

# Did the Black Summer bushfires turn up the heat on platypus populations?

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## Key Points

- The 2019/20 Black Summer bushfires affected over 13% of total platypus habitat across Australia.
- We investigated the impacts of the fires at a landscape scale with eDNA using a rigorous before-after-impact-control design.
- We found a significant impact of the fires on occupancy of platypuses with a 14-18% decline in fire affected sites compared to control sites.

## Abstract

Devastating bushfires ravaged south eastern Australia during the 2019/20 summer with over 11 million hectares burnt including 13.6% of total platypus habitat in Australia. The affected area was previously considered a stronghold for the iconic platypus – a species under ongoing threats in other parts of its range from drought, altered flow regimes, and habitat destruction. However, little empirical data exists on the impacts of bushfires on platypuses with previous studies hampered by a lack of rigorous pre-fire data.

This project used environmental DNA (eDNA) sampling to quantify the impacts of the bushfires on platypuses for the first time using a rigorous before-after-control-impact (BACI) design and generalised linear mixed models (GLMM). Water samples for eDNA analysis were collected from 142 sites before and after the fires, including recruiting local citizen scientists to circumvent Covid travel restrictions.

Site occupancy was high in both treatment groups before the fires, highlighting the health of platypus populations in the area. Prior to the bushfires, platypuses were detected at 40 of the 48 sites (83%) within the fire extent. After the fires, this decreased to 33 out of the 48 sites (69%), a decline of 14%. In comparison, of the 94 control sites, platypuses were detected at 68 sites prior to the bushfires (70%), and 70 after (75%). The estimated decline was slightly higher (18%) when data was restricted to native vegetation classes only. The GLMM estimated a significant negative impact of bushfires on platypus presence, when the dataset was restricted to native vegetation classes.

## Keywords

Platypus, bushfires, environmental DNA, before-after-control-impact design, GLMM models, site occupancy.

## Introduction

The Black Summer bushfires that devastated south eastern Australia during late 2019 and early 2020 burnt over 11 million hectares with an estimated 3 billion animals killed or affected (WWF Australia 2020). While much of the media attention was focused on terrestrial species such as the koala, aquatic species like the platypus

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may also have been severely impacted. Although aquatic species may be somewhat buffered from the immediate impacts, bushfires can have significant short- and long-term impacts of aquatic ecosystems. Smaller waterways may completely vaporise during the fires, while subsequent runoff of sediment and ash from the surrounding catchment that has been stripped of vegetation, is expected to degrade waterways for an extended period. Mass fish die-offs and local extirpation of fish species have been recorded following bushfires, attributed due to large sediment slugs and resultant low dissolved oxygen levels (Lyon and O'Connor 2008; Rinne 2003). Aquatic macroinvertebrates, the primary food source for platypuses (McLachlan-Troup *et al.* 2010; Marchant and Grant 2015), are also known to be significantly impacted by bushfires with an overall reduction in abundance and diversity (Vieira *et al.* 2004; Verkaik *et al.* 2014, 2015). However, little empirical data exists on the impacts of bushfires on platypuses populations and the consequences of the recent bushfires on their conservation status (Bino *et al.* 2020).

Platypus populations across their range are under stress from land use changes in the surrounding catchment, clearing riparian vegetation, drought, water diversion and impoundment altering flow regimes, and poor water quality with major threats expected to increase due to climate change and growing human population (Grant and Temple-Smith 2003; Bino *et al.* 2019, 2020). There is mounting evidence of population declines and localised extinctions across their range, particularly in urban and agricultural landscapes (Grant 1992, 1993, 1998; Lintermans 1998; Lunney *et al.* 1998, 2004; Rohweder and Baverstock 1999; Serena and Williams 2004; Griffiths and Weeks 2018; Griffiths *et al.* 2019; Serena and Williams 2011; Serena *et al.* 2002; Griffiths *et al.* 2020; Serena *et al.* 2014; Williams 2010). However, bushfires have not previously been considered a major threat to platypus populations. Previous research of the impacts of bushfires on platypuses has been hampered by availability of systematic pre-fire data at a local or landscape scale. Here, we leveraged extensive pre-fire baseline data collected during 2018-19, to provide a comparison of platypus occupancy before and after the 2019/20 bushfires using a rigorous before-after-control-impact (BACI) design to quantify the impacts of bushfire on platypus populations at a landscape scale for the first time.

