Science for Saving Species

Research findings factsheet

Project 8.1.2

Threatened Species Recovery Hub

National Environmental Science Programme

The power of monitoring to detect recovery of species after the 2019–20 megafires in Australia

In brief

Large-scale disturbances such as megafire play a critical role around the world in influencing biodiversity. Monitoring is crucial for understanding how species are immediately impacted by, and then respond to, such events. However, monitoring programs should be designed to have a high chance at detecting impacts and recovery, should they occur (i.e. high statistical power).

We combined species distribution models for 119 vertebrate species which were badly impacted by the 2019-20 Black Summer fires with remotely sensed fire severity maps from those fires. We simulated a range of plausible recoveries in occupancy to pre-fire levels, and combined them with estimates of detectability, and simulated monitoring at sites to evaluate the statistical power of alternative monitoring designs. We tested the performance of budget scenarios from $1M – $100M over 10 years.

Across all species and taxonomic groups, power to detect recoveries in occupancy increased as the expected magnitude of recovery increased. A total monitoring budget of $1M over 10 years resulted in very low power, even under the most optimistic rates of recovery. However, power increased as the total monitoring budget increased. A $10M budget could detect 50% of recoveries in 24% of species with greater than 80% power. This increased to 47%, 71%, 76% and 79% as total budgets increased to $25M, $50M, $75M and $100M, respectively. Our results can inform the design of monitoring programs designed to detect responses of species to megafires and other catastrophic disturbances.

Bush fire, Australia.
Image: Stephen Mitchell, Flickr, CC BY-NC-ND 2.0

Background

Large-scale disturbances, such as megafires, flooding, cyclones and drought, play a critical role around the world in influencing biodiversity. While large-scale disturbances no doubt result in the direct mortality of individuals, other immediate impacts on species and how species respond over time are poorly understood for most species. Monitoring is crucial for quantifying the impact of catastrophic events, for measuring the recovery of populations over time and for measuring management effectiveness. Sufficient conservation resources need to be allocated to monitoring to be able detect both impact and recovery.

The 2019–20 megafires in southern and eastern Australia severely impacted populations of threatened species and ecological communities. An estimated three billion vertebrates were directly affected by the fires, with many more likely to perish well after the fire event. Concern is widespread that the unprecedented size and severity of the fires may have pushed many species to the brink of extinction. It is therefore crucial that management interventions are directed towards species and communities most affected by the fires, and that rigorous, cost-effective monitoring programs are conducted to track the recovery (or lack thereof) of populations and communities over the medium-to-long term.

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LEFT: New plant growth after the Black Saturday fires in Victoria in 2009.
Image: Greenfleet Australia, CC BY-NC-ND 2.0

Background (continued)

A strategic approach is needed to design rigorous, cost-effective monitoring programs. Simulating monitoring in a virtual landscape ahead of time is a powerful way to assess and compare the likely performance of alternative monitoring design scenarios. Simulation is also a useful tool for estimating whether monitoring has sufficient statistical power to detect trends in populations should they recover. Insufficient investment in post-fire monitoring can result in false conclusions about impact and recovery which can result in a misallocation of management resources and prevent further understanding of how species respond to large-scale disturbances.

Main aims of the research

We aimed to use spatial optimisation and simulation tools to explore where and how much monitoring effort is needed after the 2019–20 megafires in Australia to detect the recovery of populations of 119 priority species over the next 10 years. We also aimed to identify which of the 119 priority species are most likely to be detected during large-scale, continental-wide occupancy monitoring programs.

What we did

We focused our research on 119 vertebrate species considered by experts to be most affected by the fires. We obtained species distribution models for each species from a recent study we led. This encompassed 24 reptiles, 37 frogs, 16 birds, 32 mammals and 10 bats.

We obtained a fire severity layer for the 2019–20 megafires from the Australian Government's National Indicative Aggregated Fire Extent Dataset at 40 m resolution (Figure 1). We created a 5 km buffer around the fire footprint and collapsed the five fire severity classes into two: burnt (fire classes 2 – 5) and unburnt (buffer and fire class 1). We combined the spatial distribution models in a spatial prioritisation tool called Zonation to identify areas with the highest pre-fire habitat suitability for post-fire monitoring, in and around the fire footprint.

We consulted experts and searched the published and grey literature to collate the most appropriate sampling method(s) for each of the 119 priority species. In total, we listed 24 different sampling methods across the four different taxonomic groups.

