Developing an integrated monitoring program for fauna within Uluṟu-Kata Tjuṯa National Park

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We acknowledge the Traditional Owners of Country throughout Australia and their continuing connection to and stewardship of land, sea and community. We pay our respects to them and their cultures and to their Ancestors, and future leaders. Our Indigenous research partnerships are a valued and respected component of National Environmental Science Program research.

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Executive Summary

Uluṟu-Kata Tjuṯa National Park (UKTNP) is recognised internationally as a UNESCO World Heritage site for its exceptional cultural and ecological significance. A fauna monitoring program was conducted at UKTNP between 1987 and 2010, recording more than 228 species of birds, reptiles, mammals, and amphibians through standardised bird transects and live trapping. That program addressed management priorities of the time and provided a strong foundation for understanding the biodiversity present within the Park. However, the ecological and management context within the Park has since shifted. Intensifying pressures from altered fire regimes, climate change, drought, and invasive predators present new challenges. This report summarises the methods and results of a collaborative project aiming to: 1) evaluate past monitoring of biodiversity within the Park and 2) design a new integrated biodiversity monitoring program for UKTNP that addresses new and emerging threats while maintaining a high level of participation by and contribution of knowledge of Aṉangu Traditional Owners.

In Section 1, we present an assessment of historical monitoring in the park. Data from the historical fauna monitoring program were compiled into a single dataset to quantify trends in vertebrate detection rates over time. The compiled dataset consisted of 58,000 individual detections of birds, reptiles, mammals and amphibians collected between 1987 and 2010. Analysis of this dataset suggests that the detection rate declined for 56% of species modelled over the monitoring period. Reptiles had the highest proportion of species in decline (71%), followed by mammals (69%) and birds (55%). Rainfall in the year preceding the surveys and time since fire were identified as important drivers of species detection rates, with varying responses across and within taxonomic groups.

Compiling this long-term dataset also revealed considerable changes in the personnel conducting surveys, ranging from consultants to government ecologists and Park staff. Therefore, care should be taken when interoperating species' detection rates, as they could be confounded by changes in survey effort or personnel over time.

Estimates of species detection rates indicate that many of the species listed in the early 1990s as ecologically and culturally significant are detected too infrequently to be reliable indicator species in an integrated biodiversity monitoring program.

In Section 2, a new list of priority indicator species is proposed based on 3 criteria:

1. cultural significance — species important to Aṉangu knowledge, practice, and identity;
2. ecological indicator value — species whose populations respond predictably to key ecological processes such as fire, drought, and changes in spinifex or mulga woodland habitats; and,
3. management relevance — species that reflect the outcomes of active management, particularly predator control within these habitat types.

The resulting list of 27 species was compiled in consultation with Aṉangu Traditional Owners, Indigenous Rangers, Parks Australia staff, and species experts. These will serve as useful species in future biodiversity monitoring within the Park.

To improve the spatial coverage of monitoring and the number of indicator species detected, we trialled the addition of camera trapping and acoustic sensors within the Park (Section 3). Camera traps and sound recorders were deployed at 30 sites across two seasons, from September to February, in 2023/24 and 2024/25. Sites contained 4 cameras within a 500 m² grid and were stratified across important habitat types, including spinifex and dune systems, mulga woodlands and the hard soils and drainage lines surrounding Uluṟu and Kata-Tjuṯa. Sites were also positioned to align with concurrent monitoring programs operating within the Park. For example, 8 sites corresponded to those used in the live fauna trapping program, and 10 aligned with drought-monitoring plots established by CSIRO and Parks Australia. The 500 m^2 grid size was selected to align with other regional monitoring networks in the Northern Territory. Acoustic recorders complement these camera deployments by extending coverage of avian species, but this aspect remains in its pilot stage and is addressed under a new National Environmental Science Program (NESP) project spanning 2025–2028.

In Section 3, we also estimate baseline site occupancy and encounter rates for all species detected by camera traps across the two survey seasons (2023/24 and 2024/25). Site occupancy is the probability that a species is present (or uses) a particular site during the survey period, accounting for the possibility that it may not be detected even when it is present. Encounter rate is the frequency with which cameras detect a species, typically expressed as the number of independent detection events per unit of sampling effort. These estimates were used to determine the amount of survey effort (i.e., the number of camera-trap sites and the duration of camera deployment) required to detect a change in the occupancy or encounter rate of the indicator species identified in Section 2 with confidence. This was done by generating simulated camera-trap data that could be expected to be collected under alternative monitoring designs, and by analysing the simulated data as you would real data. We examined three scenarios with differing levels of effort: one with 30 sites (the current level of effort), a second with half the effort (15 sites), and a third with slightly more effort (40 sites). The power analysis revealed that, if the goal is to detect a change in occupancy, deploying cameras at 30 sites for 140 days (20 weeks) each year is likely to detect only moderate changes (30%) in cat occupancy. However, if the goal of monitoring is to detect changes in encounter rates (i.e., the activity rate of a species per week), the current monitoring design has high power (>80%) to detect a 50% increase or decrease in this metric for more than half (55%) of the priority indicator species across the 30-site scenario.

Based on our results in Sections 1-3, our main recommendations are to:

1. Live trapping continues at the existing sites to target key species while involving community members, with the following prescriptions:
    - Reduce observational bias between survey years
    - Record and retain data in its most granular format
2. Camera-based surveys will continue annually at the 30 established locations for at least the next 5 years (2026 – 2031), with camera traps deployed for at least 20 weeks per deployment. This will allow the park to:
    - Broaden and diversify survey methods
    - Increase spatial and temporal coverage
    - Prioritise systematic monitoring of our selected indicator species
3. The statistical analyses presented in this report are repeated after 5 years of camera trap data (end of 2028), with the following prescriptions:
    - Prioritise encounter rate over occupancy as the primary monitoring metric, so there is a high chance of detecting changes in populations
    - For low-power priority species, consider alternative monitoring methods
4. Opportunities for acoustic monitoring and eDNA are explored to detect priority species that are poorly detected by live trapping and cameras (e.g., birds, amphibians).
5. Park managers should maintain and periodically review the long-term ‘passive’ monitoring program implemented to assess trends in priority species and the effectiveness of management actions.

Adequate and sustained monitoring is essential to achieving the objectives of this program. Ongoing monitoring will enable park staff and community members to track changes in priority species populations over time and to quantify the influence of management actions and key environmental drivers, including pest management, cultural burning, drought, and species interactions. Without consistent investment in monitoring, the ability to detect trends, evaluate management effectiveness, and support evidence-based adaptive decision-making will be significantly compromised. Therefore, we strongly recommend that sufficient resources be allocated to camera-trap deployment and processing. A team of 2 staff typically requires approximately 2 weeks to deploy cameras across all 30 monitoring sites, with an additional 2 days for equipment inspection and calibration. Retrieval requires a further week for a 2-person team, followed by 2 to 4 weeks of image processing and tagging by trained personnel.

An extended summary of all the recommendations in the report is provided in Appendix 1.

In summary, this report outlines a pragmatic and culturally grounded expansion of biodiversity monitoring at Uluṟu-Kata Tjuṯa National Park. Historical data demonstrate that, although 3 decades of surveys have produced valuable ecological knowledge, the methods traditionally used alone are no longer sufficient for robust trend detection or management evaluation. The redesigned framework—co-developed with Aṉangu and Parks Australia—is underpinned by power analysis, modern survey and detection technologies, and an adaptive management approach. By focusing on indicator species that link ecological processes to cultural values, the new program ensures that both biodiversity and cultural heritage are jointly monitored, managed, and protected into the future. The camera-based survey network now provides foundational data for several ongoing and upcoming management initiatives at Uluṟu-Kata Tjuṯa National Park, including the implementation of the Predator Management Strategy, potential post-drought recovery assessments, and the biodiversity component of the upcoming UKTNP Kapi Water Plan.

Introduction

Uluṟu-Kata Tjuṯa National Park (UKTNP) is a site of significant cultural, ecological, and geological importance, recognised internationally through its designation as a UNESCO World Heritage Site. The park spans approximately 1,325 km² in Australia's central desert and encompasses diverse arid habitats dominated by spinifex grasslands, mulga woodlands, and rocky outcrops. UKTNP holds profound spiritual and cultural importance for the Aṉangu people, its Traditional Owners, whose custodianship and knowledge systems are integral to its management. Ecologically, UKTNP encompasses unique desert landscapes that support diverse and often rare flora and fauna adapted to highly variable and extreme environmental conditions. The Park is also a major tourism destination, attracting hundreds of thousands of visitors annually, thereby complicating conservation and management efforts. Maintaining the resilience of both natural ecosystems and cultural values in this context is a critical and ongoing challenge.

The historical monitoring program at UKTNP, conducted from 1987 to 2010, employed a combination of systematic field surveys and extensive incorporation of Aṉangu traditional ecological knowledge. The program used standardised sampling methods across multiple habitat types, including spinifex grasslands, mulga shrublands, and monolith-associated environments. Birds, reptiles, and mammals were surveyed repeatedly for over 2 decades using trapping and observational counts. Amphibians were also recorded opportunistically. Surveys integrated historical records and direct knowledge from Aṉangu custodians, providing a rich, multidisciplinary baseline for the distribution, abundance, and ecological relationships of vertebrate fauna. This foundational work highlighted the dynamic nature of desert fauna populations, the importance of habitat diversity, and the influence of factors such as rainfall, fire, and tourism on fauna communities.

Building on this foundation, this current project "Developing an integrated monitoring program for fauna within Uluṟu-Kata Tjuṯa National Park" (a component of a larger NESP Resilient Landscapes hub project 3.7 Managing and Monitoring Resilience in Australia's National Parks (Component 1) aims to evaluate whether past monitoring methods remain fit-for-purpose and to develop a redesigned monitoring framework that reflects contemporary ecological understanding, evolving management priorities, and the current concerns of Aṉangu people. This updated approach is guided by principles that explicitly acknowledge the intertwined cultural and natural heritage of UKTNP and seeks to optimise data collection to support robust, statistically powerful assessments of species trends and management effectiveness.

The redesigned monitoring program is structured around 4 objectives:

Facilitation of data collection that encourages Aṉangu engagement on Country, incorporates traditional ecological knowledge into program design, and fosters intergenerational knowledge sharing;

Identification of priority and indicator species that are culturally significant to the Aṉangu people;

Development of a monitoring design that enables effective evaluation of management activities aimed at conserving priority natural and cultural values; and

Utilisation of data collection methods optimised to detect trends and management impacts across diverse species with maximal statistical power.

This report addresses the project objectives through 3 key aims, each explored in a dedicated section:

1. **Assessment of Historical Monitoring Data:** Evaluating whether historical monitoring efforts provide data of sufficient quality and relevance to meet current management objectives, particularly for assessing the effectiveness of conservation activities (Section 1).

2. **Review of Priority Species Relevance:** Investigating the continued relevance of historically designated priority and indicator species from the perspectives of both Aṉangu Traditional Owners and park management staff (Section 2).
3. **Monitoring Framework Redesign:** Redesign of the monitoring program that integrates cultural knowledge, scientific rigour, and adaptive management principles based on findings from the preceding work (Section 3).

This report presents the findings from these analyses. It concludes with recommendations (Appendix 1) for implementing a robust, culturally inclusive integrated biodiversity monitoring program that supports the joint custodianship and sustainable management of Uluṟu-Kata Tjuṯa National Park. Detailed methods are provided in 2 separate accompanying scientific articles:

Smart, A., Goumas, M., MacGregor, N., Guest, T. and Southwell, D. (2025). Thirty-year trends in detection rates of vertebrates in a central desert region of Australia. Biological Conservation (In Prep).

Smart, A., Goumas, M., MacGregor, N., Guest, T. and Southwell, D. (2025). Designing a regionally significant monitoring program around bio-cultural indicator species to maximise power to detect changes in encounter rates and site occupancy.

1. Assessment of Historical Monitoring Data

Monitoring of vertebrate fauna in UKTNP has occurred over 3 primary phases since 1987. Monitoring has evolved through these distinct phases reflecting changing priorities, methods, and management structures:

- **Phase 1 (1987–1991):** Broad-scale ecological surveys that were aimed at characterising community composition, ecological functions, and landscape-scale biodiversity patterns. During this phase, up to 14 sites representing key habitat features were sampled annually.
- **Phase 2 (1993–2010):** Transition to government-led monitoring with a focus on fauna trapping rates at a subset of 8 of the original 14 sites. Sampling frequency was reduced to biennial rotational-site sampling.

  Monitoring was suspended between 2010 and 2020, creating a gap in long-term data collection.
- **Phase 3 (2021–present):** Monitoring activities recommenced to refine survey methods, re-evaluate priority species, community engagement, and integration of new technologies.

Throughout all phases, consistent standard biological survey techniques—bird transects, pitfall traps for reptiles and small mammals, and Elliott traps for mammals—were employed primarily between September and December, aligning with the peak activity period for reptiles.

1.1 Fauna trapping survey methods

Surveys across all 3 phases targeted birds, reptiles, amphibians, and small mammals, using methods adapted to the ecological and logistical challenges of the arid desert environment. Bird populations were monitored through censuses along permanently marked transects approximately 2.5 km in length. Transects were typically rectangular, spanning about 1 km by 250 m. Each site was surveyed over 3 consecutive days, with 2 censuses conducted daily — immediately after sunrise and just before sunset — to capture periods of peak bird activity. These bird surveys were conducted primarily between September and December, coinciding with peak activity periods for many reptile and bird species.

Reptiles and small mammals were surveyed using pitfall and Elliott traps. Each site contained 4 pitfall trap sets, each comprising 9 20-litre buckets arranged in a cross formation, connected by drift fences to funnel animals into the traps. Pitfall traps were placed to maximise representation of habitat diversity within each site, with standardised distances between buckets and drift-fence lengths. These traps were checked multiple times per day to ensure animal welfare and accurate capture data.

Additionally, baited Elliott traps were deployed to capture small mammals, typically 250 per site. Elliott traps were arranged in systematic lines spaced 10 metres apart, with the number of traps per line and the total number of trap lines tailored to site characteristics and habitat heterogeneity. As with pitfall traps, the placement of Elliott traps aimed to encompass the full spectrum of habitat types present at each location. Sampling effort was generally consistent across the 3 phases of monitoring, with some adjustments made in response to fluctuating populations, such as subsampling during periods of high abundance to avoid trap saturation and minimise stress on captured species from prolonged processing times.

Opportunistic sampling of frogs was conducted when environmental conditions allowed, particularly after rainfall events. Larger mammals and reptiles not readily sampled by traps were recorded via incidental observations, including direct sightings, and indirect signs such as tracks and scats.

1.2 Site Selection and Habitat Representation

In Phase 2 of monitoring, 8 permanent monitoring sites were selected to represent the major land units and vegetation communities across the Park (Figure 1), following consultation with Aṉangu Traditional Owners to avoid areas of cultural sensitivity. These sites spanned 6 major land classes based on the Simpson Land System, differentiated by dominant spinifex species and soil types—4 sites on hard soils associated with mulga and mallee communities (sites 6, 7, 15, 14) and 4 on soft spinifex-dominated soils (sites 1, 4, 5, 8). This spatial design ensured that the diversity of broad habitats was sampled, reflecting the heterogeneity of the Park's ecosystems.

Figure 1. Location of the 8 core survey sites within Uluṟu-Kata Tjuṯa National Park (UKTNP) where annual fauna monitoring is conducted. The black box represents the Park boundary.

1.3 Historical species inventory

Over the course of the historical surveys, the program recorded an extensive vertebrate fauna comprising approximately 110 bird species, 81 reptile species, 24 mammal species, and 2 frog species (a total of 228 species; Appendix 2). This represents a substantial proportion of the known vertebrate diversity within the Park, including several species of conservation concern and taxa endemic or restricted to the region.

One of the first aims of this project was to produce a single electronic **dataset that integrates historical hard-copy reports and contemporary electronic datasets into a single species database spanning 1987–2025.** Project members digitised data contained in historical reports and applied several data quality rules to produce a single database for the subsequent analysis components of the project:

- Incidental and uncertain records were excluded to maximise geographic and taxonomic accuracy.
- records were merged or split to reflect taxonomic revisions, where new species names could be accurately prescribed, to ensure taxonomic harmonisation across the 30+ years of monitoring.

After data collation and filtering, the aggregated dataset for Uluṟu-Kata Tjuṯa National Park (UKTNP) monitoring comprised 5,694 detection events and more than 58,000 individual vertebrate detections, spanning 37 years. This formed the basis of the core analysis of this project.

1.4 Species Trend Analysis

A primary objective of this section was to quantify historical trends in species populations within Uluṟu-Kata Tjuṯa National Park (UKTNP) using the aggregated dataset. Due to a substantial temporal gap between monitoring phases 2 and 3, we restricted our trend analysis to the period spanning 1987 to 2010. This restriction was implemented to mitigate potential anchoring effects that could bias linear trend estimations across discontinuous sampling intervals. Starting with a total pool of 228 species, individual species were excluded from trend analyses if: they had been detected 5 or fewer times across multiple years and sites; records were the result of tracks of sign; and/or they were recorded opportunistically (i.e. off-survey). This resulted in a list of 143 species (71 birds, 59 reptiles, 13 mammals) that met the inclusion criterion. This list included many of the invasive and introduced predators/herbivores known to occur within UKTNP, as well as species not reliably captured via the methods prescribed above.

