Science for Saving Species

Research findings factsheet

Project 3.2.2.3

Threatened Species Recovery Hub

National Environmental Science Programme

Using power analysis and spatial prioritisation to optimise the design of monitoring approaches: detecting population declines in forest birds on Christmas Island

In brief

Monitoring is important to assess the effectiveness of management, however for monitoring to be effective it is critical to understand if the monitoring design used will likely detect population changes, should they occur. Will the data collected have enough statistical power?

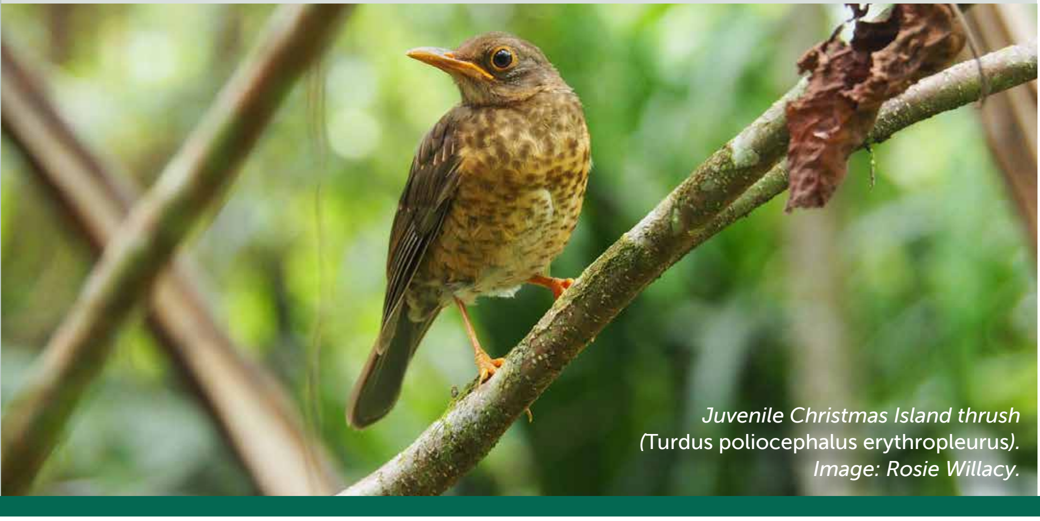
For four forest bird species of conservation concern, we evaluated the statistical power of alternative monitoring designs on Christmas Island to detect population declines over a 10-year period.

We combined estimates of detection probability with species distribution models to predict the effectiveness of alternative scenarios for monitoring design. For each scenario, we modified the survey effort in terms of the number of sites visited, number of visits per year, and number of years between surveys.

We identified both new priority areas for surveys and which survey variables contributed the most to detecting population declines.

For three of the four bird species, power across most monitoring designs was high until we decreased the number of sites surveyed to 60.

The findings are important for monitoring programs, recovery teams and managers of threatened species and communities. We have shown that data collected in the early stages of a monitoring program can be used to fine-tune design decisions and improve long-term monitoring outcomes.



Juvenile Christmas Island thrush (Turdus poliocephalus erythropleurus). Image: Rosie Willacy.

Background

Christmas Island is a site of international conservation significance. It is an external territory of Australia, located 300 km from Indonesia and around 1550 km north-west of the nearest point on the Australian mainland.

Christmas Island supports 17 threatened species and has a high proportion of species which are unique to the island. The island provides internationally significant breeding habitat for seabirds and is unique for its land crabs. However, Christmas Island biota are faced with a range of threatening processes, including invasive species and habitat disturbance and loss.

Several intensive, long-running biodiversity monitoring programs are active on Christmas Island. However, developing new approaches will be necessary to ensure that resources are targeted to most effectively monitor trends in priority species. These new approaches specifically need to include a tailored survey for forest birds, which have not been surveyed since 2015. It is essential that any new program is both cost-effective and has adequate power to detect declines in target species.