## Methods

The distribution of platypuses throughout the study area was spatially mapped using environmental DNA (eDNA). Environmental DNA can be a highly sensitive and cost-effective method of determining platypus presence over large spatial scales by detecting traces of genetic material in the water (Lugg *et al.* 2018). Sampling sites for the original project used for pre-fire data were originally selected through a hierarchical stratified random design to evaluate the impacts of major threatening processes such as land use, changes to flow regimes, and riparian vegetation. To assess the impacts of the 2019/20 bushfires, we re-surveyed these sites from March to October 2020 in both fire-affected (impact) and unburnt (control) areas where existing pre-fire eDNA data was available using a before-after-control-impact (BACI) design. BACI sampling designs are robust and statistically powerful to isolate impact effects from natural variability (Chevalier *et al.* 2019). Both pre- and post-fire sites were surveyed on a single occasion.

At each site, water samples were collected in duplicate by passing 140 – 500 ml (average 267 ml) through a 0.22 µm filter (Sterivex) on site using a sterile syringe. Filtering on site reduces DNA degradation that may occur during transport of water (Yamanaka *et al.* 2016). Clean sampling protocols were employed to minimise contamination including new sampling equipment at each site, not entering water, and taking care not to transfer soil, water or vegetation between sites. Filters were stored out of sunlight and refrigerated or on ice before being transported to the laboratory for processing.

DNA was extracted from the filters using a commercially available DNA extraction kit (Qiagen DNeasy Blood and Tissue Kit). A platypus specific probe targeting a 57 base-pair sequence of the mitochondrial cytochrome b (CytB) gene (Lugg et al. 2018) was used to screen all samples for the presence of platypus DNA. Real-time quantitative Polymerase Chain Reaction (qPCR) TaqMan® assays were used to amplify and quantify the target DNA. Assays were performed in triplicate on each sample. Positive and negative controls were included for all assays as well as an Internal Positive Control (IPC) to detect inhibition (Goldberg et al. 2016). There was no evidence of sample contamination from field or laboratory procedures with all controls returning a negative result, indicating sampling and analysis protocols were robust.

The fire affected area was defined using the National Indicative Aggregated Fire Extent Dataset (NIAFED) with a 5 km buffer to take into account the potential effects beyond the fire extent. Sites which were located within this fire extent were classified as “impact”. Sites outside of the extent were “control”. To reduce potentially confounding effects of vegetation type, the analysis restricted both control and impact sites to the VAST (Vegetation Assets, States and Transitions) native vegetation classes — classifications 0 to 3 — as most of the fire impacted sites were within these classes.

To investigate how occupancy of platypuses has changed as a result of the 2019/20 bushfires in the short term, we used a before-after, control-impact analysis. We used generalised linear mixed models (GLMM) to quantify the influence of before/after, control/impact and the interaction between these factors, on the detection of platypuses. The response data took the form of binary detection/non-detection (0/1) where a detection of platypus DNA in any of the qPCRs in a sample, at a site, would class that site as positive for that visit. We fitted binomial GLMM's using the package “glmer”. The model had 3 fixed effects: Period, Site Class and Period:Site Class (the interaction)(Pardini *et al.* 2018). Site was included as a random effect. Model residuals were analysed using the “DHARMA” package. Analysis of the simulated model residuals indicated good model fit. We extracted model coefficients for the predictor variables and explored the relationship between detection and a predictor variable by considering the size and uncertainty (95% confidence intervals) of model coefficients. We also investigated the relationship between before/after and control/impact using the GLMM to predict the probability of a presence at a site.

## **Results**

A total of 142 sites were sampled in both the pre-fire (2018/19) and post-fire period (2020). Forty-eight of these sites were within the fire extent of the National Indicative Aggregated Fire Extent Dataset (NIAFED). Prior to the 2019/20 bushfires, platypuses were detected at 40 of the 48 sites (83%) within the fire extent (Figure 1). After the fires, this decreased to 33 out of the 48 sites (69%), a decline of 14% (Figure 2). In comparison, of the 94 control sites, platypuses were detected at 68 sites prior to the bushfires (70%), and 70 after (75%). The estimated decline was slightly higher (18%) when data was restricted to native vegetation classes only.