Black-headed monitor
Dingo
Dromedary Camel
Euro
European Rabbit
Feral Cat
Finlayson's cave bat
Gould's wattled bat
Lesser Long-eared bat
Mains Frog
Perentie
Red Fox
Red Kangaroo
Sand goanna
Shoemaker Frog
Southern Marsupial Mol

Environmental Covariates and Data Preparation

Environmental variables were extracted for each site-year from remote sensing products (Google Earth Engine for rainfall and NDVI; Landsat-derived fire scar maps for fire metrics provided by the Park) to explore their effect on species population trends. Three main environmental variables were considered: lagged annual rainfall (total precipitation in the calendar year preceding the survey); the Normalised Difference Vegetation Index (NDVI), a proxy for vegetation greenness; and fire regime metrics (time since fire and fire extent). Buffer sizes used to quantify fire extent around survey sites were taxon-specific, reflecting differences in spatial ecology: 500 m for reptiles, 1 km for mammals, and 5 km for birds. For each site and year, fire extent was calculated as the percentage of the buffer area (centred on the site centroid) that burned. When calculating time since fire, a site was classified as burnt in a given year if any portion of its buffer experienced fire. Due to high collinearity ($| r | > 0.7$), NDVI was excluded from subsequent analyses. Remaining covariates were mean-centred and standardised.

Modelling Framework and Model Selection

Species-specific encounter rates (i.e. the number of times a species was detected during a survey) were modelled using generalised linear (mixed) models (GLMs/GLMMs) with Poisson or negative binomial distributions, depending on data dispersion and sample size. Models included fixed effects for a time trend, lagged rainfall, time since fire, and fire extent, with random intercepts for year to account for temporal variation. Site random effects were excluded due to limited site replication across species.

A suite of candidate models, representing all factorial combinations of covariates, was fitted for each species. To avoid model overfitting and ensure reliable parameter estimation, the number of covariates included in each candidate model was constrained relative to the available sample size, with one covariate modelled for every 10 detections. Model selection utilised Akaike Information Criterion corrected for small samples (AICc), retaining models within ΔAICc ≤ 2. Parameter estimates were averaged across these models using full conditional averaging, assigning zero effect sizes to covariates absent from particular models. Zero-inflated models were applied where appropriate, contingent on convergence diagnostics. This modelling approach provided robust estimation of species-specific trends in encounter rates and quantified environmental drivers influencing population dynamics over the 24-year study period.

1.5 Results

The integrated dataset from Uluṟu-Kata Tjuṯa National Park (UKTNP) encompasses 25 years of live trapping data (between 1987 and 2025) with 2 years of camera survey data (2023–2025), recording 113 bird species, 86 reptile species, 24 mammal species, and 2 frog species, with a total of approximately 58,938 individual detections. Detections were predominantly comprised of reptiles (42.7%) and birds (41.4%), while mammals represent 15.8% of total detections. The majority of detections occurred during the first 2 phases of monitoring (1987–2010), while the recent resumption of surveys contributed 6.5% of detections (2021–2024).

Temporal trends in species encounter rates.

The figure below shows the number of model results indicating a stable, increasing, or decreasing trend in encounter rates during the first 2 phases of monitoring (i.e., live trapping only) (Figure 2).

Of the 228 species detected, sufficient records were available to fit trend models for 71 birds, 56 reptiles, and 10 mammals (137/228). The remaining species had too few detections (<5) or were recorded in only a single year. Our results suggest that 65.7% of the modelled species (birds, mammals, reptiles) had encounter rates that declined significantly over Phases 1 and 2 of monitoring (1987 – 2010) (i.e., the 95% confidence intervals of the trend parameter did not overlap zero) (Figure 2a). This effect was particularly pronounced among mammals, with 90% (9/10) of species exhibiting a significant negative trend in encounter rates over this period. A total of 54.9% of bird species exhibited a significant decline in encounter rates, and 75% of reptiles also showed a significant negative response. A total of 25.5% of species showed no change in encounter rates over the study window. Finally, 8.6% of all species had a significant positive trend in encounter rates across UKTNP. A table of the annual trend parameter estimates for each species is provided in Appendix 3.

A key consideration is observer effort over this period. Whilst the encounter rate of many species is shown to be in decline, the level of surveyor expertise changed between Phase 1 of monitoring, where ecological consultants undertook the surveys, Phase 2, where governmental ecologists undertook the surveys, and again towards the end of Phase 2, where the surveys were transitioned to be organised and run by UKTNP Park rangers and skilled volunteers. Unfortunately, data are not recorded in a way that allows changes in encounter rates to be untangled from changes in observer ability or effort.

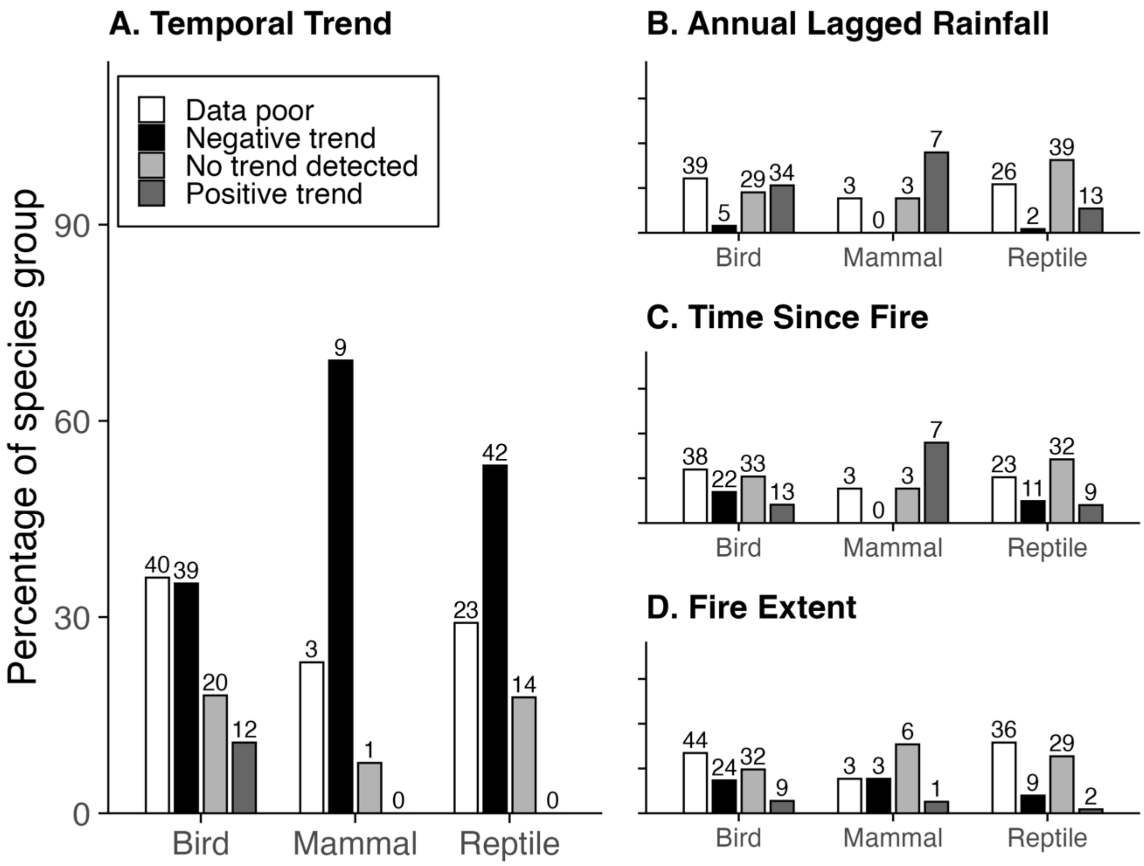

Figure 2. Summary of temporal trends in species encounter rates, showing the number of species found to declining rates (black); stable encounter rates (light grey); increasing rates (dark grey), or an insufficient number of records to fit a simple trend model (data poor; white) across the monitoring horizon (1987-2010). The numbers above each bar indicate the number of species within each data category. Panel A shows the trend in encounter rates; panel B (lagged rainfall), panel C (time since fire), and panel D (fire extent) show the influence of the corresponding covariate on each species' detection estimates.

Environmental Covariates

The effects of environmental variables on encounter rates differed among taxonomic groups and species:

Lagged Annual Rainfall: This covariate showed a significant positive relationship with encounter rates in 50% of birds (34 of 68 species), 70% of mammals (7 of 10 species) and 24% of reptiles (13 of 54 species) (Figure 2B). Negative associations were limited to a small number of bird (5 species) and reptile (2 species) taxa. A lack of data prevented estimation of the rainfall effect for 36% of birds, 23% of mammals, and 33% of reptiles, respectively.

Time Since Fire: Encounter rates in mammals positively correlated with longer time since fire for 70% of species (7 of 10), whereas only 19% of birds (13 of 68) and 16% of reptiles (9 of 54) showed similar positive associations (Figure 2C). In contrast, 32% of bird species and 20% of reptiles exhibited a significant negative relationship with time since fire, indicating a preference for more recently burnt habitats. No mammals showed this negative association. Data gaps limited analysis for 36% of birds, 23% of mammals and 30% of reptiles.

Fire Extent: Larger fire extents were negatively associated with encounter rates in 37% of birds (24/65), 30% of mammals (3/10) and 23% (9/40) of reptiles (Figure 2D). Positive associations with fire extent were less common, seen in 14% of birds, 10% of mammals and 5% of reptiles. A substantial proportion of species lacked sufficient data to evaluate this covariate (40% of birds, 23% of mammals, and 47% of reptiles).

Species-specific parameter estimates and full results are available in Appendix 4.

1.6 Recommendations

This assessment of historical monitoring data highlights key limitations and opportunities to improve biodiversity monitoring and management in Uluṟu-Kata Tjuṯa National Park. Despite considerable effort over several decades, many species remain insufficiently detected to allow robust trend modelling, underscoring critical gaps in data completeness and survey effectiveness. The recommendations below aim to address these constraints by enhancing detection capabilities, optimising survey designs, and refining the integration of environmental drivers. Emphasis is placed on developing more efficient, targeted monitoring strategies that balance logistical feasibility with ecological rigour, thereby enabling clearer interpretation of species trends and more informed management decisions in this complex arid ecosystem.

Whilst the following recommendations focus primarily on implementing passive survey methods, this should not come at the expense of continued live trapping. Live trapping not only detects species that survey cameras may not record, but also provides vital opportunities to handle animals, enabling community members to engage with them for cultural practices and teachings. It also enables additional benefits, such as collecting genetic samples and monitoring populations through physiological measurements, should the need arise.

R1 – Reduce observational bias between survey years: A key limitation in our ability to confidently understand trends in species is the current inability to disentangle the effect of different observer skill levels between survey years. The success of trapping an animal ultimately depends on underlying population levels, survey conditions, and the skill with which traps are set and animals are identified. Where possible, UKTNP management should ensure that rigorous training and supervision are provided to new Park rangers tasked with overseeing, conducting, and recording survey data. This includes new and novel survey techniques recommended in the subsequent sections.

R2 – Record and retain data in its most granular format: Data should be collected and retained at a granular level to allow accurate calculation of trap detectability and reduce observational or methodological bias. Whilst it may not be feasible to record data at the trap level (i.e. what each trap catches each day), at a minimum, data should be recorded and retained at the daily level (i.e. the species captured each day, including the level of effort at the site, such as the number of traps deployed per day). This will allow subsequent analysis to control for bias introduced through differences in observer effects, survey effort or changes in approaches. In addition, it may be informative to standardise data collection for critical risks such as the presence and abundance of feral predators (e.g., signs of cats and foxes), the presence of drought, fire extent and severity, and/or invasive plants (e.g., Buffel grass).

R3 – Broaden and diversify survey methods: Pilot the use of passive wildlife sensors to increase the number of detections for species within the Park. This will improve the detection of cryptic, nocturnal, and low-density species, broadening the scope of biodiversity surveys and increasing the ability to conduct trend analysis. In addition, it will enable monitoring of invasive predators and herbivores that are not captured by live-trapping techniques.

R4 – Increase spatial and temporal coverage: Increase the number and geographic distribution of monitoring sites across the UKTNP to capture habitat heterogeneity and environmental gradients better, and close temporal gaps between monitoring phases to provide continuous population trend data.

2. Review of Priority Species

Uluṟu-Kata Tjuṯa National Park is jointly managed by Aṉangu Traditional Owners and Parks Australia, reflecting an integrated governance model operating at multiple levels. Strategic policy decisions are directed by the UKTNP Board of Management, on which Aṉangu representatives hold a majority. Central to this arrangement is the cultural and ecological stewardship principle of "looking after country," which ensures that conservation management integrates both Indigenous and Western scientific perspectives. This partnership facilitates essential knowledge exchange that supports the conservation of the Park's unique natural and cultural values (ANPWS, 1986, 1991; UKTNPMP 2021).

2.1 Historical Monitoring Objectives

The first phase of monitoring (1987–1991) culminated in a prioritised list of species, communities, and habitats deemed critical for conservation within UKTNP, based on combined ecological survey data and Aṉangu input (Reid, Kerle & Morton 1991). This framework (summarised here; excerpt as Appendix 5) guided monitoring and management focus for several decades, categorising species and habitats by conservation priority:

- **Level 1** priorities included species such as the Crest-tailed Mulgara (Dasycercus cristicauda), the Uluṟu population of Euro (Macropus robustus, now locally extinct), and the Striated Grasswren (Amytornis striatus), alongside small mammal and reptile communities around Yulara Bores.
- **Level 2** priorities encompassed species like the Northern Marsupial Mole (Notoryctes typhlops), desert-adapted rodents, and rich reptile and bird communities in the Kata Tjuṯa area and spinifex grasslands.
- **Levels 3 and 4** included additional mammals, birds, reptiles, and amphibians of localised importance or requiring further monitoring due to rarity or ecological sensitivity.

2.2 Motivations for a new integrated biodiversity monitoring program

Our analysis of historical monitoring data in Section 1 showed that, despite more than 3 decades of systematic effort, many priority species remain too infrequently detected to quantify long-term trends. Expanding a monitoring program to more sites is often an effective way to increase power. However, the previous methods—based largely on live trapping and volunteer effort—have practical limits in personnel, funding, and time. Expanding survey coverage under that model would compromise data quality and sustainability. Given these constraints, two important factors should be considered: which species should be the focus of monitoring and whether additional or alternative methods should be considered.

Monitoring could prioritise species that serve as ecological indicators or management targets. Focusing on such species enables more efficient data collection and provides clearer metrics of ecosystem condition and management effectiveness (Lindenmayer & Likens, 2010; Nichols & Williams, 2006). Selecting indicators that also hold cultural significance allows alignment of scientific and Aṉangu priorities, supporting biocultural stewardship and the transmission of traditional knowledge through participation in monitoring (Danielsen et al., 2005; Fischer & Lindenmayer, 2007).

While live trapping remains valuable for cultural engagement and data continuity, it is less efficient at detecting certain species that require monitoring, particularly medium- to large-bodied species such as feral cats and foxes. Therefore, complementary data-collection methods should be incorporated into the program. Incorporating passive technologies, including camera traps and acoustic sensors, can substantially improve detection efficiency and species coverage. Camera traps enhance monitoring of cryptic mammals and predators (Burton et al., 2015; Glen et al., 2013), while acoustic recorders extend bird surveys across broader spatial and temporal scales (Shonfield & Bayne, 2017). Together, these tools allow broader, more consistent biodiversity assessment with reduced field effort. Integrating these methods into the monitoring framework would provide a cost-effective way to increase statistical power (see Section 3), fill critical data gaps, and enhance understanding of species' responses to key environmental pressures such as fire, drought, and invasive species.

2.3 Shift to Ecological Indicators and Expert Elicitation

With the methodological improvements outlined above in mind, a consultation process was undertaken to redefine monitoring targets. This process aimed to shift the program from a broad biodiversity inventory toward a focused set of culturally and ecologically significant indicator species—those most detectable with current and proposed methods. The list of species selected through this process is expected to provide a practical foundation for adaptive management, to enable staff and Traditional Owners to evaluate the effectiveness of interventions and refine strategies to achieve desired biocultural outcomes.

Researchers and senior Parks staff conducted consultations with A<u>n</u>angu Traditional Owners, Indigenous Rangers, and species experts through a combination of online, in-person, and on-Country meetings. Recognising limited resources and workforce capacity, participants were invited to identify species that were either culturally significant, known to respond to predefined management interventions (e.g. traditional burning practices), and/or believed to serve as reliable indicators of key ecosystem condition and processes, with this approach designed to integrate knowledge across diverse stakeholder groups. Participants were provided with a list of all species captured in the park since 1987 and asked to review this list and identify species whose population trends and ecological responses serve as meaningful indicators of one or more key indicators (See Appendix 6). Responses were refined based on overlap, the ability of available survey methods to detect the identified species, as well as through direction of local UKTNP Park rangers and management. For example, whilst the marsupial mole was identified as a priority species based on its cultural significance, surveys require a bespoke sampling method that is highly specific to the species, and due to this it was not included as a priority species for a revised monitoring program; instead, species requiring bespoke survey methods are listed in Appendix 7, with brief mention of potential monitoring approaches.