We searched the literature for estimates of detection probabilities for one unit of effort for each sampling method. We also estimated the cost of surveying any given arrangement of monitoring sites throughout the landscape given travel time, equipment costs, personnel costs and the frequency and intensity of sampling.

We simulated the immediate impact of the 2019–20 megafires on habitat suitability for each species and modelled a range of plausible recoveries in occupancy to pre-fire levels over the next 10 years. Because we do not know what the rate of recovery will be for most species, we tested a range of plausible rates ranging from 10% to 90% of pre-fire levels. We simulated alternative monitoring designs for a range of monitoring scenarios to explore the impact of design decisions on power to detect population recoveries. In all cases, we assumed a "control-impact" monitoring design, where sites were paired in burnt and unburnt habitat. We tested the performance of six budget scenarios ranging from $1M– $100M over a 10-year monitoring period.

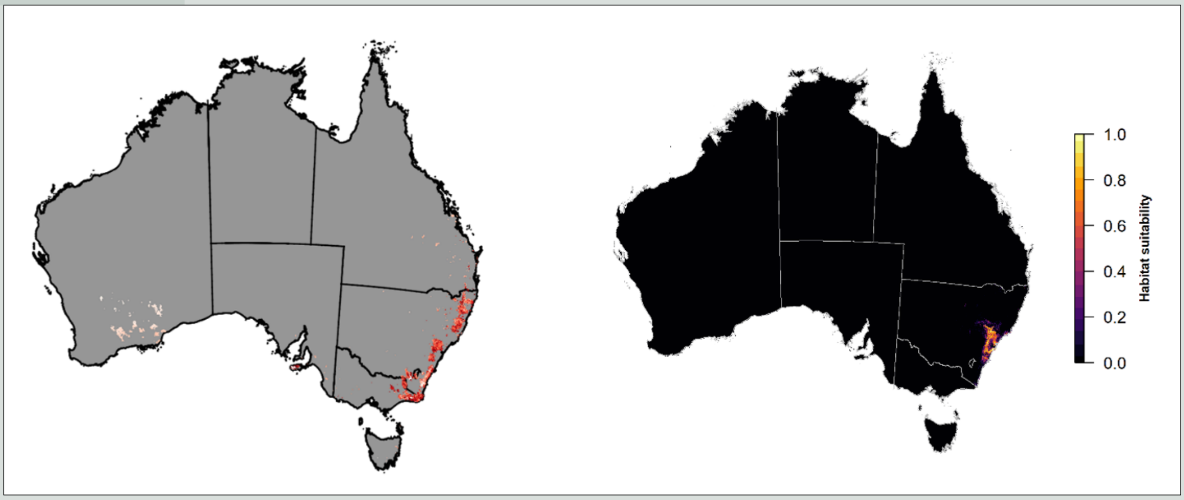

Figure 1: *The extent of the 2019–20 megafires in Australia (left) with red shading indicating fire severity, and an example of a species distribution used in the simulations for the rockwarbler (Origma solitaria) (right).*

Key findings

Across all species and taxonomic groups, the statistical power of detecting change in occupancy increased as the expected magnitude of recovery increased. For example, there was an 66% chance of detecting a 50% recovery in the Blue Mountains tree frog (*Litoria citropa*) when the total budget across all species was $10M. However, power increased to 80% and 88% under this budget scenario when we assumed a 70% and 90% recovery, respectively, over 10 years.

Our results suggest that a total monitoring budget of $1M distributed across all 119 species over 10 years was not sufficient to be reasonably confident in detecting population recoveries (>80% chance of detecting the change), even under a very optimistic rate of recovery of 90% (Figure 2). This is not surprising, given that a $1M monitoring budget over 10 years for 119 species results in only $8403 per species. However, power increased as the total monitoring budget increased. A $10M budget could detect 50% of recoveries in 24% of species with more than 80% power. This increased to 47%, 71%, 76% and 79% as total budgets increased to $25M, $50M, $75M and $100M, respectively.

