Threatened Species Recovery Hub

National Environmental Science Programme

Post-fire changes in feral cat density across burnt and unburnt landscapes, Kangaroo Island

Rosie Hohnen (John Woinarski, Sarah Legge, Chris Dickman, Brett Murphy)

April 2021

Charles Darwin University Australia
The University Of Queensland Australia
Australian National University
The University of Sydney
Landscape South Australia Kangaroo Island
Government of South Australia
Department for Environment and Water

Cite this publication as: Hohnen, R., Woinarski. J., Legge, S., Dickman, C., Murphy, B. 2021. *Post-fire changes in feral cat density across burnt and unburnt landscapes, Kangaroo Island*. NESP Threatened Species Recovery Hub Project 8.4.1 report, Brisbane.

Cover image: Almost 50% of Kangaroo Island burnt in the wildfires of 20 December 2019 to 6 February 2020. Image: Rosemary Hohnen

Contents

Executive summary

The impacts of wildfire upon biodiversity can be compounded by other factors. There is some evidence that feral cats *Felis catus* may move to, or occur in increased abundance in, recently burnt areas. As such, wildlife that have survived fire may be at increased predation risk, in part because the burnt landscape offers less shelter from predation. However, the response by cats may depend upon the severity and scale of fire: the only previous study of the impacts of a severe wildfire in temperate Australia found that cat abundance declined substantially in burnt areas.

Consistent with the previous study of cat responses to severe wildfire, we found that cat abundance declined markedly in burnt sites, but showed no consistent change in sites that were unburnt. In contrast, changes in the abundance of the common brush-tailed possum *Trichosurus vulpecula* showed a less consistent pattern, although this species declined markedly (at a rate comparable to that shown by cats) at two severely burnt sites.

Although we found that cat density was reduced in burnt areas, the likely reduced populations of many native species in burnt areas, and the fire-caused reduction in vegetation cover, may mean that predation rates are no less post-fire than pre-fire, and if the population sizes of native species have been substantially depleted by fire, even small numbers of predation events may jeopardise persistence and recovery. Management that reduces predation pressure on wildlife surviving severe wildfires is likely to enhance the likelihood of their persistence and recovery.

Introduction

Fire can have detrimental impacts on threatened species, with the extent of such impacts generally increasing with the extent and severity of the fire. The impacts of fire may also be compounded by interactive factors, and the recovery of populations post-fire may be compromised by threats that affect individuals that survived the fire. As a consequence, managers can influence the extent and pace of post-fire recovery by attempting to control these compounding threats (Hradsky 2020; Legge *et al.* in review).

In northern Australia, there is now a substantial research body that has demonstrated that feral cats *Felis catus* are attracted to recently burnt areas and exert high predation pressure on surviving mammals, presumably because such recently burnt areas offer little cover for prey species (McGregor *et al.* 2014; McGregor *et al.* 2015; Leahy *et al.* 2016; McGregor *et al.* 2016; McGregor *et al.* 2017). There is less information for temperate Australia on the responses of feral cats to fire, and the extent to which introduced predators may compound fire impacts. Hradsky *et al.* (2017) reported a 5-fold increase in the occurrence of invasive predators (feral cats and red foxes *Vulpes vulpes*) following a prescribed fire in a forest environment in Victoria. In contrast, following an extensive and severe wildfire in a mixed forest, woodland and heathland environment in south-eastern New South Wales, the abundance of feral cats declined substantially (from an abundance (track) index of ca. 0.12 to ca. 0.02) and remained below pre-fire abundance for at least 10 years (Catling *et al.* 2001; Arthur *et al.* 2012). The net impact of introduced predators on wildlife species in any post-fire environment may thus be influenced by the relative extent to which fire may have reduced predator (and prey) densities (presumably, itself related to the scale and severity of fires), the relative proportion and juxtaposition of burnt and unburnt areas, and the extent to which the post-fire ground cover increases ease of predation.