Species were categorised based on their bio-cultural significance and indicator potential across 3 key criteria:

1. cultural significance — species important to A<u>n</u>angu knowledge, practice, and identity
    - **Culturally significant species**, preserving A<u>n</u>angu heritage and recognising the integral place of species in healthy country and spiritual connections;
2. ecological indicator value — species whose populations respond predictably to ecological processes such as fire, drought, and changes in spinifex or mulga woodland habitats;
    - **Fire** response indicators, reflecting ecosystem responses to fire regimes;
    - **Drought** response indicators, capturing resilience to climatic variability;

- **Spinifex condition** and **mulga condition** indicators, assessing habitat health and integrity.

3. management relevance — species that reflect the outcomes of active management, particularly predator control within these habitat types.
   - **Feral predator and herbivore** indicators, monitoring the impact and management of introduced species;

While the expert elicitation identified species of high cultural and ecological importance, practical implementation also required evaluating likely detection rates. A subset of species was reliably detected in historical datasets and is likely to be effectively monitored using passive technologies such as camera traps and acoustic recorders. These species represent a pragmatic set of targets that balance significance with detectability, enhancing the statistical robustness and operational feasibility of the monitoring framework. The resulting priority list (Table 1) includes a broad range of taxa—amphibians, birds, mammals, reptiles, and culturally important plants.

2.4 Complementary contemporary strategies and projects

Given the park's large number of species, landscapes, and threats, it is important to acknowledge the ongoing work to understand and mitigate threats associated with our indicator list. Complementing our ecological indicators are a suite of management strategies and research priorities that aim to address the integrated challenges of invasive species, fire, and climatic variability.

Feral predators

The Uluṟu-Kata Tjuṯa National Park's 2024–2029 Integrated Pest and Culturally Significant Species Management Strategy (IDA 2024) prioritises the control of feral predators, particularly cats and foxes, to protect culturally significant fauna such as the Tjakura (Great Desert Skink). This strategy employs a combination of established and emerging control methods, including leghold and cage trapping, the use of FelixersTM, enhanced monitoring through camera traps, and community engagement and pet management programs in Mutitjulu.

Fire regimes and weeds

The 2023–2027 Integrated Fire and Buffel Grass Management Strategy addresses the escalating threat posed by buffel grass (Cenchrus ciliaris). This invasive species increases fire fuel loads and alters fire behaviour, leading to more frequent and intense fires. This strategy integrates traditional Aṉangu fire management knowledge with contemporary fire science to implement culturally informed fire regimes that promote mosaic patterns and protect fire-sensitive habitats and cultural sites. Rigorous planning, on-Country burn "look arounds" (nyanganyi), and post-burn monitoring are essential components for balancing ecological and cultural outcomes. Through providing recommendations on best-practice approaches and prioritising and sequencing areas for action, the strategy reinforces collaborative regional coordination among Indigenous ranger groups, Parks Australia staff, and neighbouring land managers.

Drought and climate resilience

Monitoring drought impacts remains vital for assessing ecosystem resilience amid increasing climatic variability. Our project supports and extends existing drought research by co-locating passive fauna monitoring sites with sites established in a collaboration between CSIRO and Parks Australia to study drought impacts, in a subset of which there has also been subsequent work by the Australian National University, University of Technology Sydney and Parks Australia to study plant physiology in relation to drought and heatwaves and to install equipment to log microclimatic conditions. The alignment of study sites enables interpretation of species trends in the context of water stress. The spatial integration of biodiversity and drought monitoring will enable land managers and Aṉangu to investigate the effects of drought on fauna assemblages and their subsequent recovery. Importantly, this project provides a framework for understanding drought impacts on biodiversity, a priority emphasised in the Aṉangu-led KAPI (water) Strategy. The KAPI Strategy, currently under development, aims to provide a comprehensive framework for water planning, management, and decision-making that explicitly incorporates climate adaptation measures to address increasing drought risk and extreme weather events. By linking species population dynamics to water availability and habitat conditions, this approach aligns conservation and cultural objectives, reinforcing resilience in both natural ecosystems and Aṉangu communities.

2.5 Culturally significant plant species

In addition to fauna, culturally significant plant species are integral to the ecological and cultural fabric of UKTNP. Although this project does not directly address vegetation monitoring, a suite of key plant species identified through consultation and previous research is recognised for their cultural, ecological, and management importance. These include iconic species such as Desert Myrtle (*Aluta maisonneuvei, pukara*), Desert Oak (*Allocasuarina decaisneana, kurkara*), Desert Raisin (*Solanum centrale, kampurarpa*), Lemon Grass (*Cymbopogon ambiguous, ilintji*), Mulga (*Acacia aneura, wanari*), Quandong (*Santalum acuminatum, mangata*), Soft Spinifex (*Triodia pungens, tjanpi*), Wild Tobacco (*Nicotiana spp., mingkulpa*), Witchetty Bush (*Acacia kempeana, ilykuwara*), and Honey Grevillea (*Grevillea eriostachya, kalinky-kalinypa*).

These plants are significant to Aṉangu as sources of food, medicine, and materials, and as markers of healthy ecosystems. Some species, such as Mulga and Soft Spinifex, also serve as habitat indicators, reflecting broader vegetation conditions and resilience to environmental pressures, including fire and drought. The inclusion of these culturally valued plants within a broader monitoring framework should be a future priority to ensure that conservation efforts align with Indigenous cultural priorities and support ecosystem integrity.

Plant ecologists are working with Anangu at UKTNP on a range of projects aimed at understanding the impacts of climate change on plants (Wright et al., 2023; Godfree and Knerr, 2025). A series of linked projects has generated knowledge about which plant species are dying, where they are dying, and why. Combinations of traditional plot-based botanical surveys, landscape-scale satellite imagery modelling, and plant physiology measurements have allowed researchers and Anangu to answer key questions. Research is focused on species of interest or concern to Anangu, species with alarming mortality rates, and species of ecological importance.

2.6 Results

List of priority species

A refined list of priority species was developed to form the foundation of an integrated, culturally informed monitoring program for Uluṟu–Kata Tjuṯa National Park. The list draws on input from Aṉangu Traditional Owners, Indigenous Rangers, species experts, and park managers, with selection guided by 3 core criteria: cultural significance, value as indicators of ecological processes, and relevance to key management actions. Detectability and feasibility were also assessed to ensure that species could be reliably monitored using current or emerging technologies, such as camera traps, acoustic sensors, and targeted surveys. The final list comprises 27 species (Table 1), each representing one or more management or cultural themes. An expanded list of all species considered during the selection process, including those excluded due to low detectability or specialised monitoring requirements, is provided in Appendix 8.

Table 1. Proposed priority indicator species, including those that are reliably detected from historical (live-trapping) data and those anticipated to be detected via future camera monitoring (identified with *).

Species	Culturally significant	Feral management	Fire	Drought	Spinifex condition	Mulga condition
Australian Ringneck	X					
Crested Bellbird		X				X
Crested Pigeon	X					
Grey Butcherbird						X
Pied Butcherbird	X					X
Purple-backed Fairywren	X					
Splendid Fairywren	X					
White-browed Babbler						X
White-winged Fairywren	X					
Yellow-throated Miner						X
Zebra Finch	X					
Desert Mouse		X	X		X	
Dingo		X				
Feral Cat*		X		X	X	
Mulgara*	X	X				
Red Fox*		X				
Sandy Inland Mouse	X	X				
Spinifex Hopping Mouse	X	X		X		
Wongai Ningaui			X		X	
Central Military Dragon	X					
Central Netted Dragon	X					
Interior Blind Snake	X					
Leopard Ctenotus	X		X	X	X	
Pygmy Desert Monitor	X					
Pygmy Mulga Monitor	X	X	X			X
Sand Goanna*	X					
Short-tailed Pygmy Monitor*	X		X		X	
Desert myrtle	X					
Desert oak	X				X	
Desert raisin	X					
Lemon grass	X					
Mulga	X			X		X
Quandong	X	X	X			
Soft spinifex	X		X			
Wild tobacco	X					
Witchetty bush	X					
Yellow flame Grevillea	X					

2.7 Recommendations

The resulting list of priority species integrates cultural significance, ecological indicator value, and practical detectability under current and emerging monitoring methods. These taxa span birds, reptiles, mammals, and culturally important plants, and are grouped by the primary ecological pressures they help represent—such as fire, drought, feral species, and vegetation condition. Detection rate was a key criterion for filtering, with only species amenable to reliable monitoring through trapping, camera traps, or acoustic sensors retained for implementation. The subsequent monitoring framework, including pilot surveys and survey design optimisation, is detailed in Section 3.

R5 - Prioritise systematic monitoring of the indicator species identified in Table 1: Evaluate management effectiveness, fire management impacts, and the trajectory of culturally significant species and habitats within the Uluṟu-Kata Tjuṯa National Park (UKTNP).

R6 — Perform a power analysis on species encounter rates: Determine the sampling effort required for the new survey methods (camera and acoustic detectors) to reliably detect changes in the encounter rates and site occupancy of indicator species listed in Table 1.

Secondary recommendations emphasise refining monitoring systems and incorporating broader ecological and cultural factors.

R7— Decide if bespoke survey methods are required: Assess the need and feasibility of developing bespoke monitoring programs for important species identified by Aṉangu and Parks Australia staff that are currently undetectable by the existing survey methods. These species include:

Australian Bustard
Bourke's Parrot
Chestnut-breasted Quail-thrush
Dusky Grasswren
Emu
Euro
Grey Fantail
Grey Honeyeater
Mistletoebird
Redthroat
Slaty-backed Thornbill
Western Gerygone
Yellow-rumped Thornbill
Burton's Legless Lizard
Desert Delma
Desert Skink
Jewelled Gecko
Monk Snake
Red Kangaroo
Short-beaked Echidna
Southern Marsupial Mole
Unbanded Delma
Centralian Blue-tongue Skink
Giant Desert Ctenotus
Northern Spiny-tailed Gecko
Sharp-snouted Delma
Striated Grasswren
Western Blue-tongued Lizard

Whilst designing a monitoring program for each of the species listed above is outside the scope of this report, we have provided information in Appendix 7 to outline previously used monitoring approaches for each of these species as a starting point for future monitoring.

3. Monitoring Framework Redesign

The first section investigated the ability of historical survey methods to detect population trends (encounter rates) reliably. In contrast, Section 2 identified a new set of culturally and ecologically significant indicator species for monitoring in the Park. These sections demonstrated that, while ongoing live-trapping programs ensure active participation and knowledge transfer by the Indigenous community, the approach on its own lacks sufficient sensitivity to detect meaningful population trends for many key species. To address these challenges, this section explores alternative and complementary survey techniques that can be used alongside live trapping, including passive methods such as camera trapping and acoustic monitoring. In addition, it conducts a formal power analysis to estimate the survey effort required for camera trapping to detect trends in the encounter rates of the priority species identified in Section 2. This section outlines how to implement the project's objectives and ensure statistical robustness, so that the redesigned monitoring program effectively supports the conservation priorities at UKTNP.

3.1 Passive Survey Methods Pilot

We investigated the integration of novel passive survey methods—specifically, camera trapping—to complement traditional live trapping. Camera trapping offers enhanced detection probabilities for cryptic, nocturnal, and low-density species. It is particularly effective in targeting introduced predators, such as feral cats (Felis catus) and red foxes (Vulpes vulpes), which are key management concerns identified in the recent UKTNP Predator Management Strategy (IDA 2024).

To increase both the spatial and temporal coverage of biodiversity monitoring across the park, 30 new passive monitoring sites were established within UKTNP to augment the existing 8 core trapping locations. These sites were strategically selected to expand spatial coverage and enable direct methodological comparisons, with 8 co-located adjacent to live trapping sites, ten positioned on long-term drought monitoring plots to integrate faunal responses with drought recovery/severity metrics (see 2.5 above), and twelve distributed broadly across the Park to enhance landscape-scale inference (Figure 3).

Each passive site is equipped with 4 baited Reconyx Hyperfire 2 motion-triggered cameras arranged in a 500 m by 500 m square. This size was chosen to ensure compatibility with other regional monitoring programs (e.g., the Parks and Wildlife Commission of the Northern Territory landscape-level cat monitoring plots), as well as to accommodate the deployment and retrieval of passive sensors within the Park. (It currently takes a team of 2 a fortnight to deploy all 30 passive sites, and a subsequent week and a half to retrieve the devices at the end of the monitoring window.) Three model HF2X cameras (baited for small mammals) utilise white-flash technology with customised focal lengths (90cm) optimised for detecting small mammals and reptiles. In contrast, the fourth HF2X model (baited for predators) employs infrared sensors configured to monitor feral predator activity. This multi-camera setup facilitates data collection to calculate species detection rates, site occupancy and predator activity. These passive sites were trialled over 16-week periods in 2023–2024 and 2024–2025 and have been formally adopted into the annual survey program from the 2025–2026 survey season onward.

3.2 Passive Audio Detectors and Data

Acoustic detectors were deployed at each survey site; however, formal analysis of this audio data is beyond the scope of the current project. This will be addressed by a newly funded NESP initiative (2025–2028) focused on optimising acoustic monitoring to support UKTNP's conservation objectives. At each camera survey site, a single Frontier Labs BAR-LT 2-channel audio recorder was deployed to capture vocalisations from avian species and other vocally active taxa, such as dingos. (Detectors were transitioned to the newer BAR-V2 model during the 2025–2026 survey period.) The new NESP project will evaluate the effectiveness of acoustic methods to enhance detection and population assessment of priority species within UKTNP, with particular emphasis on key bird species.

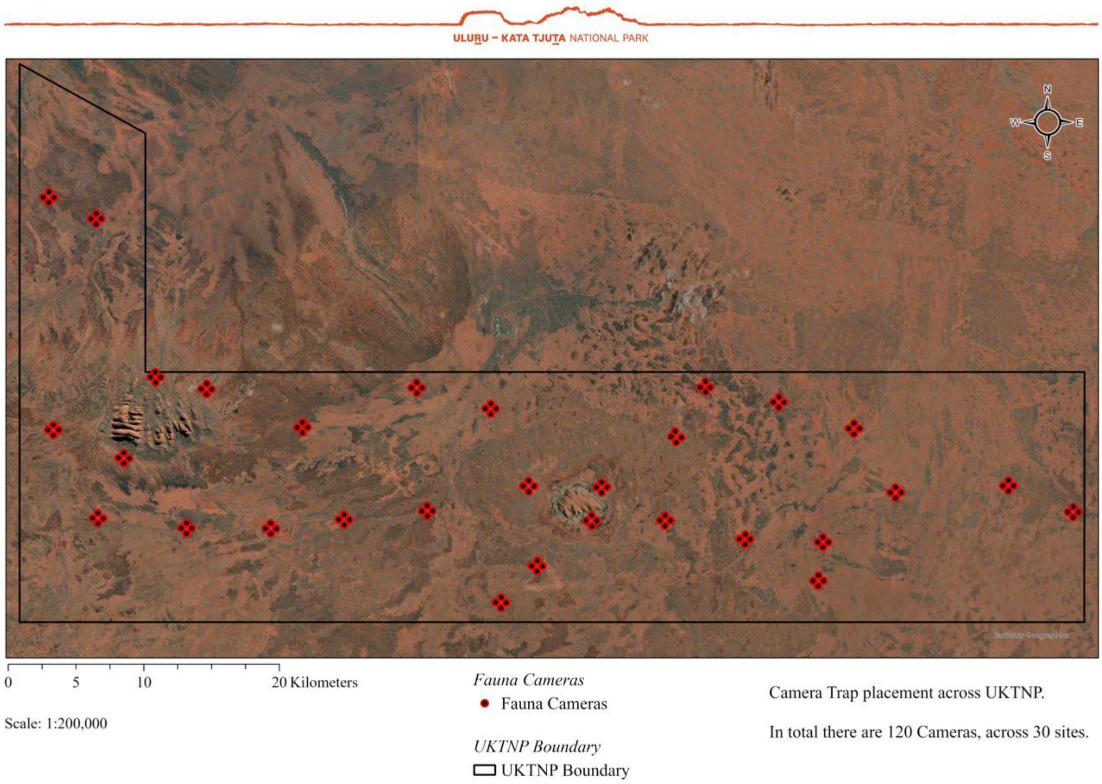

Figure 3. Passive survey locations across UKTNP. Here, each of the 30 passive survey sites comprises 4 wildlife cameras (red circles) and a single audio recorder. Eight of the 30 sites are located at the historical trapping sites.

3.3 Statistical methods

To evaluate the statistical power of the newly implemented camera survey methods and to optimise monitoring of priority species within UKTNP, we conducted a power analysis of both site occupancy and species encounter rates using camera-trap data collected over 2 survey seasons (2023–2025). Detailed statistical methods are detailed in the accompanying research paper (Smart et al. 2025), with a brief overview provided below.

