Early results from a large-scale adaptive management experiment for malleefowl

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Abstract

Adaptive management (AM) is a way to manage ecological systems under uncertainty, yet it is rarely put into practice. Here, we describe the establishment of a large-scale AM predator experiment designed to resolve uncertainty about the effect of predator management on malleefowl (*Leipoa ocellata*). We monitored predator activity and malleefowl breeding activity in 10 AM sites in South (SA) and Western Australia (WA). Foxes and cats were managed in and around treatment sites while control sites were left unmanaged. Fox activity was lower in WA (0.097 captures per 100 trap nights; 95% CI 0.058 – 0.147) compared with SA (0.901 captures per 100 trap nights; 95% CI 0.762 – 1.051). In contrast, cat activity was higher in WA (0.243 captures per 100 trap nights; 95% CI 0.178 – 0.319) compared with SA (0.153 captures per 100 trap nights; 95% CI 0.099 – 0.219). Regression modelling suggests a weak effect of predator control on malleefowl breeding activity, however, this effect was highly uncertain. Although the effectiveness of predator management is inconclusive at this stage, the experiment is ongoing and even at this early stage already represents one of the largest attempts at adaptive management.

Introduction

Adaptive management (AM) is advocated in the natural resource management literature as a framework for managing ecological systems under uncertainty (Holling 1978). It allows management to be implemented immediately without delay, rather than withhold actions until uncertainty is completely understood. To successfully implement AM, managers must: 1) identify uncertainty in an ecological system that impacts on management decisions; 2) develop a quantitative or qualitative model that predicts how the system might respond to management; 3) monitor the response of the system to some type of management, and; 4) have the capacity to switch between actions in response to what is learnt through monitoring over space and time (Williams 2011).

Although AM is much talked about in the natural resource management literature, there are very few documented examples where it has been put into practice. For example, Westgate et al. (2013) found that of 1336 studies world-wide discussing AM, <5% claimed to be doing AM, and only 13 of these studies (<1%) were supported by published monitoring data, which is a crucial step in the AM cycle. Surprisingly, there are even fewer examples of AM for threatened species, even though management is usually required urgently and there is often considerable uncertainty how populations will respond (Canessa et al. 2016).

The barriers preventing the implementation of AM are well-documented (Allen and Gunderson 2011). AM is difficult because: 1) high levels of natural variability within ecological systems makes it difficult to plan and implement studies that reliably differentiate between management options; 2) multiple stakeholders often have conflicting motivations and values, making it difficult to agree on management objectives, and; 4) monitoring is needed to evaluate the effectiveness of management actions, but is difficult to sustain for the time usually needed to learn.

Despite these challenges, the National Malleefowl Recovery Team (NMRT) have harnessed novel tools and approaches to design a nation-wide AM experiment for malleefowl (*Leipoa ocellata*) (Hauser et al. in prep). Malleefowl is a good candidate for AM because considerable uncertainty surrounds the benefits of management. In particular, the response of malleefowl populations to predator baiting - which is the most common and probably the most expensive management strategy for the species – is highly disputed and uncertain (Benshemesh et al. 2007, Walsh et al. 2012), making it difficult to know how best to manage the species now and in the future.

The initial aim of the malleefowl AM predator experiment (AMPE) is to learn about the effect of fox and cat reduction on malleefowl breeding activity by establishing a network of control and treatment AM sites (Hauser et al. in prep) to be monitored alongside existing long-term monitoring sites. Predators are managed in and around treatment sites, while nearby control sites are left unmanaged. This arrangement will help tease apart the effect of baiting from other environmental factors that might cause a change. Once resolved, the AM experiment can be modified to learn about the effectiveness of other actions as conservation strategies, such as fire or herbivore management.

Here, we report on the first round of data collected from 10 AM sites in Western and South Australia. We analysed 2 years of camera and mound activity data to estimate: 1) predator activity rates; 2) the effect of predator control on malleefowl breeding activity. We discuss the future direction of the malleefowl AM experiment in light of these results. Although this is the first round of data collection and analysis, the malleefowl AM experiment is already one of the largest attempts at adaptive management and is a rare example where multiple land managers are working together towards a shared conservation objective.