The model coefficients from the GLMM's indicated a negative effect of “impact” compared to “control”, with a significant interaction term of the time period (Before/After) and the site class (Control/Impact). This suggests there are significant differences between the groups (Control/Impact) over time (Before/After) corresponding with the observed trend of lower detections in the After/Impact group. Using predictions from the GLMM, a significant difference was detected between control and impact sites after fire when the data was restricted to VAST native vegetation classes as indicated by non-overlapping 95% credible intervals (Figure 3).

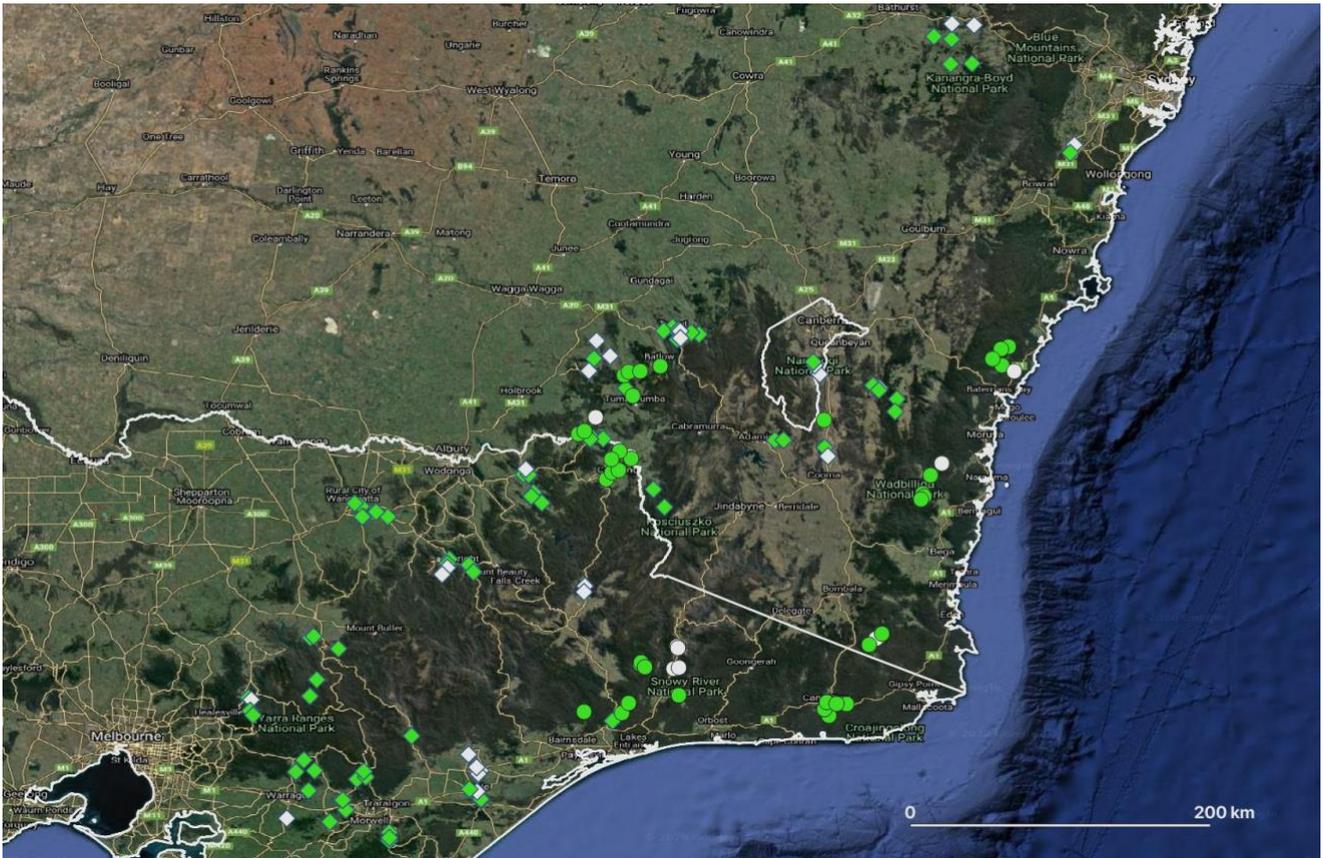


Figure 1. Occurrence of platypuses at control (diamonds) and impact sites (circles) before the 2019/20 fires. Green = detected; Grey = not detected.