Kangaroo Island was particularly affected by the 2019-20 wildfires, with almost 50% of the island (and most of its conservation reserve area) burnt in fires of high severity between the 20th of December 2019 and the 6th of February 2020 (Figure 1). The island has important conservation values, including endemic threatened taxa such as the Kangaroo Island dunnart *Sminthopsis fuliginosus aitkeni*, for which cats are a presumed threat. Over the period 2017 to 2019, Hohnen *et al.* (2020a) and Taggart *et al.* (2019) assessed the density of feral cats on Kangaroo Island, and found that this density was substantially higher than that of cats in comparable habitats on the nearby mainland. This pre-fire sampling provided an opportunity and benchmark from which to assess the extent to which feral cat abundance is affected by a severe wildfire.

Figure 1. *The devastated landscape following the 2020 wildfire on Kangaroo Island. Image: John Woinarski*

Context

Cats are widely recognised as a major threat to biodiversity in Australia (Woinarski *et al.* 2019) and, as a consequence, the enhanced control of cats is a conservation management priority for many threatened species and in many regions (Commonwealth of Australia 2015). Management is most likely to be successful if it is informed by robust knowledge of the ecology of cats, including the interaction of cats with other factors (such as fire) that may also threaten native wildlife.

There has been a major effort to control feral cats on Kangaroo Island, with the ultimate objective of eradication (Commonwealth of Australia 2015). The most intensive management has been on the Dudley Peninsula, in the east of the island, which was unburnt by the 2020 fires, but some targeted cat control occurred post-fire also in some burnt areas in the general area sampled in this study.

Methodology

This study re-sampled in 2020 (i.e., post-fire) seven of the nine camera-trap arrays (three in forest, two of the three in farmland, and two of the three on forest-farmland boundaries) that were previously sampled (from 2017 to 2019) by Hohnen *et al.* (2020a) (Figure 2). Two of the re-sampled arrays (one forest and one farmland) were not burnt in the 2020 fires; whereas the other five re-sampled arrays were burnt. Post-fire sampling of all seven re-sampled arrays took place between May and September 2020 (i.e., 5 to 8 months post-fire) and again in December 2020 and January 2021 (11-12 months post-fire). Due to cat control beginning at four out of seven sites, eight months post-fire, only three unaltered sites were resampled 11-12 months post-fire. Note that because our post-fire sampling began 5-8 months after the fires, we could not unequivocally attribute any reduction in cat population to mortality in fires as against starvation of cats that survivedthe fire itself in the largely burnt landscape. All cameras were set up following the protocol outlined in Hohnen *et al.* (2020a), with the exception of the two burnt forest arrays deployed 5-8 months post-fire. For these arrays a lure containing tuna oil and cat urine was set four metres in front of the cameras.