Methods

Establishing AM sites

A total of 10 AM sites were established in Western (WA) and South Australia (SA) containing 4 control sites and 6 treatment sites positioned in 4 'clusters'. Sites varied in size from 105 ha to 4000 ha and span a variety of land-use tenures managed by Ninghan Station Indigenous Protected Area, Bush Heritage Australia, Mt Gibson Iron Pty Ltd, Cliffs Mining, Department of Biodiversity Conservation and Attractions WA, the Department of Environment Water and Natural Resources SA, Australian Wildlife Conservancy and Birdlife Australia (Figure 1).

Within each site, 8-10 motion-triggered cameras were positioned off-tracks in a regular random grid. We chose this arrangement to minimise correlation in capture rates between cameras and to ensure spatial coverage across sites. The same camera model was used within each cluster to ensure consistency in capture rates. Cameras were powered by solar-powered-units, were not baited to attract predators, and were programmed to have a 5-minute sleep period after a triggered photo event.

Predators were managed in and around treatment sites while control sites were left unmanaged. In most cases, predators were managed by baiting an area no less than 10,000 ha in and around treatment sites. This buffer area was important to minimise the chance of foxes and cats emigrating from areas outside the treatment zone into the treatment site.

Mound and predator monitoring

All known mounds in AM sites were visited between October and September in 2016 and 2017 coinciding with the middle of the breeding season. Mounds were recorded as being active or inactive based on evidence of use that year. Mound monitoring was conducted by volunteers, citizen scientists and land managers, after being trained in mound identification by the National Malleefowl Recovery Team (NMRT).

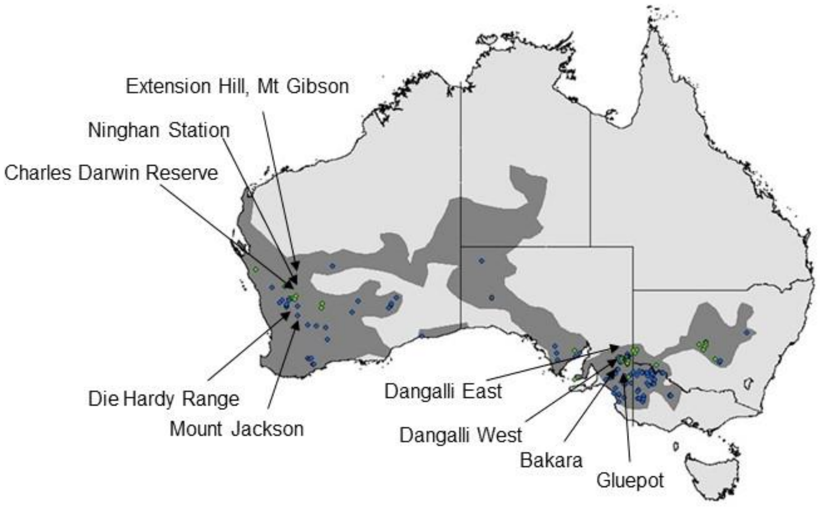

Figure 1: Location of malleefowl predator experiment AM sites in Western Australia and South Australia. Green dots show 40 candidate AM sites across the species' range (dark grey shading), while blue dots indicate long-term monitoring sites.

Data processing

We sorted camera photos by the species identified in each image. Species detected within 30 minutes of one another were collapsed into a single capture event to remove repeated photos of individuals. We recorded the number of fox and cat detections made by each camera during each day/night and month of monitoring using the package *camtrapR* (Niedballa et al. 2016) in the software R (R Development Core Team 2014).

Data analysis

We modelled fox and cat capture rates per camera per 100 trap nights. We fitted a second model to estimate the effect of baiting on malleefowl breeding activity. To do this, we modelled the observed count of active malleefowl mounds as a Poisson random variable. The effect of baiting was expressed by modelling the log of the Poisson random variable as a linear effect. Model fitting was conducted using the *rjags* package in R (v3.3), a program for Bayesian inference making use of Markov chain Monte Carlo sampling (MCMC).

Results

Predator activity at AM sites

When camera data were pooled across control and treatment sites by state, fox activity was higher in SA (0.901 captures per 100 trap nights; 95% CI 0.762 – 1.051) compared with WA (0.097 captures per 100 trap nights; 95% CI 0.058 – 0.147). In contrast, cat activity was higher in WA compared with SA: a camera detected on average 0.243 (0.178 – 0.319; 95% CI) cats per 100 trap nights in WA and 0.153 (0.099 – 0.219; 95% CI) in SA. Cat and fox capture rates were highly variable between control and treatment sites, with an uncertain effect of predator control on predator activity (Figure 2, 3).