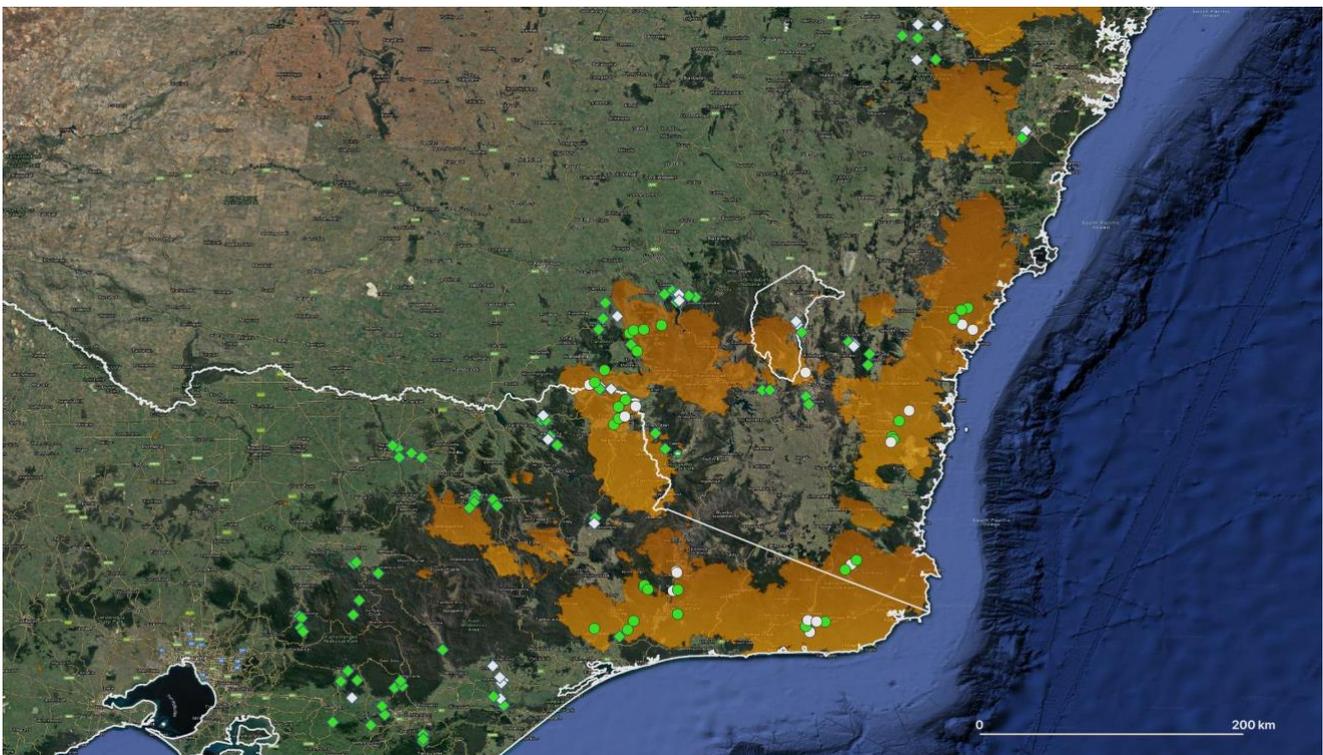
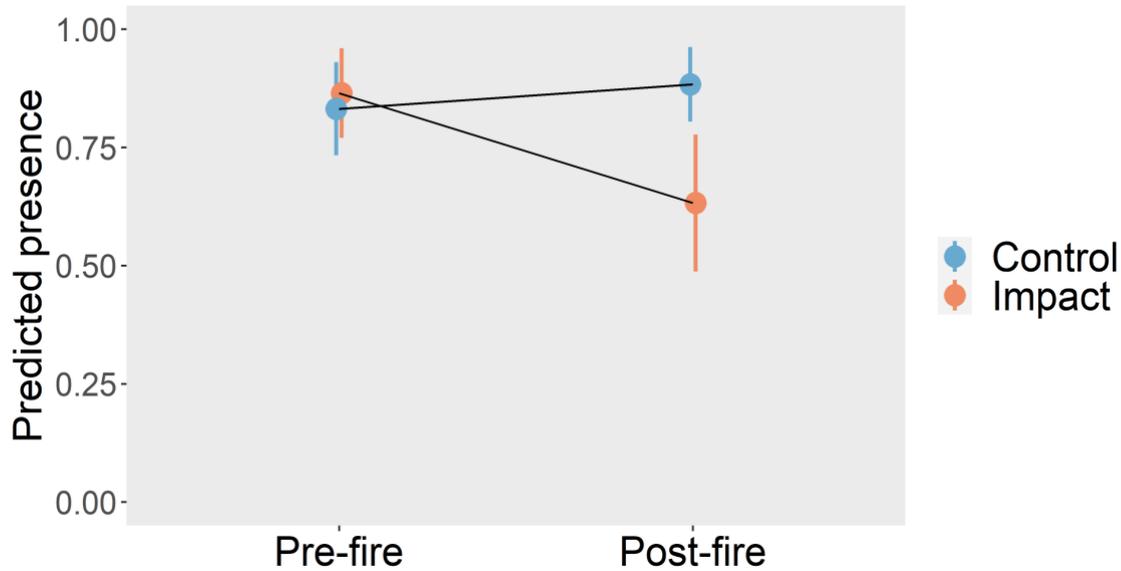


