Threatened Species Recovery Hub

National **Environmental Science** Programme

Designing better monitoring programs: Lessons from the brush-tailed rabbit-rat

In brief

Resources for biodiversity conservation are limited, so monitoring programs often target multiple species to reduce costs. But is this an effective and efficient approach for detecting population changes in threatened species?

We analysed existing data on the threatened brush-tailed rabbit-rat (*Conilurus penicillatus*) from the Tiwi Islands in northern Australia to estimate the occupancy (or the proportion of the total area occupied) and detectability (the probability of detecting the species in an area where it is present) of this threatened species.

We found that detectability is strongly seasonal and significantly influenced by environmental factors such as canopy height and cover, distance to nearest watercourse, fire history and vegetative cover.

Using this information, we designed three monitoring programs, and tested their ability to detect declines of varying sizes (i.e., 30%, 50% and 80% declines) in the brush-tailed rabbit-rat. We also calculated and compared the costs of implementing each monitoring program.

We found that targeted monitoring (i.e., surveying suitable habitat in the late dry season when the brush-tailed rabbit-rat is more easily detected) greatly reduces the survey effort required to detect population changes.

Brush-tailed rabbit-rat on the Tiwi Islands. Image: Cara Ellen Penton

When sites were selected randomly, more than twice as many sites were needed to detect the same declines, while four times as many trap nights were required in the early dry season than in the late dry season.

Typical multi-species monitoring programs (where sites are selected more randomly, and do not necessarily consider seasonality) require far more survey effort (sites and trap nights) to detect the same declines as a tailored monitoring program, and consequently cost far more to implement.

This highlights that a targeted, fit-for purpose monitoring program is likely to be far more cost-effective and efficient for detecting population changes in the brush-tail rabbit-rat compared to a program that targets multiple species.

Our findings have implications for managers striving to design the most efficient and effective monitoring regime with limited resources.

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Context

The rate of ecological change is escalating, as human impacts become more pervasive and intensive. Consequently, many species have suffered marked declines in their populations. Effective conservation of declining species depends on the ability to detect population trends through reliable, effective and efficient monitoring programs.

Imperfect detection (when a given survey method does not detect a species in an area where it occurs) is a common problem in ecological monitoring. If imperfect detection is disregarded, it can reduce the reliability of estimates of population trends, particularly if detection varies over space or time.

Despite their importance to the future of threatened species, monitoring programs are often designed without regard for their ability to deliver the types of information required by land managers – for example, their ability to detect declines of various magnitudes. However, data that is available now can be used to help guide decisions about how to design monitoring programs to ensure that they are capable of meeting project objectives.

What the research looked at

We used existing data to examine the effectiveness of alternative monitoring strategies for the threatened brush-tailed rabbit-rat (*Conilurus penicillatus*) in one of its last remaining safe havens, the Tiwi Islands in northern Australia.

What we did

We estimated the occupancy and detectability of the brush-tailed rabbit-rat using baseline data collected in 2000–2002.

We modelled several environmental variables, including field-measured site characteristics (e.g., canopy height and cover, total grass cover, distance to nearest watercourse, fire impact, and basal area, i.e., stands of large trees) and remotely sensed variables (e.g., mean annual rainfall and foliage cover) to determine the drivers of brush-tailed rabbit-rat occupancy and detectability.

We used this information to design three different monitoring regimes.

Scenario A assumed that monitoring would target habitat that was likely to be suitable for the brush-tailed rabbit-rat, excluding more marginal sites (like mangrove forests and treeless plains). Scenario A also assumed a sampling effort of two repeat visits (or trap nights) to each site during the late dry season (which was sufficient for detecting the brush-tailed rabbit-rat with more than 95% confidence). This regime takes the greatest account of the knowledge gained from the model results.

Scenario B targets the same kind of sites, but assumes surveys are conducted year-round (ignoring knowledge gained about seasonal impacts on detectability).

Scenario C assumes that sites were selected randomly, and that surveys were conducted year-round (a regime that might be implemented, for example, for a multi-species monitoring program), effectively ignoring all knowledge gained through the occupancy and detectability modelling process.

We examined the statistical power for detecting declines of relevance to the IUCN Red List of threatened species (i.e., 30%, 50% and 80% declines, which are large enough to meet criteria for listing in each of the threatened categories: Vulnerable, Endangered and Critically Endangered, respectively) under each monitoring regime.

We also calculated the costs associated with each monitoring regime.

BELOW: Brush-tailed rabbit-rat on the Tiwi Islands. Image: Hayley Geyle

Key findings and implications for conservation managers

Predictors of brush-tailed rabbit-rat occupancy and detectability

Among our key findings were that prime drivers of brush-tailed rabbit-rat presence included environmental factors such as canopy height and cover, mean annual rainfall, distance to nearest watercourse, fire impact (measured as a five-point scale of apparent severity, from 1—no sign of fire to 5—evidence of severe crown fire), and foliage projection cover (which is a remotely sensed measure of green vegetation).

Further, we found that the probability of the brush-tailed rabbit-rat occupying a site increases with canopy height, distance from the nearest watercourse, foliage projective cover and mean annual rainfall; and decreases with canopy cover and increasing fire impact.