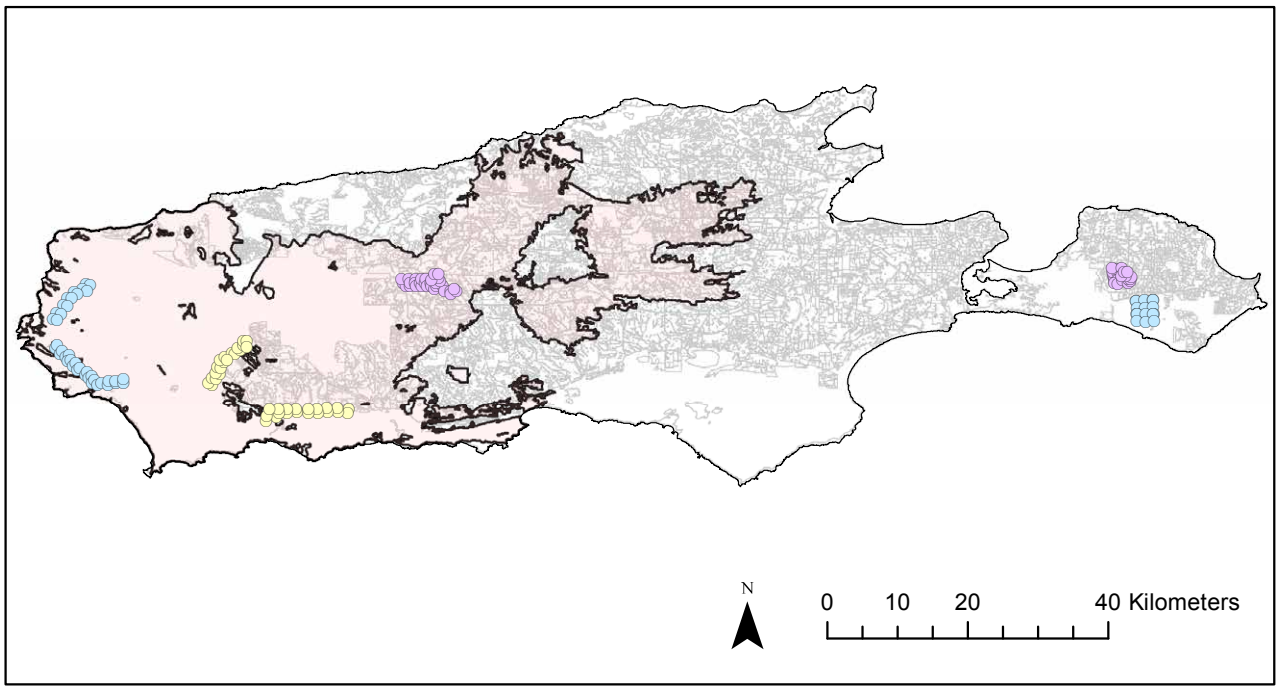


Figure 2. *Map of Kangaroo Island showing array locations and the location of the fire scar. Blue indicates arrays found primarily in forest, yellow on forest farmland borders, and purple on farmland. The fire scar is indicated in pink, and grey indicates cleared farmland.*

As with the pre-fire sampling, cat density was assessed by identifying individual cats in images (Fig. 3) and then using spatially explicit mark-resight analysis. There were insufficient images of cats on some arrays to allow calculation of density, so we also calculated the mean number of cat images per camera trap night for each array.

It's also important to note that cat management did occur within Flinders Chase National Park and Ravine des Casoars Wilderness Protected Area around three of the seven sites, sampled within 5-8 months postfire. In this period (5-8 months postfire), 10 feral cats were removed from areas within 3 km of Forest 1, and 12 cats were removed within 3 km of Forest 2, and 6 feral cats within 3 km of the Border 2 array. After the 5-8 month resample and prior to the 11-12 month resample cats were not removed from within 3 km of the three arrays sampled in that period. Arrays sampled in that period were only those where no significant cat control had occurred.

As context for our assessment of the extent to which cat population density changed due to fires, we also used the same camera-trap arrays to assess changes in the abundance of a common native mammal, the common brush-tailed possum *Trichosurus vulpecula*, from pre-fire to post-fire. As we were unable to identify individuals, we could not calculate density so we use an abundance index based on the number of passes recorded per night. A pass by a possum was counted as new if it occurred more than one minute after a preceding sighting.

Findings

We found that cat abundance 5-8 months post-fire was substantially lower (average decline of 70%) at all five sampled burnt sites (including forests, farmlands and forest-farmland boundaries) than in those sites prior to fire, whereas there was no consistent change in cat densities at the two unburnt sites (Table 1). Cat abundance showed no marked change from 5-8 months post-fire to 11-12 months post-fire at the three re-sampled arrays in burnt areas (Border 1, Farmland 1 and Farmland 3). There were sufficient cat images pre-fire to provide density estimates at all seven sites, however 5-8 months post-fire this was the case only at the two unburnt sites, and 11-12 months postfire it was only possible at the one unburnt site that was resampled in that time period.