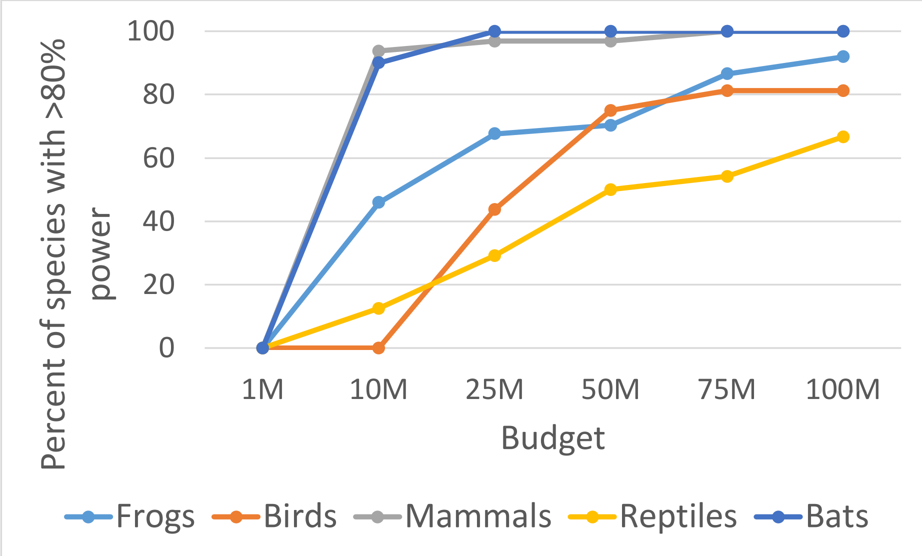

Figure 2: *The percentage of species in each group with greater than 80% statistical power to detect 90% of recovery to pre-fire levels over 10 years across a range of fixed budgets.*

Across all budgets and recovery rates, power was lowest for birds and reptiles and generally highest for mammals and bats. For example, under a $25M budget and a 90% recovery rate scenario, power to detect population recoveries exceeded 80% for all bats, 97% for all mammals, 68% for all frogs, 44% for all birds and 29% for all reptiles. The higher statistical power to detect recovery in mammals and bats was partly because they had a high proportion of species with widespread distributions, and due to the survey methods (such as motion triggered cameras) and the survey effort assigned to each site. For example, motion triggered cameras are relatively cheap to deploy and can monitor for long periods of time, increasing power to detect mammal recoveries.

The statistical power remained very low for a subset of species regardless of the budget or recovery rate. These species were generally either highly range-restricted, widespread but with very low pre-fire occupancy levels, difficult to detect and/or had few effective sampling methods, or were expensive to survey, which reduced the number of monitoring sites.

For example, the power to detect population recoveries of the rufous scrub-bird (*Atrichornis rufescens*) did not exceed 0.23 across any budget scenarios. Similarly, power to detect the recovery of the three-toed snake-toothed skink (*Coeranoscincus reticulatus*) was never greater than 0.26.

Rockwarbler, Morton National Park, NSW.
Image: David Cook, Flickr, CC BY-NC 2.0

Implications

Burnt coastal woodlands, Yamba, NSW. Image: Tatters Flickr CC BY-SA 2.0

Designing multi-species landscape-scale monitoring programs requires a series of complex decisions. When monitoring whether and how species recover from large-scale disturbances, there are trade-offs in decisions regarding the method(s) deployed, the number of repeat surveys for a given method, the years in which sites are to be monitored, and the total number and location of long-term monitoring sites established to detect changes in a species occupancy levels. These questions are further complicated by limited resources available for long-term monitoring.

We have demonstrated a simulation framework for evaluating alternative monitoring scenarios for a realistically complex nationwide monitoring program to estimate the total cost required to detect likely population recoveries over 10 years. Changes in the total available budget and the recovery rate of populations both influenced the statistical power to detect impact and change in species occupancy over time.

The statistical power was low for a subset of species with highly restricted ranges regardless of the recovery rate and budget. Our framework assumes recovery is measured only in terms of occupancy and does not yet accommodate changes in abundance or density. These species are probably better suited to monitoring programs that focus on abundance and/or density. The power to detect recoveries in abundance or density will be much higher with fewer sites, but it can be more difficult and expensive to measure. We therefore recommend that practitioners give careful consideration to whether occupancy or abundance/density is measured at long-term post-fire monitoring sites and that the likely distribution of the target species is considered.

Cited material

Southwell, D., Smart, A. & Wintle, B. (2021) Power to detect species recoveries after the 2019–20 megafires under a range of budget scenarios. NESP Threatened Species Recovery Hub Project 8.1.2 report, Brisbane.

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Further Information

Darren Southwell - darren.southwell@unimelb.edu.au

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Cite this publication as NESP Threatened Species Recovery Hub. 2021. The power of monitoring to detect recovery of species after the 2019–20 megafires in Australia, Project 8.1.2 Research findings factsheet.

This project is supported through funding from the Australian Government's National Environmental Science Program.