Data Preparation and Processing

To conduct the power analysis, raw camera-trap detection data were collated from 2 consecutive survey years (2023/24 and 2024/25) and merged into a standardised detection history dataset. Data were cleaned and processed to generate 2 datasets: 1) occupancy data, which recorded the presence or absence of species at sites for each day of camera deployment, and 2) encounter data, which was the sum of the number of species detections at each site for each week of camera deployment. Environmental covariates relevant to species occupancy, including site-level burn extent, time since fire, and precipitation metrics standardised across survey years, were extracted from spatial datasets at 1 km resolution. These covariates were summarised as site-year means and standardised to a mean of 0 and unit variance before model fitting.

Species Selection and Filtering

To ensure statistical robustness in both the encounter rate and occupancy power analyses, a filtering step was applied to both priority and non-priority species. Species were excluded from the analysis if they met one or more of the following criteria:

- Fewer than 10 total detections across all survey sites over both years;
- Low spatial variation in detection data, defined as >80% of sites with only non-detections (all 0s) or perfect detections (all 1s), indicating minimal variability between sites in the landscape; or
- Insufficient survey effort is defined as having less than 3 weeks of survey deployment.

This approach ensured that retained species had sufficient detections, spatial variability, and sampling coverage to support reliable model estimation and power analysis. These are standard practices to avoid model convergence issues and unreliable parameter estimates when data are sparse, imbalanced, or exhibit complete or quasi-complete separation (MacKenzie et al., 2002; Kéry & Royle, 2016). Species failing these thresholds were excluded before modelling commenced.

As a result, not all priority species identified for monitoring could be evaluated using the 2 seasons of camera-trap data. This reflects both the limited detectability of some species and the constraints of working with only 2 years of data in a highly variable desert ecosystem. In such systems, temporal fluctuations in species activity—driven by rainfall and temperature—can strongly influence detectability (Letnic & Dickman, 2006; Greenville et al., 2013). Species with low encounter rates or inconsistent detections across space and time are unlikely to yield reliable inferences under limited temporal replication. This filtering step defines the subset of species presented in the power analysis results that follow. We recommend re-running this analysis as data accumulate, enabling additional species to be included in future analyses. Species-level data quality is provided in Appendix 8.

Power analysis of encounter rates

We modelled the mean number of detections per week (encounter rate) for each species across the 2 years of camera-trap data using a Poisson Generalised Linear Mixed Effects model. Ideally, the model would be fitted to a longer monitoring time series (5 or more years) to estimate natural variability in the encounter rate across years explicitly; however, only 2 years of pilot data were available. We then simulated monitoring data using this baseline encounter rate across different survey designs by varying the number of sites and the number of weeks of camera deployment (see below). For each species, camera data were simulated after a period of change, in which the baseline encounter rate was modified by varying degrees (effect sizes of ±10%, ±30%, and ±50%). This data simulation process was repeated 100 times; power was calculated as the proportion of times the change in encounter rate was detected in the simulated datasets.

Power analysis of occupancy

Single-species, single-season occupancy models were fitted within a Bayesian framework using the spOccupancy package. This approach estimates the probability that a site was occupied while accounting for imperfect detection. Occupancy probability was modelled as a function of standardised environmental covariates—specifically burn extent and precipitation—while detection probability was treated as constant due to limited covariate data. Models were fit via Markov Chain Monte Carlo (MCMC) sampling with 3 parallel chains and evaluated using the R-hat diagnostic (<1.1 indicating convergence). Competing models (null, single-covariate, and combined) were compared using the Watanabe–Akaike Information Criterion (WAIC), and posterior estimates were used to derive site-level occupancy and detection probabilities for each species.

We conducted a second power analysis on occupancy to assess the monitoring program's ability to detect an alternative measure of change. First, the presence of each species at each site was simulated by conducting a Bernoulli trial with success probability equal to the occupancy probability. Second, whether each species was detected on each day of camera trapping, given that it was present, was sampled from a second Bernoulli trial with daily detection probabilities. Occupancy data were then simulated during a period of change by varying the occupancy probability (i.e. effect size) by 3 levels (±30%, ±50%, and ±80%).

Extension to Non-Indicator Species

To evaluate the broader applicability of the monitoring design optimised for priority species, we first identified the survey effort levels (site combinations and survey weeks) that provided sufficient power to detect changes in encounter rates across the indicator species. Using these optimised effort parameters, we then conducted a power analysis on a subset of non-indicator species detected by the camera network to determine which additional species would also be reliably monitored under this design. This approach yielded a list of priority and non-priority species for which we would have sufficient power to detect changes in encounter rates, thereby informing the potential for broader camera-based biodiversity monitoring within the proposed indicator-focused survey network.

Monitoring design scenarios

We conducted a power analysis on simulated occupancy and encounter-rate data for alternative monitoring designs, varying the number of sites and the deployment time of cameras. First, we explored a scenario in which the 30 'passive' survey sites established in 2023/24 and 2024/25 for the pilot program continue to be surveyed in the future. The duration of camera deployment was varied from 1 to 4 months for the occupancy simulation. Because power during occupancy exploration was generally low, we chose not to explore a longer deployment window due to the increased simulation runtimes. For the encounter rate metric, we explored an increased deployment window of up to 6 months. This is considered the upper limit of feasibility for data processing. Importantly, extending the camera deployment beyond 5 months would require replacing camera batteries or adjusting camera settings, which would add an additional week of work each year. However, we included this in the encounter rate analysis to assess how an additional 8 weeks of camera deployment affects the results (see Appendix 12). To comprehensively explore the entire survey effort window, we repeated our power analysis under a scenario in which the current camera-trap program is expanded to 40 sites across the Park.

3.4 Results

Although power analyses were conducted for both species occupancy and encounter rates, power to detect occupancy changes was very low across all scenarios tested. The following results focus on the power to detect changes in encounter rates; the results from the occupancy power analysis are provided in Appendix 9.

Monitoring 30 sites (current effort)

Under the recommended monitoring design (30 sites × ≤ 20 weeks), sufficient statistical power (≥ 0.8) to detect changes in encounter rates was achieved for 14 of the 27 priority fauna species across the 3 different effect sizes tested (±10%, ±30%, and ±50) (Table 2). Through increasing the survey effort from 16 weeks to 20 weeks, one species is able to be detected at a reduced effect size of 10%, five species are able to be detected with sufficient power at 30% and one additional priority species is able to be detected at the largest 50% effect size.

Table 2. Statistical power to detect changes in encounter rates for priority species across survey effort scenarios. Each cell indicates whether a species achieved ≥0.8 power to detect a change in encounter rate within ≤20 weeks across combinations of survey sites (15, 30, and 40) and effect sizes (10%, 30%, and 50%). Species shaded in grey were filtered out due to insufficient data and were not modelled.

	15 Sites			30 Sites			40 Sites		
Species	10%	30%	50%	10%	30%	50%	10%	30%	50%
Australian Ringneck									
Central Military Dragon			X		X	X		X	X
Central Netted Dragon		X	X		X	X		X	X
Crested Bellbird			X		X	X		X	X
Crested Pigeon									
Desert Mouse									
Dingo			X		X	X		X	X
Feral Cat		X	X		X	X	X	X	X
Grey Butcherbird									
Interior Blind Snake									
Leopard Ctenotus			X			X		X	X
Mulgara		X	X		X	X		X	X
Pied Butcherbird									X
Purple-backed Fairywren									
Pygmy Desert Monitor						X			X
Pygmy Mulga Monitor						X			X
Red Fox		X	X		X	X		X	X
Sand Goanna		X	X		X	X	X	X	X
Sandy Inland Mouse						X			X
Short-tailed Pygmy Monitor						X			X
Spinifex Hopping Mouse	X	X	X	X	X	X	X	X	X
Splendid Fairywren									
White-browed Babbler									
White-winged Fairywren									
Wongai Ningaui									
Yellow-throated Miner									
Zebra Finch									

Monitoring 40 Sites (increased effort)

Expanding survey effort to 40 sites (with a 20-week deployment) increased the number of priority species achieving ≥ 0.8 power to 15 out of the 27, with one additional priority species reaching the 0.8 statistical power threshold for a 50% change (Pied Butcherbird; Cracticus nigrogularis). The Feral Cat (Felis catus) also shifted into the smaller 10% effect-size bracket (Table 2).

Monitoring 15 sites (decreased effort)

Reducing the number of monitoring sites to 15 (with a 20-week deployment) resulted in a maximum of 10 species being detected with sufficient levels of power (>0.8) under the maximum effect size (50%)(Table 2). This comparison illustrates the statistical power achievable under a reduced sampling approach, for example, where each site is surveyed once every 2 years—analogous to the current live-trapping design where 4 of 8 sites are surveyed annually.

Nine of the 12 priority species with low power were excluded during the data filtering step, with only the Desert Mouse, White-browed Babbler and Zebra Finch being modelled. These findings indicate that the current monitoring program can estimate trends in encounter rates of a variety of common and invasive species, while rarer species or habitat specialists—such as the Fairywrens, Wongai Ningaui, and Interior Blind Snake— require a different survey approach (e.g. audio detectors, targeted habitat surveys) to achieve sufficient power for long-term trend detection.

Non-priority species

Among non-priority taxa recorded incidentally through the camera monitoring network, several also achieved statistical power ≥ 0.8 (under various effect sizes) with the increased deployment length configuration (≤ 30 sites × 20 weeks):

- Australian Magpie (*Gymnorhina tibicen*)
- Black-faced Woodswallow (*Artamus cinereus*)
- European Rabbit (*Oryctolagus cuniculus*)
- Western Bowerbird (*Chlamydera guttata*)
- Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*)

With expanded effort both spatially and temporally (≤ 40 sites × 20 weeks), additional non-priority species reached or exceeded 0.8 power (under various effect sites):

- Bearded Dragon (*Pogona minor*)
- Black-headed Monitor (*Varanus tristis*)
- Central Bluetongue (*Tiliqua multifasciata*)
- Western Bluetongue (*Tiliqua occipitalis*)
- Crimson Chat (*Epthianura tricolor*)
- Diamond Dove (*Geopelia cuneata*)
- Grey Shrike-thrush (*Colluricincla harmonica)*
- Masked Woodswallow (*Artamus personatus)*
- Rufous Songlark (*Megalurus mathewsi*)
- White-plumed Honeyeater (*Ptilotula penicillata*)
- House Mouse (*Mus musculus*)
- Singing Honeyeater (*Gavicalis virescens*)
- White-winged Triller (*Lalage sueurii*)

A table containing the power estimates for a change in encounter rates for all species can be found as Appendix 11, with the power surface plots as Appendix 10.

3.5 Recommendations

R8 – Maintain and move to increase the deployment window of cameras: We recommend that cameras be deployed for a minimum of 20 consecutive weeks (~5 months), given current operational constraints on image processing capacity. Additionally, if new methods or technologies become available that reduce image processing time, this deployment period could be extended to increase the power to pick up changes in encounter rates of priority and non-priority species. This may require that cameras be serviced one additional time during the monitoring window, which would require a team of 2 a week and a half.

R9 – Conduct a power analysis on passive audio detectors: Many of the priority species not reliably detected on wildlife cameras are birds. Once multiple years of survey data are collected with the pilot audio detector surveys (i.e. from 2026 onwards), conduct a power analysis to ascertain optimal monitoring durations and spatial extent. This could entail an additional pilot period to examine the redeployment of audio detectors to new survey sites to target habitat specialist on the indicator species list (i.e. striated grasswren).

R10 – Ensure passive detectors are deployed each year to quantify annual variation in detection rates: The recommendations outlined in this section are based on only 2 seasons of camera survey data. Given the high interannual variability of desert ecosystems, encounter rates and statistical power may shift substantially under different environmental conditions. We recommended that this analysis be reconducted after 5 consecutive years of monitoring has occurred (i.e. 2028).

R11 – For low-power priority species, consider alternative monitoring methods: After ensuring that sufficient resourcing is available to support the annual live trapping and new ‘passive’ fauna surveys, conduct a targeted consultation to understand if A<u>n</u>angu and Parks Australia require bespoke monitoring for priority species not sufficiently captured by the current survey methods.

R12 – Prioritise encounter rate over occupancy as the primary monitoring metric:
The occupancy analysis achieved adequate power only for feral cat (*Felis catus*). Occupancy should be retained solely as a supplementary indicator for feral cat, where baseline occupancy is high and the metric achieves sufficient statistical power under the current monitoring design. For all other taxa, occupancy should not be relied upon for primary inference, and effort should focus on standardised encounter rate analyses.

Appendices

Appendix 1. Summary of all recommendations within this report

R1 – Reduce observational bias between survey years: A key limitation in our ability to confidently understand trends in species is the current inability to disentangle the effect of different observer skill levels between survey years. The success of trapping an animal ultimately depends on the underlaying population levels, the survey conditions and the skill at which traps are set, and animals are identified. Where possible, UKTNP management should ensure that rigorous training and supervision is provided to new Park rangers who are tasked with overseeing, running and recording survey data. This includes in new and novel survey techniques that are recommended in subsequent sections.

R2 – Record and retain data in its most granular format: Data should be collected and retained at a granular level to allow accurate calculation of trap detectability and reduce observational or methodological bias. Whilst it may not be feasible to record data at the trap level (i.e. what each individual trap catches each day), at a minimum data should be recorded and retained at the daily level (i.e. the species captured each day including the level of effort, such as traps numbers). This will allow subsequent analysis to control for bias introduced through difference in observer effects or change in approaches. In addition, standardise data collection for critical risks such as the existence and quantity of feral predators (e.g., cats and foxes), presence of drought, fire extent and severity, and/or invasive plants (e.g., Buffel grass).

R3 – Broaden and diversify survey methods: Pilot the use of passive wildlife sensors to increase the number of detections for species within the Park. This will improve the detection of cryptic, nocturnal, and low-density species, broadening the scope of biodiversity surveys and increasing the ability to conduct trend analysis. In addition, this will allow monitoring to target invasive predators and herbivores within the Park, which are currently not captured by live trapping techniques.

R4 – Increase spatial and temporal coverage: Increase the number and geographic distribution of monitoring sites across the UKTNP to better capture habitat heterogeneity and environmental gradients, and close temporal gaps between monitoring phases to provide continuous population trend data.

R5 – Prioritise systematic monitoring of the indicator species identified in Table 1: Evaluate management effectiveness, fire management impacts, and the trajectory of culturally significant species and habitats within the Uluṟu-Kata Tjuṯa National Park (UKTNP).

R6 — Perform a power analysis on species encounter rates: Determine the sampling effort required for the new survey methods (camera and acoustic detectors) to reliably detect changes in the encounter rates and site occupancy of indicator species listed in Table 1.

R7 — Decide if bespoke survey methods are required: Assess the need and feasibility of developing bespoke monitoring programs for important species identified by Aṉangu

and Parks staff that are currently undetectable by the existing survey methods. These species include: Australian Bustard, Bourke's Parrot, Chestnut-breasted Quail-thrush, Dusky Grasswren, Emu, Euro, Grey Fantail, Grey Honeyeater, Mistletoebird, Redthroat, Slaty-backed Thornbill, Western Gerygone ,Yellow-rumped Thornbill ,Burton's Legless Lizard ,Desert Delma, Desert Skink ,Jewelled Gecko ,Monk Snake ,Red Kangaroo, Short-beaked Echidna, Southern Marsupial Mole, Unbanded Delma, Centralian Blue-tongue Skink, Giant Desert Ctenotus, Northern Spiny-tailed Gecko ,Sharp-snouted Delma, Striated Grasswren ,Western Blue-tongued Lizard.

R8 – Maintain and move to increase the deployment window of cameras: We recommend that cameras be deployed for a minimum of 20 consecutive weeks (~5 months), given current operational constraints on image processing capacity. However, if new methods or technologies become available that reduce image processing time, this deployment period could be extended to increase the power to pick up changes in encounter rates of priority and non-priority species. This may require that cameras be serviced one additional time during the monitoring window, which would require a team of 2 a week and a half.

R9 – Conduct a power analysis on passive audio detectors: Many of the priority species not reliably detected on wildlife cameras are birds. Once multiple years of survey data are collected with the pilot audio detector surveys, conduct a power analysis to ascertain optimal monitoring durations and spatial extent (i.e. 2026 onwards). This could entail an additional pilot period to examine the redeployment of audio detectors to new survey sites to target habitat specialist on the indicator species list (i.e. striated grasswren).

R10 – Ensure passive detectors are deployed each year to quantity annual variation in detection rates: The recommendations outlined in this section are based on only 2 seasons of camera survey data. Given the high interannual variability of desert ecosystems, encounter rates and statistical power may shift substantially under different environmental conditions. We recommend that this analysis be reconducted after 5 consecutive years of monitoring has occurred (i.e. 2028).

R11 – For low-power priority species, consider alternative monitoring methods: After ensuring that sufficient resourcing is available to support the annual live trapping and new ‘passive’ fauna surveys, conduct a targeted consultation to understand if Aṉangu and Parks Australia require bespoke monitoring for priority species not sufficiently captured by the current survey methods.