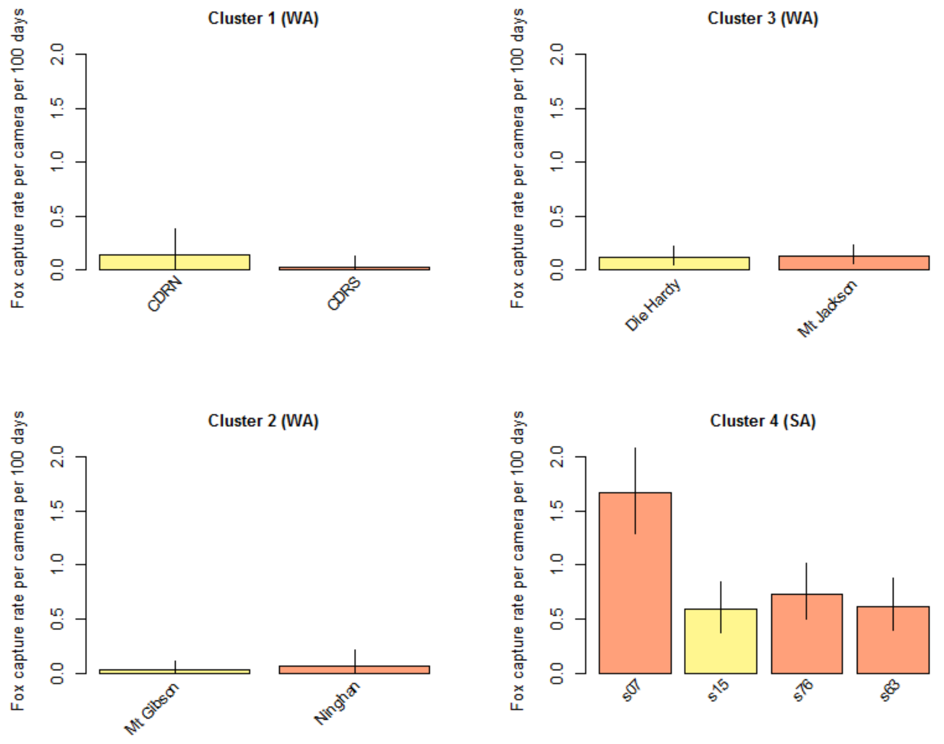

Figure 2: The fox capture rate per camera per 100 trap nights for each cluster in Western and South Australia. Yellow bars indicate control sites, orange bars represent treatment sites. Vertical error bars represent 95% credible intervals.