Key variables associated with detecting the brush-tailed rabbit-rat included (1) season and (2) fire frequency.

1. Detectability varied seasonally, with nightly detection probabilities much higher in the late dry season (0.78) compared to the early dry season (0.26), or late wet season (0.31). This suggests that surveys conducted in the late dry season would require far less survey effort (i.e., fewer repeat visits or trap nights) to ensure high certainty that the brush-tailed rabbit-rat would be detected when present.
2. The increasing frequency of fire on the Tiwis had a negative effect on brush-tailed rabbit-rat detectability, suggesting that fire regimes may be contributing to observed patterns of decline.

Analysis of monitoring scenarios

Scenario A required fewer sites and repeat visits (trap nights) than did scenario B. Less than half the number of sites were required under scenario A than under scenario C to detect declines of all magnitudes corresponding to IUCN threat categories (Vulnerable, Endangered and Critically Endangered).

We were able to show that Scenario A was the most cost-effective regime for detecting declines of magnitudes great enough to qualify the brush-tailed rabbit-rat for a threatened (or more threatened) status.

This scenario saved approximately $11,700, $40,500 and $123,200 compared to Scenario B; and approximately $46,800, $150,200 and $167,800 compared to Scenario C (for allocation of the Critically Endangered, Endangered and Vulnerable threat categories, respectively).

The detection of smaller proportional declines in occupancy (i.e., < 50%) can be substantially improved by targeting suitable habitats, thus reducing the survey effort (and therefore costs) required to detect declines.

Conducting sampling when detectability is highest is most efficient and reduces costs further – species presence can be inferred with high confidence in two repeat visits when monitoring is conducted in the late dry season, while four times as many visits are necessary to infer the same level of confidence in the early dry season.

Our results show how existing data can be used to inform the design of monitoring that will improve our ability to detect policy-relevant declines.

Recommendations

We demonstrated that a targeted, fit-for purpose monitoring regime has greater power to detect declines for the brush-tailed rabbit-rat than a regime implemented to target multiple species (e.g., year-round sampling across a random selection of sites in all habitat types).

Our findings have strong implications for the cost-effectiveness of the monitoring and management of the brush-tailed rabbit-rat, and potentially other threatened species with similar ecological characteristics and habitat preferences across seasonal environments.

The findings demonstrate the need to account for imperfect detection when analysing survey data, as declines may otherwise be masked or exaggerated by seasonal inconsistency in sampling and seasonal variation in detectability.

An important consideration is that as a species declines its detectability may also decline, thus leading to greater difficulty in detecting a change between sampling seasons. This is relevant to the brush-tailed rabbit-rat, which has declined on the Tiwi Islands in the past 15 years. The decline has been attributed primarily to predation by feral cats (most likely due to changing fire regimes and

Recommendations (continued)

their impacts on vegetation cover, particularly the understorey).

On Melville Island, the brush-tailed rabbit-rat is now restricted to areas with low numbers of feral cats and high shrub density, where the risks of predation are lowered. Trap success in 2015 was less than a third of that reported in monitoring conducted in 2000–2002. This suggests that the species is likely to have lower probabilities of both occupancy and detectability across the island now. In light of the new data, we must recognise that there is a possibility that two trap nights, sampled during the late dry season when detectability of this species is highest, may be insufficient for obtaining high (>95%) confidence in detection.

If we have reason to suspect a decline (as we do here), a more conservative survey regime should be developed that can meet the project objectives in the event of a decrease in detectability between sampling occasions.

In the context of the brush-tailed rabbit-rat, using alternative trapping methods could overcome some of the limitations associated with decreasing detectability through time. For example, motion sensor cameras are a non-invasive survey tool that have been successfully used to monitor several mammals of varying sizes, including the brush-tailed rabbit-rat. Once deployed, cameras may remain in the field for long durations of time, thus collecting data for longer with fewer resources. The data obtained from cameras can be analysed in a similar way to provide insights into survey design and detecting change.

Single-species regimes may be impractical, however, given limited resources for conservation and monitoring. The Tiwi Islands are home to many threatened species that have suffered from widespread declines across northern Australia. As our study highlights the importance of targeting particular sites based on local habitat characteristics and seasonal fluctuations in detectability, we suggest that the greatest efficiencies and effectiveness may be achieved by targeting several species with similar ecological needs, habitat preferences and life-history characteristics.

Good sampling design can provide information not only about trends, but also about the factors that might be influencing those trends. This study demonstrates that fire regimes are associated with variation in site occupancy and detectability, and hence may be contributing to the observed pattern of decline of the brush-tailed rabbit-rat on the Tiwi Islands.

Careful consideration of survey design will ultimately lead to a far greater level of confidence in our ability to detect declines and understand the reasons for them, which in turn may lead to more informed and better conservation outcomes for threatened species.

Further reading

Davies H. F., McCarthy M. A., Firth R. S. C., Woinarski J. C. Z., Gillespie G. R., Anderson A. N., Geyle H. M. Nicholson E. and Murphy B. P. (2016) Top-down control of species distributions: feral cats driving the regional extinction of a threatened rodent in northern Australia. *Diversity and Distributions* 23, 272–83.

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Further Information

Hayley Geyle
hayley.geyle@cdu.edu.au

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