Figure 2. Occurrence of platypuses control (diamonds) and impact sites (circles) after the 2019/20 fires. Green = detected; Grey = not detected.



**Figure 3. Predicted probability of platypus presence from the GLMM. Dots represent means and vertical lines represent 95% confidence intervals. Data restricted to native vegetation categories 0-3 of the VAST dataset. 5 km buffer of fire extent used.**

## Discussion

The area impacted by the 2019/20 bushfires appeared to support relatively healthy platypus populations before the fires with over 80% estimated site occupancy based on recent surveys using environmental DNA. Raw data from pre- and post-fire eDNA surveys have indicated a decline of 14-18% in occupancy of platypuses in fire affected areas compared to unburnt control sites in the 9 months after the bushfires. Analysis of the data using a generalized linear mixed model using data restricted to VAST native vegetation classes only, predicted a significant decline in the probability of platypus presence at fire impacted sites compared to control sites. Difficulties in site access due to road closures and then travel restrictions and border closures caused by Covid-19 severely limited field sampling during 2020. Further sampling during 2021 will enable more rigorous analysis and assessment of longer-term impacts.

The potential impacts of bushfires on platypus populations are likely to be complex and varied. Direct impacts from heat and reduction in surface water may cause mortality or forced migration of platypuses and exacerbate predation pressure, particularly in smaller waterways. Mass dispersal from fire-affected areas may place additional stress on populations in surrounding areas that don't have the resources to support additional animals, exacerbating intra-species competition.

The largest and most widespread impacts are expected to be indirect effects including degradation of instream habitat from high volumes of ash and sediment entering the waterway resulting in a reduction in food resources (Vieira *et al.* 2004; Verkaik *et al.* 2014, 2015). Platypuses may be better equipped to cope with altered food resources than some species due to their generalist diet (McLachlan-Troup *et al.* 2010; Marchant and Grant 2015; Klamt *et al.* 2016), allowing them to exploit a variety of prey depending on availability. However, a decrease in overall food resources will lead to reduced carrying capacity of affected waterways and longer-term mortality or migration from starvation. Such impacts may extend well beyond the burnt areas as ash and sediment is transported downstream. The timing and intensity of rainfall events following bushfires, as well as speed of vegetation regrowth, are likely to be significant factors governing the severity, extent, and duration of post-fire impacts on aquatic ecosystems.

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Given that fire-affected aquatic systems may take years to recover (Lyon and O'Connor 2008; Minshall 2003; Malison and Baxter 2010) the impacts from these devastating bushfires may be felt by platypus populations for some time. In areas where platypuses still occur there may still be declines in abundance so the decline in occupancy identified here may not fully represent the true impacts of these bushfires. In addition, there may be longer term impacts of further declines or reduction in reproduction. Many mammals will halt or delay reproduction in times of nutritional stress and several long-term monitoring programs have revealed reproductive output was lower in platypus populations during the Millennium Drought (Griffiths *et al.* 2016; Griffiths and Weeks 2017). Conversely, some areas may see rapid recolonization if conditions improve and platypuses persist in nearby, hydrologically connected refuge areas. Further monitoring planned for 2021 will help to assess these outcomes.

