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decision brief A guide to good environmental decision making

Understanding species distributions

A checklist for designing and conducting field surveys

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To understand the distribution and habitat requirements of threatened animals, managers often need to undertake field surveys, or contract others to do it for them.

The effectiveness of these surveys depends on a lot more than simply selecting the best survey method. The importance of sampling design and the adequacy of the survey effort can easily be overlooked with severe consequences for the accuracy and utility of survey results.

The following checklist provides a starting point in designing and implementing an effective fauna survey for understanding the distribution of threatened species. Included is a list of key questions with tick boxes. If you can't tick all the boxes presented here, there could be serious gaps in your survey plan.

Elements of good design

1. Method of observation
2. Sampling design
3. Timing of survey
4. Observer experience
5. Method of analysis
6. Probability of detection
7. Confidence in species being absent
8. Adequately characterising habitat requirements
9. Accounting for key environmental gradients

1. Method of observation

Observation methods must be appropriate to the species and location under study. A range of observation approaches are available, such as spotlight surveys, cage-trapping, scat searches, hair-tube sampling, and auditory detection with (or without) call-playback. However, generally only one, or a combination of two, will be most appropriate for a given species at a particular location.

There is considerable published advice on observation methods most appropriate to particular species (see below, Resources). In the case where there is no published advice about appropriate survey methods, it is preferable to use methods recommended for similar species, together with advice from experts about the appropriateness of the detection method for the focal species in the study area. Consistency of survey effort and method across survey locations facilitates meaningful interpretation and analysis of the data.

☐ *Is the choice of observation method supported by published advice relating to the species or species group of interest?*

2. Sampling design

The sampling design describes the way in which observation methods will be deployed in space and time.

The most appropriate sampling design depends on the purpose of the survey, the observation method being used, and the assumptions of the statistical technique proposed for data analyses. For example, if the aim is to simply determine the presence or absence of a particular species at a particular location, then it may be sufficient to undertake repeat spotlight searches at that location.

However, if the aim of the survey is to estimate the density of individuals in a fixed area (individuals/hectare), it may be necessary to use a more intensive sampling strategy such as mark-recapture, distance-sampling along transects, or repeat point-counts.

It is difficult to overstate the importance of considering the requirements and assumptions of the proposed analytical approach when designing a sampling strategy. The sampling strategy and analytical techniques are fundamental determinants of whether a survey will meet its objectives, and must be carefully considered from the outset. The same is true of the effort allocated to the survey (see points 6 & 7). Insufficient effort will lead to imprecise estimates of the parameters of interest. In extreme cases, the level of imprecision arising from inadequate effort may be so large that the survey is a waste of time.

- ☐ *Is the sampling design justified with respect to the purpose of the study and the observation method used?*
- ☐ *Does the sampling design factor in the requirements and assumptions of the analytical methods to be employed?*
- ☐ *Is the survey effort sufficient to be confident in the findings of the survey (see 6, 7)?*

3. Timing of survey

Ensuring correct timing and conditions of survey are critical for producing reliable field survey results.

Most fauna species display some form of variability in active periods, either on a daily, seasonal and even yearly basis. Reasons vary greatly from species to species, but are often related to short and longer-term weather patterns. The probability of detecting a species at a particular location can vary by an order of magnitude or more depending of the time of day and time of the year in which the survey is conducted (see 6). The timing of any field survey must therefore carefully consider the focal species activity patterns. Wherever possible, existing information on variation in activity patterns and detection rates should be used to guide the survey timing.

- ☐ *Are the timing and conditions of the survey justified with reference to published advice about the most appropriate time to survey the species?*

4. Observer experience

Observers' level of experience impacts on the probability that a species will be detected during a biological survey. Experienced observers tend to be less prone to false-negatives (i.e. failing to find a species that is present at the survey site) and misidentification errors (i.e. recording as present a species which is, in fact, absent). Observers need to have sufficient field experience to provide reliable data. Variation in observer experience should also be incorporated in survey design and analysis.