Table 1. *Abundance and density of cats at all re-sampled sites pre- and post-fire.*

		Density (cats km^{-2})			Abundance (% of trap-nights with cat detections)		
Site	Burn status	Pre-fire	Post-fire (5 to 8 months)	Post-fire (11 to 12 months)	Pre-fire	Post-fire (5 to 8 months) [% change from pre-fire]	Post-fire (11 to 12 months) [% change from pre-fire]
Border 1	Burnt	0.06	*	*	4.56	1.43 (-69%)	0.94 (-80%)
Border 2	Burnt	0.27	*	-	5.56	0.69 (-88%)	-
Forest 1	Burnt	0.30	*	-	10.19	1.56 (-84%)	-
Forest 2	Burnt	0.87	*	-	3.98	1.88 (-52%)	-
Forest 3	Unburnt	0.53	1.18	-	2.48	4.62 (+86%)	-
Farmland 1	Burnt	0.19	*	*	4.34	1.34 (-69%)	1.88 (-57%)
Farmland 3	Unburnt	3.27	1.22	1.81	6.79	3.58 (-47%)	6.82 (+3%)

* Refers to an array in which too few cats were detected for the models to be able to produce a density estimate.

The abundance of common brush-tailed possums was also lower at three burnt sites where cameras were set without lures, relative to their abundance at those sites pre-fire (average decline of 82%). Estimates of possum abundance post-fire were much higher than pre-fire at two sites in the burnt area (Forest 1 and Forest 2), potentially due to the use of a lure in cameras in these two arrays. As evident from Table 1, there was no comparable increase in cat abundance at these two baited arrays, indicating that possums but not cats were attracted to baits. A previous study on Kangaroo Island also reported that possums were readily attracted to baits (Hohnen *et al.* 2020b). There was no consistent change in possum densities at the two unburnt sites (Table 2).

Table 2. *Abundance of possums at all re-sampled sites pre- and post-fire.*

Site	Were lures used?	Burn status	Pre-fire abundance	Post-fire (5 to 8 months) abundance [% change from pre-fire]	Post-fire (11 to 12 months) abundance [% change from pre-fire]
Border 1	Not lured	Burnt	42.9	5.0 (-89%)	7.7 (-82%)
Border 2	Not lured	Burnt	24.3	3.9 (-84%)	-
Forest 1	Lured	Burnt	4	20.4 (+410%)	-
Forest 2	Lured	Burnt	6.3	17.1 (+171%)	-
Farmland 1	Not lured	Burnt	5.3	1.4 (-73%)	2.8 (-47%)
Forest 3	Not lured	Unburnt	29.2	10.9 (-62%)	-
Farmland 3	Not lured	Unburnt	5.9	9.9 (+68%)	9.1 (+54%)

* Refers to a site that was not sampled during that time period due to cat control occurring in the preceding months.

More details of methods, analyses and results will be presented in a published paper.

Figure 3. *An example of a camera trap image of a feral cat where pelage patterns, particularly areas of the tail, fore and hind leg can be used for individual identification. Image: Rosemary Hohnen*

Discussion - What does it mean?

Our study demonstrates that cat populations are drastically reduced in or following severe wildfire, consistent with the only comparable study of cat responses to severe and extensive wildfire in temperate Australia. These results contrast with previous studies that have shown increased abundance of cats in areas burnt by fires that are of lower severity or extent, or that burn more patchily. This contrast demonstrates that the response of cats to fires is contextual. We found that cat survival (or at least changes in abundance) ca. 6-12 months following fire was not appreciably different to that of a common native mammal species, suggesting that cats may not be exceptionally capable of adapting to the burnt landscape.

However, we demonstrated that cats do persist in extensively burnt landscapes, and as such continue to exert predation pressure on the fire-depleted wildlife populations. Such pressure is likely to compound the impacts of fire on at least some species, especially given that burnt landscapes provide wildlife with less shelter and refuge from predation. Hence, the persistence and recovery of fire-affected native wildlife is likely to benefit from targeted programs that seek to further reduce the abundance of cats (or, in some settings, foxes) and/or provide supplementary shelter.