The 2019/20 bushfire affected a significant amount of the best remaining platypus habitat in south eastern Australia. Research undertaken immediately before the bushfires revealed the affected area to be a stronghold for platypuses with high occupancy compared to other areas of Victoria and southern NSW (cesar unpublished data). It has been estimated that 13.6% of available platypus habitat across their entire range was impacted during the 2019-20 bushfires (UNSW unpublished data). An estimated 14-18% decline in platypuses throughout fire affected areas would equate to a loss of 1.9-2.4% of Australia's entire platypus population in a single catastrophic event. This is not only significant for platypuses at a local and regional scale but would have consequences for their national conservation status.

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## References

- Bino G., Kingsford R. T., Archer M. *et al.* (2019) The platypus: evolutionary history, biology, and an uncertain future. *J. Mammal.* **100**, 308–327.
- Bino G., Kingsford R. T. & Wintle B. A. (2020) A stitch in time – Synergistic impacts to platypus metapopulation extinction risk. *Biol. Conserv.* **242**, 108399. [online].
- Chevalier M., Russell J. C. & Knappe J. (2019) New measures for evaluation of environmental perturbations using Before-After-Control-Impact analyses. *Ecol. Appl.* **29**, e01838.
- Goldberg C. S., Turner C. R., Deiner K. *et al.* (2016) Critical considerations for the application of environmental DNA methods to detect aquatic species. *Methods Ecol. Evol.* **7**, 1299–1307.
- Grant T. R. (1992) Historical and current distribution of the platypus, *Ornithorhynchus anatinus*, in Australia. In: *Platypus and Echidnas* (ed M. L. Augee) pp. 232–254 Royal Zoological Society of New South Wales.
- Grant T. R. (1993) The past and present freshwater fishery in New South Wales and the distribution and status of the platypus *Ornithorhynchus anatinus*. *Aust. Zool.* **29**, 105–113.
- Grant T. R. (1998) Current and historical occurrence of platypuses, *Ornithorhynchus anatinus*, around Sydney. *Aust. Mammal.*

## Full Paper

Griffiths et.al. – Impact of bushfires on platypuses

Grant T. R. & Temple-Smith P. D. (2003) Conservation of the platypus, *Ornithorhynchus anatinus*: Threats and challenges. *Aquat. Ecosyst. Heal. Manag.* **6** , 5–18.

Griffiths J., Maino J., Tingley R. & Weeks A. (2020) *Distribution and relative abundance of platypuses in the greater Melbourne area: survey results 2018-20 (Report for Melbourne Water)*. Parkville, VIC.

Griffiths J., Maino J. & Weeks A. (2019) *Identifying key flow variables and quantifying their impact on platypus populations (Report to Melbourne Water)*. cesar, Parkville, VIC.

Griffiths J., Van Rooyen A. & Weeks A. (2016) *Platypus distribution and relative abundance in the MacKenzie River and upper Wimmera 2016 (Report to Wimmera CMA)*. cesar, Parkville, VIC.

Griffiths J. & Weeks A. (2017) *Distribution and relative abundance of platypuses in the greater Melbourne area: survey results 2016/17. (Report to Melbourne Water)*. cesar, Parkville.

Griffiths J. & Weeks A. (2018) *Investigating the current distribution of platypuses, rakali, and blackfish in the upper Wimmera region (Report to Project Platypus)*. EnviroDNA, Parkville, VIC.

Klamt M., Davis J. A., Thompson R. M., Marchant R. & Grant T. R. (2016) Trophic relationships of the platypus: Insights from stable isotope and cheek pouch dietary analyses. *Mar. Freshw. Res.* **67** , 1196–1204.

Lintermans M. (1998) The status and distribution of the platypus (*Ornithorhynchus anatinus*) in the Australian Capital Territory with notes on some localised declines. *Aust. Mammal.*

Lugg W. H., Griffiths J., van Rooyen A. R., Weeks A. R. & Tingley R. (2018) Optimal survey designs for environmental DNA sampling. *Methods Ecol. Evol.* **9** , 1049–1059.

Lunney D., Grant T. & Matthews A. (2004) Distribution of the platypus in the Bellinger catchment from community knowledge and field survey and its relationship to river disturbance. *Proc. Linn. Soc. New South Wales*. [online].