R12 – Prioritise encounter rate over occupancy as the primary monitoring metric: The occupancy analysis achieved adequate power only for feral cat (*Felis catus*). Occupancy should be retained solely as a supplementary indicator for feral cat, where baseline occupancy is high and the metric achieves sufficient statistical power under the current monitoring design. For all other taxa, occupancy should not be relied upon for primary inference, and effort should focus on standardised encounter rate analyses.

Appendix 2: All species detected across the monitoring period of 1987-2025.

Table A2. List of species detected showing candidate priority species in grey. Inclusion is based on cultural significance, ecological indicator value (feral species, fire, drought), and representation of vegetation condition (spinifex and mulga). A value of "X" indicates relevance to the corresponding category.

Species	Cultural	Feral	Fire	Drought	Spinifex	Mulga
Australasian Pipit						
Australian Bustard	X					
Australian Hobby						
Australian Kestrel						
Australian Magpie						
Australian Magpie-lark						
Australian Owlet-nightjar						
Australian Ringneck	X					
Banded Whiteface						
Barn Owl						
Barred Wedge-snout Ctenotus						
Beaded Gecko						
Black Honeyeater						
Black Kite						
Black-breasted Buzzard						
Black-eared Cuckoo						
Black-faced Cuckoo-shrike						
Black-faced Woodswallow						
Black-headed Monitor						
Black-shouldered Kite						
Blue-tailed Finesnout Ctenotus						
Bourke's Parrot	X					
Brooks' Wedge-snouted Ctenotus						
Brown Falcon						
Brown Goshawk						
Brown Honeyeater						
Brown Quail						
Brown Songlark						
Brown Thornbill						
Budgerigar						
Buff-tailed Finesnout Ctenotus						
Burton's Legless Lizard	X					
Bynoe's Gecko						
Feral Cat	X	X		X		
Central Deserts Robust Slider						
Central Military Dragon	X	X				
Central Netted Dragon	X					
Centralian Blue-tongue Skink	X					
Centralian Dtella						
Centralian Earless Dragon						
Chestnut-breasted Quail-thrush	X					
Chestnut-rumped Thornbill						
Chiming Wedgebill						

Species	Cultural	Feral	Fire	Drought	Spinifex	Mulga
Chiming Whipbird						
Clay-soil Ctenotus						
Cockatiel						
Collared Sparrowhawk						
Common Bronzewing						
Common Dwarf Skink						
Copperback Quail-thrush						
Corvus sp.						
Course Sand Ctenotus						
Crest-tailed Mulgara	X	X	X		X	
Crested Bellbird	X	X	X			
Crested Pigeon						
Crimson Chat						
Desert Delma	X		X		X	
Desert Egernia						
Desert Mouse	X	X	X		X	
Desert Pygmy Monitor	X					
Desert Rainbow-skink						
Desert Skink	X	X	X	X	X	
Desert Whipsnake						
Diamond Dove						
Dingo		X				
Dromedary Camel						
Dunnart						
Dusky Grasswren	X	X				
Dwarf Bearded Dragon						
Emu	X					
Euro	X					
European Rabbit						
Excitable delma						
Fairy Martin						
Fairywren						
Fat-tailed Dunnart						
Fat-tailed False Antechinus						
Fine Side-lined Ctenotus						
Finlayson's Cave Bat						
Fork-tailed Swift						
Fourteen-lined Ctenotus						
Galah						
Ghost Skink						
Giant Desert Ctenotus	X	X	X	X	X	
Goanna						
Gould's Wattled Bat						
Grey Butcherbird						
Grey Fantail	X					
Grey Honeyeater	X					
Grey Shrike-thrush						
Grey-fronted Honeyeater						
Grey-headed Honeyeater						

Species	Cultural	Feral	Fire	Drought	Spinifex	Mulga
Grey-striped Western Dragon						
Ground Cuckooshrike						
Hairy-footed Dunnart						
Hooded Robin						
Hooded Scaly-foot						
Horsefield's Bronze Cuckoo						
House Mouse						
Inland Snake-eyed Skink						
Inland Thornbill						
Interior Blind Snake	X	X				
Jacky Winter						
Jewelled Gecko	X	X	X	X	X	
King Brown Snake						
Kultarr						
Leonhardi's Ctenotus						
Leopard Ctenotus	X	X	X	X	X	
Lesser Hairy-footed Dunnart						
Lesser Long-eared Bat						
Lined Firetail Skink						
Little Buttonquail						
Little Crow						
Little Eagle						
Little Woodswallow						
Long-beaked Blind Snake						
Long-nosed Water Dragon						
Main's Frog						
Masked Woodswallow						
Massive-gibber Ctenotus						
Mistletoebird	X					
Monk Snake	X	X	X	X	X	X
House Mouse						
Mulga Parrot						
Mulgara	X					
Nankeen Kestrel						
Narrow-banded Burrowing Snake						
Nasute Finesnout Ctenotus						
Night Skink						
Nimble Ctenotus						
North-western Sandslider						
Northern Desert Banded Snake						
Northern Snake-lizard						
Northern Spiny-tailed Gecko	X	X	X	X	X	X
Ooldea Dunnart						
Orange-tailed Finesnout Ctenotus						
Ornate Soil-crevice Skink						
Painted Finch						
Pale Knob-tailed Gecko						
Pallid Cuckoo						
Peaceful Dove						

Species	Cultural	Feral	Fire	Drought	Spinifex	Mulga
Peregrine Falcon						
Perentie	X					
Pied Butcherbird	X	X				
Pied Honeyeater						
Pink Cockatoo						
Purple-backed Fairywren						
Purplish Dtella						
Pygmy Desert Monitor						
Pygmy Mulga Monitor	X	X	X			X
Rainbow Bee-eater						
Red Fox	X	X				
Red kangaroo	X			X		
Red-backed Kingfisher						
Red-browed Pardalote						
Red-capped Robin						
Redthroat	X	X			X	
Ringed Brown Snake						
Rufous Songlark						
Rufous Whistler						
Sand Goanna	X	X	X			
Sandy Inland Mouse	X	X				
Scarlet-chested parrot						
Sharp-snouted Delma	X	X	X		X	
Shoemaker frog	X					
Short-beaked Echidna	X	X				
Short-tailed Pygmy Monitor	X		X		X	
Singing Honeyeater						
Slaty-backed Thornbill	X					
Southern Boobook						
Southern Marsupial Mole	X	X				X
Southern Sandslider						
Southern Shovel-nosed Snake						
Southern Whiteface						
Spinifex Hopping Mouse	X	X		X		
Spinifex Slender Blue-tongue						
Spiny-cheeked Honeyeater						
Splendid Fairywren	X					
Spotted Harrier						
Spotted Nightjar						
Stony-soil Ctenotus						
Striated Grasswren	X	X	X			X
Striated Pardalote						
Tawny Frogmouth						
Thorny Devil	X					
Three-lined Knob-tailed Gecko						
Torresian Crow						
Tree Dtella						
Tree Martin						
Unbanded Delma	X	X	X		X	

Species	Cultural	Feral	Fire	Drought	Spinifex	Mulga
Variable Fat-tailed Gecko						
Varied Sittella		X				
Wedge-tailed Eagle						
Weebill						
Western Beaked-gecko						
Western Blue-tongued Lizard	X		X		X	
Western Bowerbird						
Western Brown Snake						
Western Gerygone	X					
Western Sandplain Gecko						
Whistling Kite						
White-backed Swallow						
White-browed Babbler	X					
White-fronted Honeyeater						
White-plumed Honeyeater						
White-winged Fairywren						
White-winged Triller						
Willie Wagtail						
Witchetty bush	X					
Wongai Ningaui			X		X	
Yellow-rumped Thornbill	X					
Yellow-tailed Plain Slider						
Yellow-throated Miner	X					
Zebra Finch	X					

Appendix 3. Estimated yearly trend coefficients on detection rates for each modelled species

Table A3. Estimated yearly trend coefficients for each modelled species based on 2 years of camera trap data. Values represent the mean effect size for the "Year" parameter, with standard deviation expressed as a ±1 SD range. These values reflect the direction and magnitude of interannual change in detection probability, assuming consistent survey effort and detectability across time. Positive values suggest increasing trends, while negative values indicate declining trend.

Species	Year Trend Parameter(¬±SD)		
Little Buttonquail	0.25 (0.21, 0.29)	Yellow-rumped Thornbill	0.01 (0.0, 0.02)
Cockatiel	0.09 (0.08, 0.1)	Brown Songlark	0.01 (-0.01, 0.03)
Black-eared Cuckoo	0.06 (0.04, 0.08)	Rainbow Bee-eater	0.01 (0.0, 0.02)
Pied Honeyeater	0.06 (0.05, 0.07)	Desert Delma	0.01 (-0.03, 0.05)
Diamond Dove	0.04 (0.03, 0.05)	Crested Bellbird	0.01 (0.01, 0.01)
Budgerigar	0.03 (0.03, 0.03)	Grey Shrike-thrush	0.0 (-0.01, 0.01)
White-winged Triller	0.03 (0.03, 0.03)	Hooded Scaly-foot	0.0 (0.0, 0.0)
Masked Woodswallow	0.03 (0.03, 0.03)	Hairy-footed Dunnart	0.0 (-0.02, 0.02)
Black Honeyeater	0.03 (0.02, 0.04)	Willie Wagtail	0.0 (0.0, 0.0)
Rufous Songlark	0.03 (0.01, 0.05)	Zebra Finch	-0.01 (-0.01, -0.01)
Grey Fantail	0.02 (0.0, 0.04)	Brown Falcon	-0.01 (-0.03, 0.01)
Pallid Cuckoo	0.02 (0.0, 0.04)	Spinifex Hopping Mouse	-0.01 (-0.01, -0.01)
Australian Kestrel	0.02 (0.01, 0.03)	Course Sand Ctenotus	-0.01 (-0.04, 0.02)
Collared Sparrowhawk	0.02 (0.0, 0.04)	Spiny-cheeked Honeyeater	-0.01 (-0.01, -0.01)
Ground Cuckooshrike	0.02 (0.0, 0.04)	White-fronted Honeyeater	-0.01 (-0.01, -0.01)
Banded Whiteface	0.01 (0.0, 0.02)	Crimson Chat	-0.01 (-0.01, -0.01)
Little Woodswallow	0.01 (0.0, 0.02)	Torresian Crow	-0.01 (-0.02, 0.0)
Rufous Whistler	0.01 (0.01, 0.01)	Grey-headed Honeyeater	-0.02 (-0.02, -0.02)
Fairy Martin	0.01 (0.01, 0.01)	Black-faced Woodswallow	-0.02 (-0.02, -0.02)

Species	Year Trend Parameter(¬±SD)		
White-winged Fairywren	-0.02 (-0.02, -0.02)	Desert Rainbow-skink	-0.04 (-0.08, 0.0)
Weebill	-0.02 (-0.04, 0.0)	Desert Whipsnake	-0.04 (-0.08, 0.0)
North-western Sandslider	-0.02 (-0.02, -0.02)	Dwarf Bearded Dragon	-0.04 (-0.05, -0.03)
Singing Honeyeater	-0.02 (-0.02, -0.02)	Hooded Robin	-0.05 (-0.06, -0.04)
Red-backed Kingfisher	-0.02 (-0.04, 0.0)	White-plumed Honeyeater	-0.05 (-0.05, -0.05)
Bynoe's Gecko	-0.02 (-0.16, 0.12)	Chiming Wedgebill	-0.05 (-0.06, -0.04)
Red-capped Robin	-0.02 (-0.02, -0.02)	Red-browed Pardalote	-0.05 (-0.07, -0.03)
Clay-soil Ctenotus	-0.03 (-0.04, -0.02)	Variable Fat-tailed Gecko	-0.05 (-0.06, -0.04)
Horsefield's Bronze Cuckoo	-0.03 (-0.04, -0.02)	Western Beaked-gecko	-0.05 (-0.06, -0.04)
Black-faced Cuckoo-shrike	-0.03 (-0.04, -0.02)	Slaty-backed Thornbill	-0.05 (-0.06, -0.04)
Inland Thornbill	-0.03 (-0.03, -0.03)	Northern Desert Banded Snake	-0.05 (-0.06, -0.04)
Ornate Soil-crevice Skink	-0.03 (-0.06, 0.0)	White-browed Babbler	-0.05 (-0.05, -0.05)
Crested Pigeon	-0.03 (-0.04, -0.02)	Centralian Dtella	-0.05 (-0.08, -0.02)
Massive-gibber Ctenotus	-0.03 (-0.03, -0.03)	Wongai Ningaui	-0.05 (-0.06, -0.04)
Splendid Fairywren	-0.03 (-0.03, -0.03)	Australian Magpie	-0.05 (-0.06, -0.04)
Varied Sittella	-0.03 (-0.04, -0.02)	Grey Butcherbird	-0.05 (-0.07, -0.03)
Orange-tailed Finesnout Ctenotus	-0.03 (-0.04, -0.02)	Jacky Winter	-0.06 (-0.11, -0.01)
Nasute Finesnout Ctenotus	-0.04 (-0.14, 0.06)	Pygmy Mulga Monitor	-0.06 (-0.09, -0.03)
Redthroat	-0.04 (-0.05, -0.03)	Purple-backed Fairywren	-0.06 (-0.07, -0.05)
Southern Whiteface	-0.04 (-0.04, -0.04)	Leonhardi's Ctenotus	-0.06 (-0.07, -0.05)
Yellow-throated Miner	-0.04 (-0.04, -0.04)	Leopard Ctenotus	-0.06 (-0.07, -0.05)
Lesser Hairy-footed Dunnart	-0.04 (-0.05, -0.03)	Pink Cockatoo	-0.06 (-0.07, -0.05)
Chestnut-rumped Thornbill	-0.04 (-0.05, -0.03)	Fat-tailed False Antechinus	-0.06 (-0.09, -0.03)
Common Bronzewing	-0.04 (-0.04, -0.04)	Monk Snake	-0.06 (-0.1, -0.02)
Desert Egernia	-0.04 (-0.05, -0.03)	Galah	-0.06 (-0.08, -0.04)
Desert Mouse	-0.04 (-0.05, -0.03)	Fourteen-lined Ctenotus	-0.06 (-0.07, -0.05)

Species	Year Trend Parameter(¬±SD)		
Fine Side-lined Ctenotus	-0.07 (-0.08, -0.06)	Mulga Parrot	-0.18 (-0.21, -0.15)
Southern Shovel-nosed Snake	-0.07 (-0.24, 0.1)	Purplish Dtella	-0.21 (-0.22, -0.2)
Night Skink	-0.07 (-0.07, -0.07)	Western Brown Snake	-0.22 (-0.3, -0.14)
Centralian Blue-tounge Skink	-0.08 (-0.09, -0.07)	Black-headed Monitor	-0.22 (-0.34, -0.1)
Ringed Brown Snake	-0.08 (-0.11, -0.05)	Interior Blind Snake	-0.23 (-0.25, -0.21)
Grey-striped Western Dragon	-0.08 (-0.11, -0.05)	Western Bowerbird	-0.25 (-0.25, -0.25)
Tree Dtella	-0.08 (-0.17, 0.01)	Crest-tailed Mulgara	-0.28 (-0.34, -0.22)
Bourke's Parrot	-0.09 (-0.11, -0.07)	Northern Spiny-tailed Gecko	-0.29 (-0.34, -0.24)
Blue-tailed Finesnout Ctenotus	-0.09 (-0.12, -0.06)	Australasian Pipit	-0.29 (-0.36, -0.22)
Australian Ringneck	-0.09 (-0.11, -0.07)	Central Military Dragon	-0.31 (-0.33, -0.29)
Wedge-tailed Eagle	-0.09 (-0.14, -0.04)	Central Deserts Robust Slider	-0.4 (-0.45, -0.35)
Pied Butcherbird	-0.1 (-0.12, -0.08)	Ooldea Dunnart	-0.5 (-0.55, -0.45)
Sandy Inland Mouse	-0.1 (-0.1, -0.1)	Nankeen Kestrel	-0.57 (-0.62, -0.52)
Little Crow	-0.1 (-0.11, -0.09)	Buff-tailed Finesnout Ctenotus	-0.58 (-0.61, -0.55)
Jewelled Gecko	-0.11 (-0.14, -0.08)	Spinifex Slender Blue-tongue	-0.64 (-1.12, -0.16)
Lined Firetail Skink	-0.11 (-0.13, -0.09)	Central Netted Dragon	-0.75 (-0.8, -0.7)
Thorny Devil	-0.12 (-0.14, -0.1)	Desert Pygmy Monitor	-0.77 (-0.87, -0.67)
Mistletoebird	-0.13 (-0.27, 0.01)	Burton's Legless Lizard	-0.91 (-1.01, -0.81)
Sand-Plain Gecko	-0.13 (-0.19, -0.07)	Unbanded Delma	-0.98 (-1.08, -0.88)
Brooks' Wedge-snouted Ctenotus	-0.13 (-0.17, -0.09)	Sharp-snouted Delma	-1.04 (-1.19, -0.89)
House Mouse	-0.14 (-0.14, -0.14)	White-backed Swallow	-1.26 (-2.13, -0.39)
Common Dwarf Skink	-0.15 (-0.18, -0.12)	Short-beaked Echidna	-1.7 (-1331.22, 1327.82)
Short-tailed Pygmy Monitor	-0.15 (-0.17, -0.13)	Inland Snake-eyed Skink	-1.7 (-3026.25, 3022.85)
Giant Desert Ctenotus	-0.16 (-0.41, 0.09)	Australian Bustard	-2.1 (-3.49, -0.71)
Pale Knob-tailed Gecko	-0.16 (-0.18, -0.14)		
Barred Wedge-snout Ctenotus	-0.17 (-0.23, -0.11)		

Appendix 4. Environmental Covariate Effects on Species Detection Rates

Table A4. Estimated effects of environmental covariates on detection probability for each modelled species. Each cell presents the mean coefficient estimate for a given covariate with its ±1 standard deviation range, based on 2 years of camera trap data. Covariates include fire history (e.g., time since fire, area burnt) and the rainfall in the year proceedings the surveys. Positive values indicate an increase in detection probability with increasing covariate values, while negative values indicate a decrease. Only species and covariates retained in final model fits are shown.