Application of research (to-date and anticipated)

Control of cats is a major management priority for many threatened species in Australia. Such management will be most effective when it is grounded on a robust evidence base. Predation by cats is known to compound the impacts of fire on native wildlife in some settings, but there is some inconsistency in the findings of previous studies that have assessed the responses of cats to fire. Our results – showing a marked decline in abundance of cats following fire – are comparable to the only previous study that has evaluated the impacts on cats of a severe wildfire in a similar system.

Notwithstanding our finding that cats are at markedly lower abundance in areas affected by severe wildfire, it is likely that predation by those surviving cats will still compound the impacts of fire on native wildlife, so management to further reduce cat numbers (or to provide refuge to prey species) is still desirable because it will enhance the likelihood of persistence of fire-affected wildlife populations, and to increase the likelihood and rate of their recovery.

Intensive and targeted management of the fire-reduced populations of cats in landscapes that are largely burnt by severe fire could cause cat populations to fall further to critically low numbers such that short-term local eradication or longer-lasting suppression may be achievable. This may be the case especially if food resources for cats in burnt landscapes are scarce and cats are hence more readily trappable or more willing to take baits.

Impact of the research (to-date and potential in future)

This study supported, and was supported by, Kangaroo Island Landscapes Board, as part of the process of collecting evidence to guide and enhance the program to control cats on Kangaroo Island. Given the scale of wildlife loss on Kangaroo Island due to the 2020 fires, there has been an urgent need to help surviving populations of native animal species to persist and recover in burnt areas, and reducing predation pressure (through trapping, baiting, exclosure fencing and provision of shelters) has been a major component of this post-fire recovery effort. Knowledge of cat density and dispersion in largely burnt landscapes provides critical evidence to help guide the location and intensity of such conservation response effort.

Broader implications – for other places or species

This study was opportunistic in that it was possible to assess changes in cat density caused by a severe fire because we had established a baseline sample that could be re-purposed as a monitoring program. For most Australian biodiversity, there is little or no long-term monitoring (Scheele *et al.* 2019), and as a consequence it is difficult to assess the impacts of any unexpected event. Severe fire is likely to be an increasingly frequent feature of the Australian environment, and broad-scale development and implementation of monitoring programs will allow for much more scope for robust assessment of the impacts of such events.

This study demonstrated that a severe and extensive fire caused a marked reduction in the density of feral cats, a major threat to many native wildlife species. This result is consistent with the findings of the only other study (from a similar habitats in south-eastern Australia) that compared cat abundance before and after a severe fire (Catling *et al.* 2001). It is possible that at such lowered post-fire densities, targeted control programs could eradicate cats from local areas or continue to suppress cat populations at low levels, although this is conjectural.

Future research priorities

We found that cat densities were lower in burnt areas relative to their density at these sites before fires. However, fires probably also caused comparable reductions in many native wildlife species (as evident in our study for possums), such that the fire may have caused no change in the *per capita* impact of cats on prey species. Furthermore, cat populations have higher reproductive potential than most wildlife species, so the ratio of cats to native wildlife species may rise rapidly following fire.

These results and their potential implications justify a set of future research priorities, including:

i. In landscapes dominated by severely burnt areas, do cats preferentially hunt in and/or find refuge in (or recruit from) unburnt patches?

ii. How does the proportional loss of cat populations due to fire compare with the proportional loss in fires of native wildlife species, and as a consequence how do *per capita* predation rates (i.e., the likelihood of any individual of a wildlife species being killed by a cat) vary pre- and post-fire?

iii. Can targeted control efforts for cats (or foxes) in burnt landscapes result in at least localised eradication, sufficient to give some respite to wildlife survivors of fire, or achieve longer-lasting suppression of cat densities?

iv. How do some cats survive severe fire, and find shelter in post-fire landscapes, and can knowledge of such shelter sites aid control measures?

v. Is the fire-associated reduction in the abundance of cats, as observed here, due mainly to mortality in the fire itself, or subsequent mortality in a largely burnt landscape in which food (or other resources) may be scarce?

Data sets

This study produced thousands of images of cats, possums and other animals. Images of cats (including where possible, recognisable individuals) and possums were collated, with the core of such databases to be made available as Supplementary Material to any journal publication arising from this study.