THE UNIVERSITY OF MELBOURNE

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Background (continued)

Statistical power analysis is a useful tool for designing and evaluating biological monitoring programs ahead of time. These analyses are used to assess the probability that a specific monitoring approach will be able to detect a change in population size (i.e., effect size), or to quantify the amount of effort needed to meet a management objective.

Power analysis is also useful for re-evaluating biodiversity monitoring programs. The initial data collected can be analysed and then used to inform the improvement of monitoring design and guide allocation of scarce monitoring resources.

Research aims

We aimed to evaluate the statistical power of several monitoring design scenarios to detect declines in forest bird occupancy on Christmas Island. We aimed to use this analysis to:

- understand the variability in species occupancy across the Island;
- estimate how difficult it is to detect certain species during surveys;
- evaluate the chance of monitoring being able to detect future declines; and
- explore how monitoring could be more cost-effective.

Christmas Island imperial pigeon (Ducula whartoni). Image: Doug Janson, Wikipedia, CC BY-SA 3.0

What we did

We determined how varying the approach to monitoring would impact the statistical power to detect forest bird declines. We focused our analysis on four species of conservation concern:

- Christmas Island imperial pigeon (*Ducula whartoni*),
- Christmas Island white eye (*Zosterops natalis*),
- Christmas Island thrush (*Turdus poliocephalus erythropleurus*; Engangered), and
- Christmas Island emerald dove (*Chalcophaps indica natalis*; Endangered).

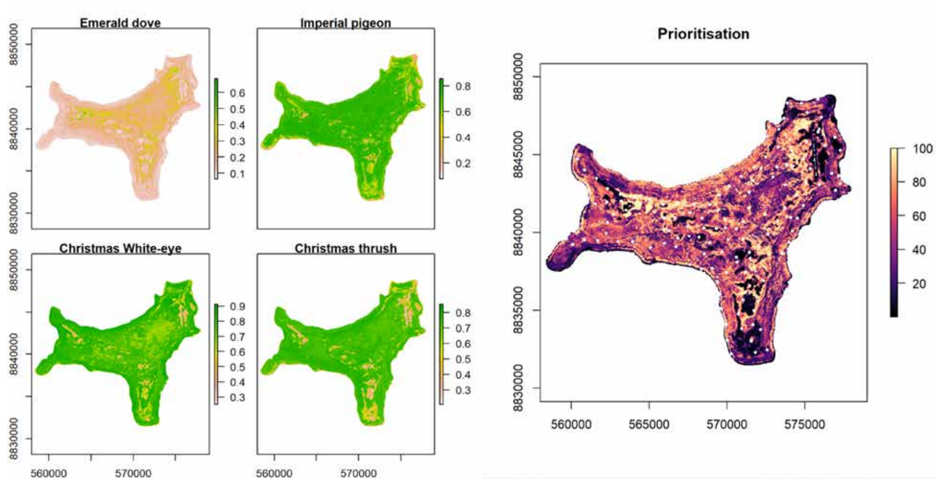

Figure 1: Species distribution models and the spatial prioritisation, with yellow representing the highest ranked cells for new surveys. The white circles represent existing survey sites, which have been masked out of the zonation analysis.

We obtained species distribution models for each species from previous research conducted by The University of Melbourne. We then extracted bird occurrence data from three Christmas Island surveys that were conducted in 2011, 2013 and 2015. In these point-surveys, all bird species that were detected within 20 minutes from a central point were counted. Using these data, we generated detection histories for forest birds that were observed at least once during a point-survey from across multiple seasons. We fitted models to these detection histories that allowed us to estimate the probability of detecting each species during a survey on Christmas Island.

We assumed that the priority of any future forest bird monitoring program is first to survey the existing 128 flying-fox monitoring sites, followed by areas in the landscape with the highest predicted suitability

What we did (continued)

for forest birds. We identified new sites for surveys by ranking highly suitable areas using the species distribution models in the spatial prioritisation tool, Zonation. Zonation ranked cells on the island in terms of forest bird occupancy from 0 (lowest value) –100 (highest value). We used simulations to model how likely several alternative monitoring designs were to detecting future occupancy trends for the four forest birds over a 10-year period. We used the species distribution models and estimations of the probability of each bird being detected in a single visit to simulate a range of monitoring design decisions.