Lunney D., Grant T., Matthews A., Esson C., Moon C. & Ellis M. (1998) Determining the distribution of the platypus (*Ornithorhynchus anatinus*) in the Eden region of south-eastern New South Wales through community-based surveys. *Aust. Mammal.* [online].

Lyon J. P. & O'Connor J. P. (2008) Smoke on the water: Can riverine fish populations recover following a catastrophic fire-related sediment slug? *Austral Ecol.* **33** , 794–806.

Malison R. L. & Baxter C. V (2010) Effects of wildfire of varying severity on benthic stream insect assemblages and emergence. *J. North Am. Benthol. Soc.* **29** , 1324–1338. [online].

Marchant R. & Grant T. R. (2015) The productivity of the macroinvertebrate prey of the platypus in the upper Shoalhaven River, New South Wales. *Mar. Freshw. Res.* **66** , 1128–1137.

McLachlan-Troup T. A., Dickman C. R. & Grant T. R. (2010) Diet and dietary selectivity of the platypus in relation to season, sex and macroinvertebrate assemblages. *J. Zool.* **280** , 237–246.

Minshall G. W. (2003) Responses of stream benthic macrovertebrates to fire. *For. Ecol. Manage.* doi: 10.1016/S0378-1127(03)00059-8.

## Full Paper

### Griffiths et.al. – Impact of bushfires on platypuses

Pardini E. A., Parsons L. S., Ştefan V. & Knight T. M. (2018) GLMM BACI environmental impact analysis shows coastal dune restoration reduces seed predation on an endangered plant. *Restor. Ecol.*

Rinne J. N. (2003) Flows, fishes, foreigners, and fires: relative impacts on Southwestern native fishes. *Hydrol. Water Resour. Southwest.*

Rohweder D. A. & Baverstock P. R. (1999) Distribution of platypus *Ornithorhynchus anatinus* in the Richmond river catchment, northern New South Wales. *Aust. Zool.* **31** , 30–37.

Serena M. & Williams G. A. (2004) Progress report : an experimental reintroduction of platypus (*Ornithorhynchus anatinus*) to Cardinia Creek April-June 2004 ). Australian Platypus Conservancy, Wiseleigh.

Serena M. & Williams G. A. (2011) *Distribution and status of platypus in the Gunbower Creek system. (Report to North Central Catchment Authority)*. Australian Platypus Conservancy, Wiseleigh.

Serena M., Williams G. A. & Johnston L. D. (2002) *Status of platypus in the Curdies River catchment: live-trapping and local sightings, summer 2002. (Report to Corangamite Catchment Management Authority)*. Australian Platypus Conservancy, Whittlesea.

Serena M., Williams G. A., Weeks A. R. & Griffiths J. (2014) Variation in platypus (*Ornithorhynchus anatinus*) life-history attributes and population trajectories in urban streams. *Aust. J. Zool.* **62** , 223–234.

Verkaik I., Prat N., Rieradevall M. & Reich P. (2014) Effects of bushfire on macroinvertebrate communities in south-east Australian streams affected by a megadrought. *Mar. Freshw. Res.* doi: 10.1071/MF13039.

Verkaik I., Vila-Escale M., Rieradevall M. et al. (2015) Stream macroinvertebrate community responses to fire: Are they the same in different fire-prone biogeographic regions? *Freshw. Sci.* doi: 10.1086/683370.

Vieira N. K. M., Clements W. H., Guevara L. S. & Jacobs B. F. (2004) Resistance and resilience of stream insect communities to repeated hydrologic disturbances after a wildfire. *Freshw. Biol.* **49** , 1243–1259. [online].

Williams G. A. (2010) *Results of a platypus live-trapping survey along Coliban River, Malmsbury, October 2010. (Report to North Central Catchment Management Authority)*. Australian Platypus Conservancy, Wiseleigh.

WWF Australia (2020) *Australia's 2019-2020 Bushfires: The Wildlife Toll - Interim Report*.

Yamanaka H., Motozawa H., Tsuji S., Miyazawa R. C., Takahara T. & Minamoto T. (2016) On-site filtration of water samples for environmental DNA analysis to avoid DNA degradation during transportation. *Ecol. Res.* **31** , 963–967.