Species	Percentage of Site burnt	Lagged Annual Precipitation	Time since last fire
Australasian Pipit	-0.28 (-0.55, -0.01)	-	-0.07 (-0.17, 0.03)
Australian Bustard	-16.64 (-53.28, 20.0)	-	-
Australian Kestrel	-0.99 (-1.6, -0.38)	3.19 (2.12, 4.26)	-0.03 (-0.12, 0.06)
Australian Magpie	-0.03 (-0.04, -0.02)	0.02 (-0.05, 0.09)	-0.06 (-0.08, -0.04)
Australian Ringneck	-0.0 (-0.01, 0.01)	-0.03 (-0.04, -0.02)	0.0 (-0.01, 0.01)
Banded Whiteface	-	0.01 (0.0, 0.02)	-
Barred Wedge-snout Ctenotus	-0.14 (-0.32, 0.04)	0.01 (-0.03, 0.05)	-0.2 (-0.37, -0.03)
Black Honeyeater	-0.91 (-1.21, -0.61)	0.6 (0.5, 0.7)	-0.04 (-0.09, 0.01)
Black-eared Cuckoo	-2.01 (-3.42, -0.6)	-0.92 (-1.3, -0.54)	-0.36 (-0.56, -0.16)
Black-faced Cuckoo-shrike	0.0 (-0.01, 0.01)	0.23 (0.17, 0.29)	-0.06 (-0.08, -0.04)
Black-faced Woodswallow	-0.0 (-0.0, 0.0)	0.01 (0.01, 0.01)	-0.0 (-0.0, 0.0)
Black-headed Monitor	-5.37 (-6957.75, 6947.01)	0.79 (0.23, 1.35)	-0.21 (-0.34, -0.08)
Blue-tailed Finesnout Ctenotus	-0.1 (-0.14, -0.06)	0.03 (0.0, 0.06)	0.18 (0.11, 0.25)
Bourke's Parrot	-1.47 (-2.8, -0.14)	0.13 (-0.07, 0.33)	-0.22 (-0.28, -0.16)
Brooks' Wedge-snouted Ctenotus	-0.01 (-0.03, 0.01)	0.06 (0.03, 0.09)	0.14 (0.08, 0.2)
Brown Falcon	-	0.18 (0.15, 0.21)	0.12 (0.08, 0.16)
Brown Songlark	0.01 (-0.01, 0.03)	0.2 (-0.03, 0.43)	0.52 (0.36, 0.68)
Budgerigar	-0.45 (-0.48, -0.42)	0.21 (0.2, 0.22)	0.05 (0.05, 0.05)
Buff-tailed Finesnout Ctenotus	-0.02 (-0.05, 0.01)	1.38 (1.04, 1.72)	0.02 (-0.15, 0.19)

Species	Percentage of Site burnt	Lagged Annual Precipitation	Time since last fire
Burton's Legless Lizard	-0.04 (-0.16, 0.08)	-	-
Bynoe's Gecko	0.15 (-0.11, 0.41)	-0.08 (-0.36, 0.2)	-
Central Deserts Robust Slider	0.01 (-0.02, 0.04)	0.02 (-0.02, 0.06)	-0.14 (-0.2, -0.08)
Central Military Dragon	-0.15 (-0.2, -0.1)	0.01 (-0.01, 0.03)	0.17 (0.15, 0.19)
Central Netted Dragon	0.03 (-0.03, 0.09)	0.04 (-0.03, 0.11)	-
Centralian Blue-tounge Skink	-0.04 (-0.09, 0.01)	-0.23 (-0.51, 0.05)	-0.01 (-0.06, 0.04)
Centralian Dtella	-5.1 (-841.2, 831.0)	1.08 (0.48, 1.68)	-0.41 (-0.62, -0.2)
Chestnut-rumped Thornbill	0.01 (0.0, 0.02)	-0.1 (-0.18, -0.02)	-0.12 (-0.14, -0.1)
Chiming Wedgebill	-0.04 (-0.05, -0.03)	0.12 (0.06, 0.18)	0.16 (0.12, 0.2)
Clay-soil Ctenotus	0.01 (0.01, 0.01)	0.24 (0.17, 0.31)	0.0 (-0.01, 0.01)
Cockatiel	0.04 (0.04, 0.04)	0.15 (0.03, 0.27)	0.03 (-0.02, 0.08)
Collared Sparrowhawk	-0.9 (-1.25, -0.55)	0.46 (0.35, 0.57)	0.13 (0.05, 0.21)
Common Bronzewing	-0.01 (-0.02, 0.0)	0.12 (-0.01, 0.25)	0.04 (-0.01, 0.09)
Common Dwarf Skink	-0.16 (-0.22, -0.1)	0.0 (-0.01, 0.01)	-
Course Sand Ctenotus	-	0.0 (-0.02, 0.02)	-
Crest-tailed Mulgara	-0.02 (-0.04, 0.0)	0.42 (0.27, 0.57)	0.14 (0.06, 0.22)
Crested Bellbird	-0.01 (-0.01, -0.01)	0.17 (0.15, 0.19)	0.04 (0.03, 0.05)
Crested Pigeon	-0.02 (-0.03, -0.01)	0.2 (0.14, 0.26)	0.05 (0.02, 0.08)
Crimson Chat	-0.06 (-0.07, -0.05)	0.0 (0.0, 0.0)	-
Desert Delma	-7.26 (-1455.49, 1440.97)	-0.78 (-1.2, -0.36)	0.04 (-0.02, 0.1)
Desert Egernia	-0.04 (-0.07, -0.01)	0.04 (-0.04, 0.12)	0.01 (0.0, 0.02)
Desert Mouse	0.01 (0.01, 0.01)	0.27 (0.23, 0.31)	0.08 (0.07, 0.09)
Desert Pygmy Monitor	-0.18 (-0.44, 0.08)	0.07 (-0.05, 0.19)	-0.09 (-0.28, 0.1)
Desert Rainbow-skink	-5.83 (-24844.67, 24833.01)	0.65 (0.38, 0.92)	-0.2 (-0.25, -0.15)
Desert Whipsnake	0.0 (-0.02, 0.02)	-1.64 (-2.33, -0.95)	0.06 (0.02, 0.1)
Diamond Dove	-1.21 (-1.42, -1.0)	0.11 (0.04, 0.18)	0.14 (0.1, 0.18)

Species	Percentage of Site burnt	Lagged Annual Precipitation	Time since last fire
Dwarf Bearded Dragon	-7.69 (-598.9, 583.52)	0.17 (0.03, 0.31)	-0.01 (-0.04, 0.02)
Fairy Martin	0.01 (0.0, 0.02)	0.41 (0.38, 0.44)	-0.19 (-0.23, -0.15)
Fat-tailed False Antechinus	-0.25 (-0.56, 0.06)	-0.16 (-0.46, 0.14)	0.07 (0.01, 0.13)
Fine Side-lined Ctenotus	-7.11 (-1031.11, 1016.89)	0.09 (-0.05, 0.23)	0.01 (-0.02, 0.04)
Fourteen-lined Ctenotus	-0.01 (-0.01, -0.01)	0.17 (0.12, 0.22)	0.04 (0.03, 0.05)
Galah	-0.02 (-0.04, 0.0)	-0.23 (-0.48, 0.02)	-0.07 (-0.11, -0.03)
Ghost Skink	-	0.02 (-0.07, 0.11)	0.11 (0.07, 0.15)
Giant Desert Ctenotus	-	-0.03 (-0.15, 0.09)	0.11 (-0.26, 0.48)
Grey Butcherbird	-0.01 (-0.02, 0.0)	0.01 (0.0, 0.02)	-
Grey Fantail	0.03 (0.01, 0.05)	-1.96 (-2.53, -1.39)	0.07 (-0.04, 0.18)
Grey Shrike-thrush	-0.03 (-0.04, -0.02)	0.24 (0.2, 0.28)	-0.0 (-0.02, 0.02)
Grey-fronted Honeyeater	-0.02 (-0.04, 0.0)	-	0.01 (0.0, 0.02)
Grey-headed Honeyeater	-0.0 (-0.0, 0.0)	0.13 (0.1, 0.16)	-0.06 (-0.07, -0.05)
Grey-striped Western Dragon	-6.6 (-3073.04, 3059.84)	0.16 (-0.03, 0.35)	-0.03 (-0.08, 0.02)
Ground Cuckooshrike	0.09 (0.07, 0.11)	-2.34 (-3.13, -1.55)	-0.05 (-0.16, 0.06)
Hairy-footed Dunnart	0.01 (0.0, 0.02)	0.02 (-0.28, 0.32)	0.24 (0.12, 0.36)
Hooded Robin	-0.12 (-0.15, -0.09)	-0.0 (-0.06, 0.06)	0.17 (0.14, 0.2)
Hooded Scaly-foot	-0.01 (-0.03, 0.01)	-0.07 (-0.23, 0.09)	-0.01 (-0.03, 0.01)
Horsefield's Bronze Cuckoo	-0.24 (-0.44, -0.04)	-0.11 (-0.32, 0.1)	-0.14 (-0.2, -0.08)
House Mouse	0.0 (0.0, 0.0)	0.38 (0.36, 0.4)	0.16 (0.15, 0.17)
Inland Snake-eyed Skink	-8.51 (-6180.45, 6163.43)	-0.64 (-1.27, -0.01)	1.71 (-3022.84, 3026.26)
Inland Thornbill	-0.01 (-0.01, -0.01)	-0.03 (-0.03, -0.03)	-0.0 (-0.0, 0.0)
Interior Blind Snake	-0.05 (-0.07, -0.03)	0.0 (-0.01, 0.01)	-0.01 (-0.03, 0.01)
Jacky Winter	0.0 (-0.02, 0.02)	0.55 (0.29, 0.81)	-0.03 (-0.12, 0.06)
Jewelled Gecko	-0.0 (-0.01, 0.01)	0.12 (-0.07, 0.31)	0.05 (0.02, 0.08)
Leonhardi's Ctenotus	-0.02 (-0.03, -0.01)	0.33 (0.29, 0.37)	-0.04 (-0.05, -0.03)

Species	Percentage of Site burnt	Lagged Annual Precipitation	Time since last fire
Leopard Ctenotus	-0.01 (-0.02, 0.0)	0.1 (0.05, 0.15)	0.03 (0.02, 0.04)
Lesser Hairy-footed Dunnart	-0.02 (-0.03, -0.01)	0.26 (0.2, 0.32)	0.06 (0.04, 0.08)
Lined Firetail Skink	-0.02 (-0.03, -0.01)	-0.12 (-0.28, 0.04)	0.21 (0.17, 0.25)
Little Buttonquail	-0.01 (-0.05, 0.03)	0.19 (0.15, 0.23)	-0.01 (-0.05, 0.03)
Little Crow	0.02 (0.01, 0.03)	-0.22 (-0.66, 0.22)	-0.23 (-0.34, -0.12)
Little Woodswallow	-0.05 (-0.07, -0.03)	0.04 (-0.06, 0.14)	-0.02 (-0.06, 0.02)
Masked Woodswallow	0.01 (0.01, 0.01)	0.3 (0.28, 0.32)	0.03 (0.02, 0.04)
Massive-gibber Ctenotus	0.02 (0.02, 0.02)	0.53 (0.53, 0.53)	-0.15 (-0.15, -0.15)
Mistletoebird	-0.1 (-0.32, 0.12)	-	-
Monk Snake	0.01 (0.0, 0.02)	-0.17 (-0.62, 0.28)	0.02 (-0.03, 0.07)
Mulga Parrot	-0.33 (-0.44, -0.22)	0.02 (0.0, 0.04)	0.02 (-0.01, 0.05)
Nankeen Kestrel	-	0.03 (-0.02, 0.08)	-0.22 (-0.32, -0.12)
Nasute Finesnout Ctenotus	-0.04 (-0.18, 0.1)	0.42 (0.29, 0.55)	-0.23 (-0.62, 0.16)
Night Skink	-0.05 (-0.13, 0.03)	-0.1 (-0.31, 0.11)	-0.02 (-0.02, -0.02)
Nimble Ctenotus	-12.22 (-323803.09, 323778.65)	-0.17 (-0.4, 0.06)	0.06 (-0.04, 0.16)
North-western Sandslider	-0.0 (-0.0, 0.0)	-0.02 (-0.02, -0.02)	0.0 (0.0, 0.0)
Northern Desert Banded Snake	-0.02 (-0.03, -0.01)	0.06 (-0.05, 0.17)	0.11 (0.09, 0.13)
Northern Spiny-tailed Gecko	-	0.01 (-0.02, 0.04)	-0.19 (-0.25, -0.13)
Ooldea Dunnart	-0.02 (-0.06, 0.02)	0.01 (-0.02, 0.04)	0.03 (-0.02, 0.08)
Orange-tailed Finesnout Ctenotus	-0.02 (-0.03, -0.01)	-0.2 (-0.34, -0.06)	0.02 (-0.01, 0.05)
Ornate Soil-crevice Skink	-6.51 (-4107.5, 4094.48)	-0.28 (-0.61, 0.05)	-0.1 (-0.17, -0.03)
Pale Knob-tailed Gecko	-0.16 (-0.22, -0.1)	0.01 (-0.01, 0.03)	0.03 (-0.02, 0.08)
Pallid Cuckoo	-1.13 (-1.63, -0.63)	0.15 (0.0, 0.3)	0.1 (0.03, 0.17)
Pied Butcherbird	-0.01 (-0.03, 0.01)	0.05 (0.04, 0.06)	-0.0 (-0.01, 0.01)
Pied Honeyeater	-1.32 (-1.5, -1.14)	0.25 (0.2, 0.3)	0.15 (0.13, 0.17)
Pink Cockatoo	-1.57 (-2.64, -0.5)	0.14 (-0.07, 0.35)	-0.06 (-0.14, 0.02)

Species	Percentage of Site burnt	Lagged Annual Precipitation	Time since last fire
Purple-backed Fairywren	0.01 (0.0, 0.02)	0.02 (0.02, 0.02)	-0.01 (-0.02, 0.0)
Purplish Dtella	0.0 (-0.01, 0.01)	0.05 (-0.27, 0.37)	-0.13 (-0.19, -0.07)
Pygmy Mulga Monitor	-0.04 (-0.09, 0.01)	-0.27 (-0.58, 0.04)	0.02 (-0.02, 0.06)
Rainbow Bee-eater	0.02 (0.02, 0.02)	0.23 (0.17, 0.29)	-0.09 (-0.13, -0.05)
Red-backed Kingfisher	-0.28 (-0.42, -0.14)	0.56 (0.44, 0.68)	-0.13 (-0.21, -0.05)
Red-browed Pardalote	-0.0 (-0.01, 0.01)	-0.29 (-0.51, -0.07)	0.05 (-0.01, 0.11)
Red-capped Robin	0.0 (0.0, 0.0)	0.23 (0.19, 0.27)	-0.04 (-0.05, -0.03)
Redthroat	-0.02 (-0.04, 0.0)	-0.08 (-0.2, 0.04)	-0.11 (-0.14, -0.08)
Ringed Brown Snake	-8.13 (-3501.77, 3485.51)	0.12 (-0.09, 0.33)	0.01 (-0.02, 0.04)
Rufous Songlark	-0.07 (-0.16, 0.02)	-	-
Rufous Whistler	-0.01 (-0.01, -0.01)	0.21 (0.19, 0.23)	-0.04 (-0.05, -0.03)
Sand-Plain Gecko	-0.29 (-0.44, -0.14)	-0.01 (-0.04, 0.02)	-0.3 (-0.38, -0.22)
Sandy Inland Mouse	-0.01 (-0.01, -0.01)	0.15 (0.13, 0.17)	0.09 (0.09, 0.09)
Sharp-snouted Delma	-0.95 (-2.38, 0.48)	-	-
Short-beaked Echidna	-5.33 (-3793.45, 3782.79)	0.16 (-1.07, 1.39)	2.07 (-1327.45, 1331.59)
Short-tailed Pygmy Monitor	0.0 (-0.01, 0.01)	0.38 (0.21, 0.55)	-0.07 (-0.12, -0.02)
Singing Honeyeater	0.01 (0.01, 0.01)	0.22 (0.2, 0.24)	-0.07 (-0.08, -0.06)
Slaty-backed Thornbill	0.02 (0.02, 0.02)	0.37 (0.33, 0.41)	-0.13 (-0.15, -0.11)
Southern Sandslider	-0.09 (-0.4, 0.22)	0.07 (0.06, 0.08)	-0.14 (-0.16, -0.12)
Southern Shovel-nosed Snake	0.03 (-0.07, 0.13)	-0.06 (-0.24, 0.12)	-
Southern Whiteface	-0.02 (-0.03, -0.01)	0.03 (-0.04, 0.1)	0.01 (-0.02, 0.04)
Spinifex Hopping Mouse	0.0 (0.0, 0.0)	0.01 (0.01, 0.01)	0.03 (0.03, 0.03)
Spiny-cheeked Honeyeater	-0.0 (-0.0, 0.0)	0.02 (0.02, 0.02)	-0.01 (-0.01, -0.01)
Splendid Fairywren	0.01 (0.01, 0.01)	0.06 (0.01, 0.11)	-0.13 (-0.15, -0.11)
Stony-soil Ctenotus	-2.04 (-1450.2, 1446.12)	1.5 (0.45, 2.55)	1.43 (0.98, 1.88)
Thorny Devil	-0.01 (-0.03, 0.01)	0.47 (0.32, 0.62)	-0.02 (-0.07, 0.03)