Recommendations

This study demonstrated the utility of monitoring programs to provide otherwise unachievable opportunities to respond to, and assess the impacts of, unexpected events that may have significant impacts on biodiversity. Hence, we support many previous calls to enhance the quality and extent of biodiversity monitoring in Australia (Lindenmayer and Gibbons 2012; Legge *et al.* 2018), with such monitoring designed not only to assess population trajectories of threatened species, but also of the extent and intensity of threats, and of interactions among threats.

This study confirmed that feral cats still occur in landscapes largely burnt by severe fires, and are likely to be compounding the impacts that those fires had on native wildlife. Hence, we support previous recommendations that a priority recovery effort post-fire should be to reduce that compounding impact, through intensive targeted control programs to further reduce the numbers of introduced predators (Legge *et al.* in review).

As detailed in a section above, we also identify some research priorities, including ecological studies to better understand how cats use landscapes largely burnt by severe fires.

Conclusion

This study demonstrates that the responses of feral cats to fire are contextual. Our findings – that cat abundance declined substantially following an extensive and severe fire – are consistent with the only previous comparable study of cat responses to severe wildfire in temperate Australia, and contrast markedly with evidence from other studies, mostly in tropical Australia, that have found that cat abundance increases in areas recently burnt by less severe fires.

Acknowledgements

This study was funded by the National Environmental Science Program's Threatened Species Recovery Hub, and the Kangaroo Island Landscapes Board. We thank everyone who helped with fieldwork including James Smith, Georgina Smith, Manfred, Kelly Geldhill, Jody Gates, Matt Heard, Alex James, Karleah Berris, Paul Jennings, Dan Rogers, Pat Hodgens and other employees from the fire recovery team at the South Australian Department of Environment and Water.

Ethics statement

Study methods were approved by Charles Darwin University's Animal Ethics Committee (Permit Number A20021), and the South Australian Department for Environment, Water and Natural Resources (Scientific Research Permit Y26970-1).

We recommend ecological studies to better understand how cats use landscapes largely burnt by severe fires. Image: Rosemary Hohnen

References

Arthur AD, Catling PC, Reid A (2012) Relative influence of habitat structure, species interactions and rainfall on the post-fire population dynamics of ground-dwelling vertebrates. *Austral Ecology* 37, 958-970.

Catling PC, Coops N, Burt RJ (2001) The distribution and abundance of ground-dwelling mammals in relation to time since wildfire and vegetation structure in south-eastern Australia. *Wildlife Research* 28, 555-565.

Commonwealth of Australia (2015) 'Threatened species strategy.' Commonwealth of Australia, Canberra.

Hohnen R, Berris K, Hodgens P, Mulvaney J, Florence B, Murphy BP, Legge SM, Dickman CR, Woinarski JCZ (2020a) Pre-eradication density of feral cat density and population size across Kangaroo Island, South Australia. *Wildlife Research* 47, 580-588.

Hohnen R, Murphy BP, Legge SM, Dickman CR, Woinarski. J (2020b) Uptake of "Eradicat" feral cat baits by non-target species on Kangaroo Island. *Wildlife Research* 47, 547-556.

Hradsky BA (2020) Conserving Australia's threatened native mammals in predator-invaded, fire-prone landscapes. *Wildlife Research* 47, 1-15.

Hradsky BA, Mildwaters C, Ritchie EG, Christie F, Di Stefano J (2017) Responses of invasive predators and native prey to a prescribed forest fire. *Journal of Mammalogy* 98, 835–847.

Leahy L, Legge SM, Tuft K, McGregor H, Barmuta L, Jones ME, Johnson CN (2016) Amplified predation after fire suppresses rodent populations in Australia's tropical savannas. *Wildlife Research* 42, 705-716.