For these monitoring simulations, we varied the number of monitoring sites, their location on Christmas Island and survey effort. The number of sites varied between 60, 128, 300 and 500; the number of repeat surveys within a year varied between 1, 2 or 4; and the number of years between surveys was 1, 2 or 4. We ran 1000 simulations for each monitoring scenario.

Christmas Island white eye (Zosterops natalis). Image: Antony Grossy, Flickr, CC BY 2.0

Key findings

Our results suggest that the power of monitoring to detect trends in forest bird occupancy is highly sensitive to the number of sites being surveyed and the rate of population decline. In our simulations, prioritising sites with the highest predicted levels of occupancy and increasing the number of sites surveyed led to the largest gains in power.

Our analysis suggests that, if the survey focus was primarily on detecting changes in the Christmas Island imperial pigeon, Christmas Island white eye and the Christmas Island thrush, then the existing monitoring network would have a high chance of detecting even small population declines.

However, power to detect declines in the Christmas Island emerald dove was consistently lower than for the other three forest bird species because this bird has relatively low levels of occupancy and detectability across the island.

We found that when simulating surveys of 128 sites from the existing network twice every two years, we were not able to detect 10% declines in any of the four target species within a decade, with at least 80% power. However, when we increased the magnitude of population decline, the power of the monitoring approach to detect declines increased considerably. For example, if we assumed a 30% decline in site occupation over the 10-year period, the power of detection was greater than 80% for three of the four species, even when as few as 128 survey sites were monitored.

For emerald doves, increasing the number of monitoring sites to 300 and 500 increased the chance of detecting 30% declines. Similarly, increasing the number of repeated annual visits on each survey site from 2 to 4 increased the power of detecting declines for the emerald dove.

When we positioned survey plots specifically for detecting declines in emerald doves, very little loss of power resulted for the remaining three species. This highlights the usefulness of clearly selecting a target species before starting a monitoring program.

Power was sensitive to the number of survey sites across the island, but it was not as sensitive to changes in the number of repeated surveys within a year. The negligible impact of repeated surveys was because three out of the four forest bird species had a very high probability of being detected within a single site visit. Therefore, increasing the number of site visits did not increase the rate of detection.

Importantly, the relative impact that survey frequency has on the success of a monitoring program is highly dependent on factors such as species status, resource and logistical constraints, and biological factors including generation times.

Research implications

The Christmas Island survey is traditionally very intensive, with up to 1000 sites surveyed in some years. Our simulations showed that we are able to detect small to moderate declines in occupancy for three of the four forest birds with many fewer sites than have been previously surveyed. Reducing survey effort by reducing the number of sites visited could be an effective approach to reducing management costs without sacrificing accuracy or survey outcomes.

The power to detect changes in the emerald dove was maximised by targeting a subset of new sites towards regions of highest predicted occupancy. We recommend modelling monitoring approaches to target high-value sites.

We also recommend that a subset of sites on Christmas Island be searched twice per year, so that data can be analysed in an occupancy-detection framework. This approach would help to increase confidence in the accuracy of monitoring survey results.

Our study demonstrates how data collected during the early stages of monitoring can be used to fine-tune the design of monitoring programs so that they have the greatest chance at meeting management objectives. Although this study focused on forest bird species on Christmas Island, our data simulation approach is likely applicable to many monitoring programs.

Cited material

Southwell, D., Smart, A., MacGregor, N., Merson, S. In prep. Using power analysis and spatial prioritisation to optimise design of monitoring to detect population declines of forest birds on Christmas Island. NESP Threatened Species Recovery Hub Project 3.2.2.3 Final report, Brisbane.

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Christmas Island emerald dove (Chalcophaps indica natalis).
Image: Lip Kee, Flickr, CC BY-SA 2.0

Further Information

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