Species	Percentage of Site burnt	Lagged Annual Precipitation	Time since last fire
Three-lined Knob-tailed Gecko	-	-0.01 (-0.09, 0.07)	-0.05 (-0.19, 0.09)
Torresian Crow	-	-0.0 (-0.01, 0.01)	0.04 (0.03, 0.05)
Tree Dtella	-0.01 (-0.06, 0.04)	-0.03 (-0.1, 0.04)	-0.58 (-0.72, -0.44)
Unbanded Delma	-	0.1 (0.0, 0.2)	0.21 (0.06, 0.36)
Variable Fat-tailed Gecko	-0.01 (-0.01, -0.01)	0.11 (0.06, 0.16)	-0.03 (-0.04, -0.02)
Varied Sittella	-1.96 (-2.48, -1.44)	0.12 (-0.01, 0.25)	-0.16 (-0.22, -0.1)
Wedge-tailed Eagle	0.0 (-0.03, 0.03)	-0.34 (-1.0, 0.32)	-0.17 (-0.31, -0.03)
Weebill	-0.03 (-0.05, -0.01)	-0.27 (-0.43, -0.11)	0.05 (0.01, 0.09)
Western Beaked-gecko	-0.11 (-0.15, -0.07)	-0.0 (-0.01, 0.01)	-0.01 (-0.03, 0.01)
Western Bowerbird	0.0 (-0.01, 0.01)	0.33 (0.18, 0.48)	-0.01 (-0.09, 0.07)
Western Brown Snake	-7.15 (-3491.57, 3477.27)	0.44 (0.09, 0.79)	0.0 (-0.07, 0.07)
Western Gerygone	0.01 (-0.04, 0.06)	-0.05 (-0.16, 0.06)	-0.01 (-0.07, 0.05)
White-backed Swallow	-14.06 (-47.92, 19.8)	-	-
White-browed Babbler	0.01 (0.01, 0.01)	0.26 (0.22, 0.3)	-0.07 (-0.08, -0.06)
White-fronted Honeyeater	-0.02 (-0.03, -0.01)	0.45 (0.41, 0.49)	0.01 (-0.01, 0.03)
White-plumed Honeyeater	-0.01 (-0.01, -0.01)	-0.0 (-0.03, 0.03)	-0.02 (-0.04, 0.0)
White-winged Fairywren	-0.0 (-0.0, 0.0)	0.01 (-0.01, 0.03)	-0.1 (-0.12, -0.08)
White-winged Triller	-0.29 (-0.34, -0.24)	0.42 (0.39, 0.45)	0.09 (0.08, 0.1)
Willie Wagtail	0.0 (0.0, 0.0)	0.02 (0.02, 0.02)	0.01 (0.01, 0.01)
Wongai Ningaui	-0.03 (-0.04, -0.02)	0.15 (0.09, 0.21)	0.17 (0.15, 0.19)
Yellow-rumped Thornbill	-0.05 (-0.07, -0.03)	0.26 (0.2, 0.32)	0.1 (0.06, 0.14)
Yellow-throated Miner	-0.0 (-0.0, 0.0)	0.02 (0.02, 0.02)	-0.02 (-0.02, -0.02)
Zebra Finch	0.0 (0.0, 0.0)	0.43 (0.42, 0.44)	-0.12 (-0.13, -0.11)

Appendix 5: The priority species list from the original fauna inventory surveys conducted in the late 1980s

Table A5. Recommendations of the important species, communities and habitats of UKTNP taken from by Reid, Kerle and Morton (Uluṟu Fauna Survey Final Report, 1991).

Important Species	Important Communities	Important habitat and locations
<u>*Level 1*</u> *Dasycercus cristicauda* *Macropus robustus* (Uluṟu population) *Egemia kintorei Delma pax* Striated Grasswren Rufous-crowned Emu-wren	Small mammal and reptile community in the Yulara Bores - sunset viewing area.	The buried drainage/transitional sandplain area, bounded by the sunset viewing area in the south and the Sedimentaries in the north (refer to Fig. 9.1).
<u>*Level 2*</u> *Notaryctes typhlops* *Pseudantechinus macdonnellensis* (Uluṟu population) *Pseudomys desertor* (drought refuge) *Ctenotus septenarius* Scarlet-chested Parrot Grey Honeyeater	Bird and reptile community at Kata Tjuṯa. Rich reptile community of the spinifex grasslands. Rich bird community in mulga shrublands.	Kata Tjuṯa (domes and within-domes habitat). Site 1 (earthworms, frogs, *Delma pax, Pseudomys desertor,* rare plants, *Pseudantechinus macdonnellensis,* euro). Areas of *Themeda avenacea* habitat in effluvial zones around Uluṟu and Kata Tjuṯa *{P. desertor, D. pax).* Sedimentaries (rare birds).
<u>*Level 3*</u> *Sminthopsis hirtipes* Grey Fantail (inland form) Dusky Grasswren Grey-fronted Honeyeater Spotted Bowerbird	Frog community at base of Uluṟu. Bird community of mallee shrublands.	Mulga habitat (birds). Mallee-spinifex habitat (birds), in particular, Site 7. Spinifex landscapes generally (reptiles, marsupials).
<u>*Level 4*</u> *Sminthopsis macroura* *Ctenophoms clayi* *Egemia striata* *Lerista xanthura* *Ramphotyphlops bituberculata*	*Rgrypus* *Notaden nicholsi* Grey Falcon Alexandra's Parrot	Australian Bustard Chestnut Quail-thrush Cinnamon Quail-thrush White-browed Treecreeper

Appendix 6: Criteria for inclusion as a priority species

Table A6. Bio-cultural indicators used in defining monitoring targets

Indicator	Justification
Culturally significant species	Monitoring these species helps preserve the cultural heritage and traditional knowledge of the Aṉangu people. These species often hold spiritual significance and are integral to maintaining the cultural landscape of UKTNP.
Feral predator/herbivore management	Tracking the population and impact of feral predators (e.g., cats, foxes) and herbivores (e.g., rabbit, camels) is crucial for protecting native species and habitats from predation and overgrazing. Effective management of these species helps maintain ecological balance.
Effects of fire	Fire plays a key role in shaping the park's ecosystems. Monitoring the effects of fire, including fire frequency, intensity, and recovery, provides insights into its impact on vegetation, wildlife, and habitat structure, aiding in fire management strategies.
Effects of drought	Droughts are a significant stressor on the park's ecosystems. Monitoring drought impacts allows for the assessment of how species and habitats respond to prolonged dry conditions, informing conservation efforts and adaptive management during drought periods.
Spinifex condition	Spinifex grasslands are a dominant habitat type within UKTNP, supporting a rich diversity of species. Monitoring the condition and age of spinifex helps assess habitat quality and the availability of resources for species dependent on this ecosystem
Mulga condition	Mulga woodlands are an important habitat for many species in UKTNP. Monitoring the health and extent of mulga stands provides critical information on the resilience of this habitat to threats such as drought, fire, and invasive species.

Appendix 7: Recommended Monitoring Approaches and Key References for Priority Species Not Amenable to General Biodiversity Surveys

Table A7. Recommended monitoring approaches for priority species not adequately covered by the current suite or deployment framework of monitoring methods used in the Park.

Species	Recommended Monitoring Approaches	Key References
Australian Bustard (Ardeotis australis)	Camera trapping and direct observation; Line transect and point counts	Palmer et al. (2015); Paton & Dwyer (2017)
Bourke's Parrot (Neopsephotus bourkii)	Mist netting and point counts; Acoustic monitoring of vocalisations	Garnett & Crowley (2000); Rowley & Russell (1990)
Burton's Legless Lizard (Lialis burtonis)	Pitfall trapping and artificial shelter surveys; Visual encounter surveys	Wilson & Swan (2013); Cogger (2014)
Chestnut-breasted Quail-thrush (Cinclosoma castanotum)	Playback surveys; Transect surveys with visual and auditory detection	Johnston & Baker-Gabb (2012); McCarthy et al. (2013)
Desert Delma (Delma desmosa)	Pitfall trapping and active searching under rocks; Environmental DNA sampling	Harvey & Hamilton (2012); Lugg et al. (2018)
Dusky Grasswren (Amytornis purnelli)	Point counts and call playback; Targeted acoustic surveys during breeding season	Garnett et al. (2011); Lindgren & Varley (2003)
Emu (Dromaius novaehollandiae)	Camera trapping and spoor counts; Aerial surveys combined with ground transects	Davies et al. (2014); Paton & McGregor (2001)
Euro (Macropus robustus)	Camera trapping and pellet counts; Spotlight surveys at night	Fleming et al. (2001); Friend et al. (1988)
Grey Fantail (Rhipidura albiscapa)	Mist netting and point counts; Acoustic monitoring of song frequency	Blancher et al. (2007); Baker et al. (2012)
Grey Honeyeater (Conopophila whitei)	Mist netting and auditory surveys; Habitat-based presence/absence surveys	Ford & Barrowclough (1985); Ford (1986)
Mistletoebird (Dicaeum hirundinaceum)	Mist netting and fruit baiting; Point counts and call playback	Ford & Paton (1977); Ingram & Dawson (1984)
Redthroat (Pyrrholaemus brunneus)	Call playback surveys; Mist netting for capture-mark-recapture studies	Paltridge & Paull (1996); Blakers et al. (1984)
Slaty-backed Thornbill (Acanthiza robustirostris)	Mist netting and visual point counts; Habitat transects with auditory detection	Blakers et al. (1984); Ford (1977)
Western Gerygone (Gerygone fusca)	Mist netting and auditory surveys; Habitat-based transect surveys	Ford (1986); Higgins et al. (2001)
Yellow-rumped Thornbill (Acanthiza chrysorrhoa)	Mist netting and visual surveys; Call playback and habitat assessment	Blakers et al. (1984); Ford (1977)
Desert Pygmy Monitor (Varanus eremius)	Active searching and opportunistic sightings; Camera trapping at burrow entrances	Wilson & Swan (2013); Auffenberg (1981)
Desert Skink (Liopholis inornata)	Pitfall trapping and cover board surveys; Visual encounter surveys	Hutchinson & Daugherty (1987); Cogger (2014)

Species	Recommended Monitoring Approaches	Key References
Dingo (Canis lupus dingo)	Camera trapping and track surveys; Scat detection dogs and genetic sampling	Letnic et al. (2009); Smith et al. (2009)
Jewelled Gecko (Strophurus elderi)	Night spotlighting and visual encounter surveys; Artificial refuge surveys	Wilson & Swan (2013); Oliver et al. (2007)
Monk Snake (Notechis scutatus)	Funnel trapping and pitfall arrays; Visual encounter surveys during peak activity	Shine (1991); Covacevich & Archer (1975)
Pygmy Mulga Monitor (Varanus gilleni)	Active searching and shelter inspections; Camera traps near refuges	Pianka & Pianka (1976); Auffenberg (1981)
Red Kangaroo (Osphranter rufus)	Aerial surveys and spotlight counts; Camera traps and pellet counts	Fleming et al. (2001); Caughley (1977)
Short-beaked Echidna (Tachyglossus aculeatus)	Camera trapping and spotlighting; Burrow surveys and spoor counts	Munks et al. (1996); Smith et al. (2003)

Appendix 8: Assigned criteria for inclusion as a priority species based on expert consolations

Table A8. Entire set of Indicator species identified through expert elicitation, spanning amphibians, birds, mammals, reptiles, and culturally significant plants.

Species	Detections Trad/Cam*	Culturally significant	Feral management	Fire	Drought	Spinifex condition	Mulga condition
Amphibians							
Shoemaker frog	1/0	X					
Aves							
Australian Bustard	13/0	X					
Bourke's Parrot	34/0						X
Chestnut-breasted Quail-thrush	5/0		X				
Crested Bellbird	1515/37		X				X
Crested Pigeon	181/1	X					
Dusky Grasswren	7/0			X		X	
Emu	5/0	X					
White-winged Fairywren	402/0						
Purple-backed Fairywren	512/0						
Splendid Fairywren	443/32**						
Grey Butcherbird	243/0						X
Pied Butcherbird	272/6	X					
Grey Fantail	12/0						X
Grey Honeyeater	1/0						X
Mistletoebird	43/0						X
Redthroat	102/0		X			X	X
Australian Ringneck	260/0	X					
Scarlet-chested parrot	9/0						
Slaty-backed Thornbill	408/0						X
Striated Grasswren	8/0			X		X	
Varied Sittella	73/0						X
Western Gerygone	44/0						X

Species	Detections Trad/Cam*	Culturally significant	Feral management	Fire	Drought	Spinifex condition	Mulga condition
White-browed Babbler	632/0						X
Yellow-throated Miner	967/0	X					
Yellow-rumped Thornbill	128/0						X
Zebra Finch	4565/1	X					
Mammals							
Mulgara	51/120		X	X		X	
Dingo	49/48	X					
Desert Mouse	566/8		X	X		X	
Feral Cat	31/116		X		X		
Red Fox	23/96		X				
Euro (Common wallaroo)	24/0	X					
Red kangaroo	33/0	X			X		
Sandy Inland Mouse	4353/49		X				
Short-beaked Echidna	8/0	X	X				
Southern Marsupial Mole	3/0	X	X				
Spinifex Hopping Mouse	1708/3162		X				
Wongai Ningaui	269/0	X		X		X	
Reptiles							
Centralian Blue-tongue Skink	30/6	X		X		X	
Burton’s Snake Lizard	39/0	X					
Central Netted Dragon	80/187	X					
Desert Delma	11/0			X		X	
Interior Blind Snake	265/0	X					
Desert Skink	3/0	X	X	X	X		
Giant Desert Ctenotus	26/0			X	X	X	
Jewelled Gecko	36/0			X		X	
Leopard Ctenotus	490/11			X	X	X	
Central Military Dragon	201/118	X					
Monk Snake	9/0			X			X
Northern Spiny-tailed Gecko	165/0			X			X

Species	Detections Trad/Cam*	Culturally significant	Feral management	Fire	Drought	Spinifex condition	Mulga condition
Perentie	13/4	X					
Pygmy Mulga Monitor	20/10			X			X
Sand Goanna	71/237	X					
Sharp-snouted Delma	42/0			X		X	
Short-tailed Pygmy Monitor	35/14			X		X	
Thorny Devil	42/0	X					
Unbanded Delma	82/0			X		X	
Western Blue-tongued Lizard	6/3	X		X		X	
Desert Pygmy Monitor	85/7	X					
Plants							
Desert myrtle	-	X				X	
Desert oak	-	X					
Desert raisin	-	X					
Lemon grass	-	X					
Mulga	-	X			X		X
Quandong	-	X	X	X			
Soft spinifex	-	X		X			
Wild tobacco	-	X					
Witchetty bush	-	X					
Yellow flame Grevillea	-	X					

Appendix 9: Power to detect occupancy changes in Priority Species.

Occupancy power analyses under the current 30-site design and ≤112 survey nights indicate limited capacity to detect changes in site use. Across the priority fauna, only feral cat (*Felis catus*) achieved statistical power ≥0.80 for at least one evaluated effect size, whereas all other species failed to reach this threshold.

Figure A9. Statistical power to detect a change in site level occupancy for each species across varying effect sizes and survey effort. Each row represents a species, with colour indicating the proportion of simulations (0–1) achieving statistical significance ($\alpha = 0.05$) for a given combination of effect size (columns) and number of survey sites (x-axis). The y-axis shows the number of survey sessions, and contour lines denote power thresholds (0.8 shown in black). Red markers highlight conditions achieving ≥80% power.