Legge S, Lindenmayer DB, Robinson NM, Scheele BC, Southwell DM, Wintle BA (2018) (Eds.) 'Monitoring threatened species and ecological communities.' (CSIRO Publishing: Melbourne)

Legge S, Woinarski J, Scheele B, Garnett ST, Lintermans M, Nimmo D, Whiterod NS, Southwell D, Ehmke G, Buchan A, Gray JE, Rumpff L, van Leeuwen S, Williams D, Ahyong ST, Hossain A, Hunter D, Kennard M, Marsh J, McCormack RB, Michael D, Mitchell N, Newell D, Raadik TA, Tingley R (in review) Rapid assessment of the biodiversity impacts of a megafire to guide urgent management intervention and recovery. *Diversity and Distributions*.

Lindenmayer D, Gibbons P (2012) (Eds.) 'Biodiversity monitoring in Australia.' (CSIRO Publishing: Collingwood)

McGregor H, Legge S, Jones ME, Johnson CN (2015) Feral cats are better killers in open habitats, revealed by animal-borne video. *PLoS ONE* 10, e0133915.

McGregor HW, Cliff HB, Kanowski J (2017) Habitat preference for fire scars by feral cats in Cape York Peninsula, Australia. *Wildlife Research* 43, 623-633.

McGregor HW, Legge S, Jones ME, Johnson CN (2014) Landscape management of fire and grazing regimes alters the fine-scale habitat utilisation by feral cats. *PLoS ONE* 9, e109097.

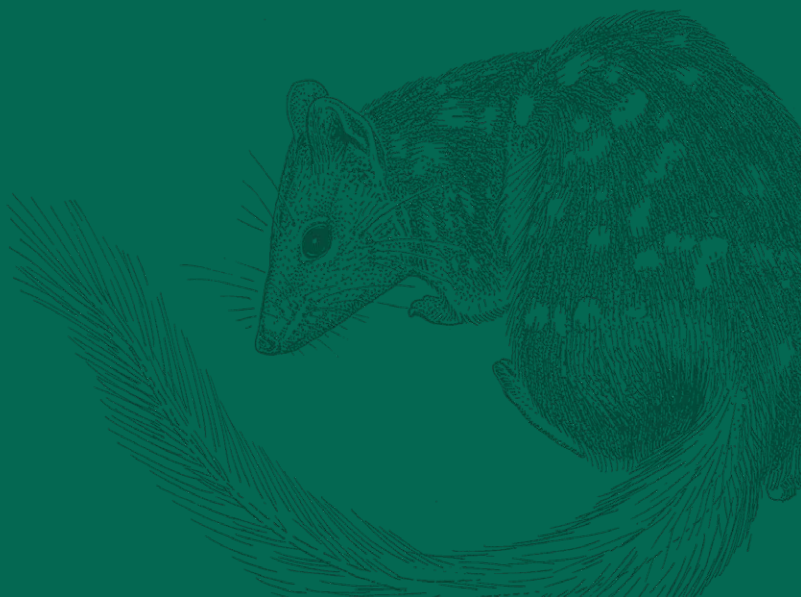
McGregor HW, Legge SM, Jones ME, Johnson CN (2016) Extraterritorial hunting expeditions to intense fire scars by feral cats. *Scientific Reports* 6, 22559.

Scheele BC, Legge S, Blanchard W, Garnett ST, Geyle HM, Gillespie GR, Harrison PL, Lindenmayer DB, Lintermans M, Robinson NM, Woinarski JCZ (2019) Continental-scale assessment reveals inadequate monitoring for threatened vertebrates in a megadiverse country. *Biological Conservation* 235, 273-278.

Taggart PL, Fancourt BA, Bengsen AJ, Peacock DE, Hodgens P, Read JL, McAllister MM, Caraguel CGB (2019) Evidence of significantly higher island feral cat abundance compared with the adjacent mainland. *Wildlife Research* 46, 378-385.

Woinarski JCZ, Legge SM, Dickman CR (2019) 'Cats in Australia: companion and killer.' (CSIRO Publishing: Melbourne)

Further information:
http://www.nespthreatenedspecies.edu.au



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

Threatened Species Recovery Hub

National Environmental Science Programme