may decrease by up to 25% (or 50% in extreme cases) compared to pre-fire averages. This decrease is caused by the simultaneous regrowth of forested areas, drastically increasing drawdown on river water as new growth consumes significantly more water than established plants (Cornish and Vertessy, 2001; Baldwin, 2022). This impact is variable and highly dependent on the composition of species in the vegetation community.

Photo credit: John Spencer DCCEEW

Fire effects on vegetation communities

Riparian vegetation forms the interface between terrestrial and aquatic ecosystems, influencing hydrology, geomorphology, sediments, light, temperature, organic matter, nutrients, and biota (Naiman et al., 2005).

Bushfires affect the composition, structure, and regenerative capacity of riparian vegetation. High intensity burns can result in reduced species richness, abundance, total area, seed production and canopy cover of woody riparian vegetation and a complete removal of small to medium sized vegetation and shrubs (Douglas et al., 2015). High intensity fire can also lead to tree death and the collapse of the trees, effectively removing them from the riparian zone. These changes to the structure and function of riparian vegetation affects several processes in aquatic ecosystems including alterations in hydrology, increased erosion and sedimentation, decreased water quality, and reduced habitat availability (Rice et al., 2012; Verkaik et al., 2013; Bixby et al., 2015).

Steep declines in riparian canopy cover may increase rainfall run-off and in-stream light availability. Changes to light and water quality impact in-stream primary productivity and can increase macrophytes, benthic algae growth and the likelihood of cyanobacterial blooms. The impacts of bushfires on riparian vegetation typically occur immediately following fires however can last for several years until the riparian zone has recovered.

Photo credit: John Spencer DCCEEW

Fire effects on geomorphology and erosion

Trees killed during bushfires no longer actively hold the soil together with their root systems, resulting in bank erosion and collapse. Burnt landscapes are highly sensitive to erosion, particularly during rainfall. Increased erosion and subsequent sediment deposition into waterways caused by bushfires is a major pathway for the degradation of aquatic ecosystems. Increases in post-fire erosion vary between 10 and 1000 times the pre-burnt state, with post-fire rainfall and flow pulses playing a major role in increasing erosion levels. As erosion increases, the amount of sediment mobilised by eroded landscapes greatly increases. Increased sediment leads to changes in the morphology and heterogeneity of riverbeds with sedimentation a key cause in the degradation of in-stream habitat. These changes to river form may take years to recover. Sediment slugs caused by erosion and run-off may lead to fish kills and the smothering of riverbeds and habitat as they move downstream of burnt areas, expanding the effects of a bushfire kilometres downstream of the burn.

Photo credit: John Spencer DCCEEW

Fire effects on water quality

Bushfires can severely degrade river water quality (Robinne et al., 2020). Sediment, ash and debris from burnt areas affect both the physical and chemical make-up of riverine waters. In the days to weeks following high intensity bushfires; turbidity, suspended sediments, nutrients, organic carbon, metals and ions have all been found to increase drastically, with phosphorus and nitrogen recording respective increases of 450- and 100-times pre-fire levels (Sheridan et al., 2007; Smith et al., 2011; Johnston and Maher, 2022). Dissolved oxygen, pH and salinity have all been found to reach dangerous levels following fires with in-stream anoxia being commonly reported for >12-hour periods. In the longer-term, concentration-discharge relationships for nutrients and organic carbon, in-stream phosphorus dynamics and nutrient and sediment loads have all been found to be significantly higher than long-term monthly averages and take several years to recover to pre-fire levels (Smith et al., 2011; Baldwin, 2022; Johnston and Maher, 2022). These changes to water quality may affect in-stream productivity, ecosystem processes, habitat availability and may surpass survival thresholds for biota in the river.

Photo credit: John Spencer DCCEEW

Fire effects on aquatic fauna

Riverine biodiversity is underpinned by a healthy ecosystem. Bushfires affect riverine biodiversity through several different processes; by directly causing mortality due to heat, anoxia or turbidity; indirectly through loss of habitat, food resources and physiological stress; and by a failure to successfully breed and/or recruit due to changes in breeding habitat and flow regimes (Vieira et al., 2004; Rodríguez-Lozano et al., 2015; Dahm et al., 2015; Sherson et al., 2015). Adverse water quality caused by ash, sediment and contaminants from fires have been found to cause steep declines in benthic macroinvertebrate abundance (Vieira et al., 2004) and mass fish kills through anoxia and turbidity (Da Silva et al., 2020). Fish populations in burnt reaches have been found to decline by 90-100% with fish stocks taking up to 3 years to recover (Lyon and O'Connor, 2008; Serena et al., 2022). Severe impacts to the growth, reproduction and death rates of aquatic biota have also been attributed to the combined effects of sedimentation and poor water quality post-fire (McInerney et al., 2020).

Semi-terrestrial animals such as platypus and turtles may be more resilient to bushfires due to their ability to avoid anoxic conditions and potentially move to areas of better water quality. However, loss of food resources such as macroinvertebrates and sediments smothering habitat may still lead to significant negative impacts to platypus and turtle populations including mortality of individuals. The response of frog populations to bushfires is highly species dependent, however, abundance, metacommunity occupancy and species richness have all been found to decline following severe bushfires (Hossack and Pilliod, 2011; Beranek et al., 2023), with local extinction events also recorded (Lemckert, 2000). Changes to the availability of shelter, breeding habitat and the number of refuges in-stream or in riparian vegetation may also cause lagged declines in frog populations (Hossack et al., 2013).

Photo credit: Ian Dicker DCCEEW

Management options

As large-scale fire events often occur during dry or drought conditions, they typically coincide with periods when water resources are already under stress. Understanding how wildfire may exacerbate the effect of drought on water availability is critical for planning and setting long-term strategies for river management. How to manage water to best protect and rehabilitate ecosystems while still balancing water for human consumption requires further research and understanding. Management options addressing post-fire conditions in water sharing plans should:

- Manage for long-term changes to flow regimes, affecting water availability for the environment and stakeholders.
- Reduce pre-existing ecological stress on waterways during drought conditions leading to wildfires. For example, ensure water quality and productivity are appropriate for fish dispersal and growth during drought conditions.
- Manage or reduce the impacts of increased frequency, size and intensity of wildfires through healthy riparian buffers.
- Increase the resilience of riparian buffer zones from fire via the provision of appropriate low flow access rules that prolong lateral and longitudinal hydrologic connectivity.
- Enable flows that flush sediment from and enhance the water quality of important refuges.
- Maintain longitudinal connectivity to allow fish passage away from impacted environments.
- Incorporate bushfire risk for identified locations into risk assessments.

Photo credit: John Spencer DCCEEW

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