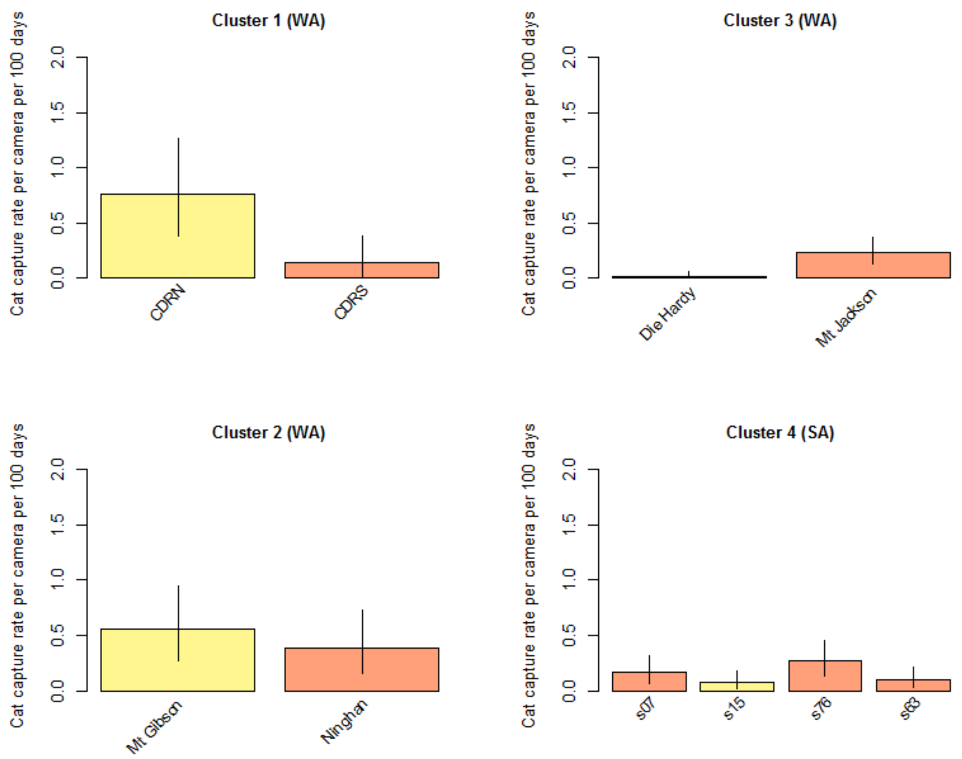

Figure 3: The cat capture rate per camera per 100 trap nights for each cluster in Western and South Australia. Yellow bars indicate control sites, orange bars represent treatment sites. Vertical error bars represent 95% credible intervals.

Effect of baiting on predator and mound activity

Our regression modelling suggests a weak positive effect of predator control on malleefowl breeding activity (1.593; 95%CI -5.641 – 10.062); however, this effect was highly uncertain given the relatively few site-years or data at this stage of the experiment. The effect of winter rainfall lags on malleefowl breeding activity was also modelled, but was equivocal at this stage due to the number of sites.

Discussion

We present the first round of results from a nation-wide AM experiment for the threatened malleefowl. The experiment runs alongside the existing long-term monitoring program to accelerate learning about the impact of predator management for malleefowl conservation. The sheer spatial coverage of sites and the number of partner organisations involved already makes it one of the largest and complicated attempts at AM in the world. Not only will it help us learn about the effectiveness of predator control as a conservation strategy, it will also help us better understand broader relationships between predator control and predator activity in different regions of Australia.

Motion-triggered cameras deployed at AM sites revealed fewer fox detections in WA than SA. Interestingly, we found the opposite result for cats, with higher capture rates in the 6 WA sites compared with the 4 SA sites (Figure 4). These results are surprising, although stakeholder workshops revealed that managers consider cats to be a bigger problem in WA than in eastern states. Predator capture rates were highly variable between control and treatment sites, which meant that the overall effect of predator control on predator activity is uncertain at this stage of the experiment. However, we expect this to be partly resolved over time as more cameras are deployed at new AM sites, and as existing sites are continually monitored. However, we may have to increase the baiting effort at some treatment sites if current levels appear to have no impact on predator capture rates.

Predator baiting had a weak positive effect on malleefowl breeding activity across all AM sites, although this effect was highly uncertain. Once again, this is not surprising given we analysed only two years of mound activity data from 10 sites. We expect uncertainty surrounding this effect to reduce substantially over time as more mound data are collected from these sites, and more sites are added to the AMPE program. A statistical power analysis suggests that 20 pairs of AM sites are needed to detect moderate increases in mound activity within a 5 year time-frame (Hauser et al. in prep). At this early stage we have only achieved about 20% of this target and uncertain results are expected. Nonetheless, we are also looking at combining data from AMPE sites with data from the long-term monitoring sites in order to reduce uncertainty and further accelerate learning.

Figure 4: Camera-trap image of a fox and cat detected at Die Hardy Range in Western Australia

Further work

The number of photos triggered in WA sites for any species was much lower than initially expected. We will now investigate whether this is an effect of camera model, settings or placement, or whether it reflects lower productivity levels compared with SA. If we are unable to increase capture rate, one implication of low capture rates is that it might more difficult than expected to detect changes in fox activity with 8 – 10 cameras deployed at sites. To resolve this issue, we will re-run a power analysis to re-evaluate the number of cameras needed to detect a change, given the number of sites as well as the variation in predator capture rates.

We are also pursuing a range of opportunities to increase the number of AMPE sites across the range of Malleefowl and are encouraged by the degree of interest shown by agencies and citizen scientists in the program.

Conclusion

We have successfully established one the largest predator control experiments in Australia and one of the biggest ever attempts at adaptive management. Effort will now be spent ensuring new sites are established in Victoria and New South Wales so the experiment is truly nationwide, and has sufficient statistical power to detect change. In doing so, it should resolve the long-running debate about the effectiveness of predator management as a conservation strategy for malleefowl.

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