This pattern reflects a combination of high among-site heterogeneity in detection, low baseline occupancy for several taxa, and the limited number of sites—factors that collectively depress power for detecting modest occupancy changes. Under these constraints, additional temporal effort produced minimal gains for low-occupancy species, implying diminishing returns from extending deployments alone. Substantive improvements would require increased spatial replication and/or targeted placement in habitat most likely to be occupied; however, these options are currently limited by logistics. For a landscape the size of UKTNP, occupancy is a limited primary indicator because it is insensitive to abundance changes when site occupancy is already high, requires large site numbers for adequate power, and is vulnerable to annual variability in detection in arid systems (MacKenzie et al., 2002; Guillera-Arroita et al., 2014; Burton et al., 2015). Standardized detection rates from camera traps offer a more sensitive metric for many taxa, as they respond to changes in activity or abundance within occupied sites and can achieve higher power under fixed site numbers (Rowcliffe et al., 2008; Steenweg et al., 2017). Accordingly, occupancy is retained only as a secondary indicator—principally for species such as feral cat, where power is sufficient—while detection-rate trends form the primary basis for assessing population change.

Appendix 10: Power to detect changes in encounter rates across combinations of survey effort and effect size for each species.

Figure A10. Statistical power to detect a change in encounter for each species across varying effect sizes and survey effort. Each row represents a species, with colour indicating the proportion of simulations (0–1) achieving statistical significance ($\alpha = 0.05$) for a given combination of effect size (columns) and number of survey sites (x-axis). The y-axis shows the number of survey weeks, and contour lines denote power thresholds (0.8 shown in black).

Appendix 11. Detection power to identify changes in encounter rate across priority and non- priority species, effect sizes, and survey efforts.

Table A11. Detection power to identify changes in encounter rate across priority and non- priority species, effect sizes, and survey efforts. The table reports statistical power (rounded to 2 decimals), number of sites, and survey weeks required for each species and effect size. Priority species are marked with an asterisk (*). Cells shaded in grey indicate survey efforts currently achievable in the field, while light orange shading highlights scenarios where increased survey effort is required to achieve the reported power. Simulations were capped at a maximum of 40 sites and 24 survey weeks. Species not listed here had insufficient detections to conduct a power analysis.

Common Name	Effect Size	Statistical Power	Sites	Survey Weeks	Meets ≥0.8	Under current effort
Australian Magpie	0.1	40	22	0.32	No	No
Australian Magpie	0.3	21	23	0.8	Yes	26, 20
Australian Magpie	0.5	15	15	0.81	Yes	15, 15
Australian Owlet-Nightjar	0.1	25	17	0.13	No	No
Australian Owlet-Nightjar	0.3	25	23	0.2	No	No
Australian Owlet-Nightjar	0.5	39	23	0.43	No	No
Bearded Dragon	0.1	40	11	0.14	No	No
Bearded Dragon	0.3	37	20	0.27	No	No
Bearded Dragon	0.5	31	24	0.54	No	No
Black-Headed Monitor	0.1	38	19	0.14	No	No
Black-Headed Monitor	0.3	40	22	0.27	No	No
Black-Headed Monitor	0.5	40	22	0.5	No	No
Black-faced Woodswallow	0.1	37	23	0.37	No	No
Black-faced Woodswallow	0.3	19	22	0.82	Yes	20, 20
Black-faced Woodswallow	0.5	15	12	0.81	Yes	15, 12
Camel	0.1	28	19	0.13	No	No
Camel	0.3	31	22	0.21	No	No
Camel	0.5	36	21	0.38	No	No
Cat	0.1	25	24	0.87	Yes	No
Cat	0.3	15	6	0.83	Yes	15, 6
Cat	0.5	15	3	0.94	Yes	15, 3
Central Bluetongue	0.1	31	17	0.14	No	No
Central Bluetongue	0.3	39	24	0.45	No	No
Central Bluetongue	0.5	36	24	0.8	Yes	No
Central Military Dragon	0.1	38	24	0.55	No	No
Central Military Dragon	0.3	15	22	0.87	Yes	16, 18
Central Military Dragon	0.5	15	8	0.85	Yes	15, 8
Central Netted Dragon	0.1	40	23	0.64	No	No
Central Netted Dragon	0.3	15	12	0.87	Yes	15, 12
Central Netted Dragon	0.5	15	5	0.85	Yes	15, 5

Copperback Quail-Thrush	0.1	36	20	0.09	No	No
Copperback Quail-Thrush	0.3	37	21	0.15	No	No
Copperback Quail-Thrush	0.5	40	19	0.28	No	No
Crested Bellbird	0.1	40	22	0.39	No	No
Crested Bellbird	0.3	16	23	0.81	Yes	20, 20
Crested Bellbird	0.5	15	12	0.81	Yes	15, 12
Crested Pigeon	0.1	32	15	0.14	No	No
Crested Pigeon	0.3	40	17	0.22	No	No
Crested Pigeon	0.5	39	23	0.44	No	No
Crimson Chat	0.1	36	23	0.21	No	No
Crimson Chat	0.3	39	23	0.8	Yes	No
Crimson Chat	0.5	18	22	0.83	Yes	20, 20
Desert Mouse	0.1	40	24	0.11	No	No
Desert Mouse	0.3	37	24	0.22	No	No
Desert Mouse	0.5	34	23	0.33	No	No
Desert Pygmy Monitor	0.1	39	16	0.11	No	No
Desert Pygmy Monitor	0.3	39	18	0.22	No	No
Desert Pygmy Monitor	0.5	39	24	0.36	No	No
Diamond Dove	0.1	20	24	0.22	No	No
Diamond Dove	0.3	39	21	0.81	Yes	No
Diamond Dove	0.5	17	22	0.81	Yes	18, 20
Dingo	0.1	32	23	0.28	No	No
Dingo	0.3	21	24	0.83	Yes	28, 20
Dingo	0.5	15	13	0.83	Yes	15, 13
European Rabbit	0.1	38	23	0.48	No	No
European Rabbit	0.3	15	18	0.8	Yes	15, 18
European Rabbit	0.5	15	9	0.83	Yes	15, 9
Fox	0.1	37	24	0.82	Yes	No
Fox	0.3	15	9	0.82	Yes	15, 9
Fox	0.5	15	3	0.81	Yes	15, 3
Grey Shrike-thrush	0.1	39	21	0.17	No	No
Grey Shrike-thrush	0.3	39	24	0.54	No	No
Grey Shrike-thrush	0.5	31	23	0.81	Yes	No
Hooded Robin	0.1	34	24	0.12	No	No
Hooded Robin	0.3	33	23	0.19	No	No
Hooded Robin	0.5	40	24	0.35	No	No
House Mouse	0.1	39	20	0.15	No	No
House Mouse	0.3	34	24	0.37	No	No
House Mouse	0.5	37	22	0.62	No	No
Knob-Tailed Gecko	0.1	26	23	0.08	No	No
Knob-Tailed Gecko	0.3	39	24	0.15	No	No
Knob-Tailed Gecko	0.5	39	24	0.24	No	No

Leopard Ctenotus	0.1	36	22	0.31	No	No
Leopard Ctenotus	0.3	26	23	0.81	Yes	28, 20
Leopard Ctenotus	0.5	15	18	0.81	Yes	15, 18
Little Button-quail	0.1	37	23	0.51	No	No
Little Button-quail	0.3	15	22	0.83	Yes	16, 20
Little Button-quail	0.5	15	10	0.86	Yes	15, 10
Little Crow	0.1	33	24	0.82	Yes	No
Little Crow	0.3	15	7	0.85	Yes	15, 7
Little Crow	0.5	15	4	0.87	Yes	15, 4
Long-Nosed Dragon	0.1	35	24	0.1	No	No
Long-Nosed Dragon	0.3	39	21	0.15	No	No
Long-Nosed Dragon	0.5	38	20	0.28	No	No
Masked Woodswallow	0.1	31	23	0.17	No	No
Masked Woodswallow	0.3	40	24	0.58	No	No
Masked Woodswallow	0.5	27	23	0.84	Yes	No
Mulga Snake	0.1	35	20	0.12	No	No
Mulga Snake	0.3	40	24	0.14	No	No
Mulga Snake	0.5	37	22	0.2	No	No
Mulgara	0.1	40	23	0.67	No	No
Mulgara	0.3	15	12	0.82	Yes	15, 12
Mulgara	0.5	15	5	0.8	Yes	15, 5
Night Skink	0.1	30	24	0.1	No	No
Night Skink	0.3	33	22	0.17	No	No
Night Skink	0.5	40	23	0.25	No	No
Perentie	0.1	38	16	0.14	No	No
Perentie	0.3	37	20	0.21	No	No
Perentie	0.5	39	24	0.4	No	No
Pied Butcherbird	0.1	31	21	0.23	No	No
Pied Butcherbird	0.3	38	22	0.66	No	No
Pied Butcherbird	0.5	22	23	0.81	Yes	No
Pygmy Desert Monitor	0.1	35	13	0.2	No	No
Pygmy Desert Monitor	0.3	40	24	0.76	No	No
Pygmy Desert Monitor	0.5	20	22	0.84	Yes	22, 19
Pygmy Mulga Monitor	0.1	32	20	0.21	No	No
Pygmy Mulga Monitor	0.3	34	23	0.61	No	No
Pygmy Mulga Monitor	0.5	23	24	0.84	Yes	26, 20
Red-Capped Robin	0.1	39	24	0.08	No	No
Red-Capped Robin	0.3	31	23	0.12	No	No
Red-Capped Robin	0.5	39	22	0.22	No	No
Rufous Songlark	0.1	21	6	0.13	No	No
Rufous Songlark	0.3	40	24	0.43	No	No
Rufous Songlark	0.5	39	24	0.77	No	No

Sand Goanna	0.1	29	23	0.8	Yes	No
Sand Goanna	0.3	15	7	0.82	Yes	15, 7
Sand Goanna	0.5	15	3	0.83	Yes	15, 3
Sandy Inland Mouse	0.1	40	21	0.21	No	No
Sandy Inland Mouse	0.3	37	24	0.77	No	No
Sandy Inland Mouse	0.5	16	24	0.8	Yes	22, 19
Short-Tailed Pygmy Monitor	0.1	31	11	0.17	No	No
Short-Tailed Pygmy Monitor	0.3	36	24	0.59	No	No
Short-Tailed Pygmy Monitor	0.5	26	24	0.8	Yes	30, 19
Singing Honeyeater	0.1	36	19	0.28	No	No
Singing Honeyeater	0.3	22	21	0.8	Yes	27, 19
Singing Honeyeater	0.5	15	14	0.8	Yes	15, 14
Spinifex Hopping Mouse	0.1	15	6	0.81	Yes	15, 6
Spinifex Hopping Mouse	0.3	15	1	0.88	Yes	15, 1
Spinifex Hopping Mouse	0.5	15	1	1.0	Yes	15, 1
Spiny-Cheeked Honeyeater	0.1	38	21	0.39	No	No
Spiny-Cheeked Honeyeater	0.3	18	21	0.8	Yes	25, 17
Spiny-Cheeked Honeyeater	0.5	15	12	0.82	Yes	15, 12
Tawny Frogmouth	0.1	24	20	0.14	No	No
Tawny Frogmouth	0.3	39	20	0.26	No	No
Tawny Frogmouth	0.5	40	22	0.47	No	No
Variable Fat-Tailed Gecko	0.1	32	19	0.13	No	No
Variable Fat-Tailed Gecko	0.3	40	21	0.27	No	No
Variable Fat-Tailed Gecko	0.5	40	23	0.52	No	No
Western Beaked Gecko	0.1	26	21	0.1	No	No
Western Beaked Gecko	0.3	33	23	0.16	No	No
Western Beaked Gecko	0.5	40	23	0.28	No	No
Western Bluetongue	0.1	37	19	0.12	No	No
Western Bluetongue	0.3	38	22	0.3	No	No
Western Bluetongue	0.5	36	22	0.59	No	No
Western Bowerbird	0.1	31	23	0.38	No	No
Western Bowerbird	0.3	15	24	0.81	Yes	18, 20
Western Bowerbird	0.5	15	10	0.8	Yes	15, 10
White-Browed Babbler	0.1	28	21	0.12	No	No
White-Browed Babbler	0.3	30	23	0.15	No	No
White-Browed Babbler	0.5	34	23	0.23	No	No
White-Fronted Honeyeater	0.1	30	20	0.07	No	No
White-Fronted Honeyeater	0.3	36	20	0.12	No	No
White-Fronted Honeyeater	0.5	29	24	0.23	No	No
White-Plumed Honeyeater	0.1	33	24	0.14	No	No
White-Plumed Honeyeater	0.3	37	23	0.34	No	No
White-Plumed Honeyeater	0.5	39	24	0.58	No	No

White-winged Triller	0.1	40	24	0.26	No	No
White-winged Triller	0.3	28	24	0.8	Yes	No
White-winged Triller	0.5	15	15	0.8	Yes	15, 15
Willie Wagtail	0.1	37	22	0.61	No	No
Willie Wagtail	0.3	15	12	0.8	Yes	15, 12
Willie Wagtail	0.5	15	6	0.82	Yes	15, 6
Zebra Finch	0.1	31	20	0.12	No	No
Zebra Finch	0.3	40	22	0.21	No	No
Zebra Finch	0.5	40	22	0.43	No	No

Appendix 12. Power to detect changes in encounter rate of species under the current number of survey sites (30) and half the survey sites (15).

Figure A12. Statistical power to detect a change in encounter rates for all species with sufficient data across varying effect sizes under the current number of survey sites (30) and a halving of survey sites (15). Each row represents a species, with colour indicating the simulated effects size number of survey weeks (x-axis). The y-axis shows the statistical power for a given site number (column) and survey effort.

Appendix 13: Culturally significant plant species found within UKTNP

Table A13: Culturally significant plant species identified through consultation with Aṉangu and previous research in Uluṟu–Kata Tjuṯa National Park.

Species			Family
Pitjantjatjara name	**Scientific name**	**Common name**	
Altarpa	*Eucalyptus gamophylla*	Blue mallee	Myrtaceae
Altarpa	*Eucalyptus oxymitra*	Sharp-capped mallee	Myrtaceae
Arnguḻi	*Santalum lanceolatum*	Bush plum	Santalaceae
Iḻi	*Ficus platypoda*	Rock fig	Moraceae
Ilintji	*Cymbopogon ambiguus/obtectus*	Lemon grass	Poaceae
Iltilpa	*Grevillea striata*	Beefwood	Proteaceae
Ilykuwarra	*Acacia kempeana*	Witchetty bush	Fabaceae
Irmangka-irmangka	*Eremophila alternifolia*	Narrow-leaved emu bush	Scrophulariaceae
Itaṟa	*Eucalyptus camaldulensis* subsp. *arida*	River red gum	Myrtaceae
Kaliny-kalinypa	*Grevillea eriostachya*	Honey Grevillea	Proteaceae
Kampuṟarpa	*Solanum centrale*	Desert raisin	Solanaceae
Kantuṟangu	*Codonocarpus cotinifolius*	Desert poplar	Gyrostemonaceae
Kuniya-kuniya	*Exocarpos sparteus*	Slender cherry, broom ballart	Santalaceae
Kurkaṟa	*Allocasuarina decaisneana*	Desert oak	Casuarinaceae
Kurutanpa	*Acacia maitlandii*	Maitland's wattle	Fabaceae
Mangaṯa	*Santalum acuminatum*	Quandong	Santalaceae
Mingkuḻpa	*Nicotiana excelsior/gossei*	Wild tobacco	Solanaceae
Mintjingka	*Eremophila latrobei*	Native fuschia	Scrophulariaceae
Mintju	*Acacia melleodora*	Waxy wattle	Fabaceae
Muur-muurpa	*Corymbia opaca*	Desert bloodwood	Myrtaceae
Ngalta	*Brachychiton gregorii*	Desert kurrajong	Malvaceae
Ngapaṟi	*Eucalyptus socialis subsp. eucentrica*	Red mallee	Myrtaceae
Nyintilpa	*Grevillea stenobotrya*	Rattlepod Grevillea	Proteaceae
Pukaṟa	*Aluta maisonneuvei* subsp. *maisonneuvei*	Desert myrtle, Thryptomene	Myrtaceae
Tjanpi	*Triodia pungens*	Soft spinifex	Poaceae
Tjanpi	*Triodia basedowii*	Hard spinifex	Poaceae
Tjanpi	*Triodia schinzii*	Feathertop spinifex	Poaceae
Tulypurpa	*Eremophila longifolia*	Long leaf Eremophila	Scrophulariaceae
Uḻtukunpa	*Grevillea juncifolia*	Desert Grevillea	Proteaceae
Utjulpara	*Acacia ammobia*	Mt Connor wattle	Fabaceae
Wakalpuka	*Acacia tetragonophylla*	Dead finish	Fabaceae
Wanaṟi	*Acacia aneura*	Mulga	Fabaceae
Watarka	*Acacia ligulata*	Umbrella bush	Fabaceae

Wiriny-wirinypa	*Solanum cleistogamum*	Shy nightshade	Solanaceae

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