- ☐ *Can the choice of observers be justified given their experience?*
- ☐ *Are observer effects included in data analysis?*

5. Method of analysis

A range of analytical methods exist for interpreting field survey data, such as detectability modelling, mark-recapture analysis and distance estimation. The most appropriate method depends on the aim of the survey (e.g. to gain estimates of occupancy rates, abundance, or survival rates); the observation method and the sampling strategy must then be built around the requirements and assumptions of the chosen statistical technique.

Analytical methods support estimation of:

i. the probability that a species would have been detected were it present at a particular location,
ii. abundance or density of individuals in a specified area, or
iii. the strength of species-habitat associations (see CEED Decision Brief #3.2 Species Distribution Modelling).

☐ *Is the choice of analytical method justified with respect to the data being analysed (and based on references to advice in the published literature)?*

6. Probability of detection

Explicit consideration of a species' detection probability is necessary to determine the required survey effort.

Most threatened species will not be detected with absolute certainty during fauna surveys at occupied locations. They will be detected with some detection probability which tends to be quite low for many species of Australian forest fauna, especially when they are small, and/or nocturnal and arboreal, and/or non-vocal, and/or existing in dense vegetation or difficult terrain. In cases where estimates of detection probability do not exist and cannot be estimated with available data, assumptions about the detectability of the species that are being used when designing the sampling strategy (see 2, 3) must be made explicit.

☐ *Have species' detection probabilities been obtained from the literature or estimated from the data?*

☐ *Have the assumptions about the detectability of the species that are being used when designing the sampling strategy been made explicit?*

7. Confidence in species being absent

The survey effort necessary to determine species occupancy at a location depends on:

i. the desired certainty with which the species will be detected (e.g. 95% sure of detection if present),
ii. the prior probability that a site will be occupied by the species, and
iii. the detection probability of the species for a single unit of survey effort (e.g. a single trap-night, or a spotlight survey of a particular duration over a given area).

If the aim of a survey is to ascertain the occupancy status for a species at a site or set of sites, the effort in terms of time spent at the site(s) must be explicitly justified on the basis of the aspired confidence with which a conclusion of 'absent' is reached (e.g. "Having completed the surveys, I am 95% sure that the species is not present"), the probability that the species would have been detected in a single unit of survey effort if present, and the prior probability of occupancy based on knowledge about the quality of the habitat and the proximity to other known populations.

☐ *Has the probability that the species would have been detected in a single unit of survey effort if present been explicitly stated?*

☐ *Has the before-survey probability of occupancy, based on knowledge about the quality of the habitat and the proximity to other known populations, been explicitly stated?*

8. Adequately characterising habitat requirements

Not all habitats suitable for a species will be occupied by the species at all times.

If the aim of a fauna survey is to underpin analysis of species' habitat preferences (and implied distribution), a defensible estimate of the number of survey locations necessary to model habitat requirements should be provided (see CEED Decision Brief #3.2 Species Distribution Modelling). Guidance on the minimum number of detections necessary to fit habitat models is provided in the published literature.

☐ *Has a sufficient number of sites been surveyed to adequately characterise the habitat requirements of the species?*

9. Accounting for key environmental gradients

Environmental variables such as topography, land-use, disturbance history, temperature and rainfall tend to influence species' distribution and abundance. It is important to spread (stratify) surveys across the ranges of those variables, and replicate surveys at each level of those variables. This allows statistical analyses that follow surveys to deal with natural variability and account for un-modelled influences on distribution and abundance. A rough guide is that at least 20 data points per environmental variable is necessary to build a decent distribution model, although this will vary substantially from case to case. A major problem with many survey data sets is that they are inherently biased toward roadside sampling and sampling of public land (e.g. national parks). Randomising survey locations with environmental strata can help to reduce these key biases.

☐ *Has sampling been stratified across key environmental gradients with a sufficient number of randomized samples allocated to each gradient?*

For more information

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Resources

Numerous text books and online resources provide a wealth of detail on how to carry out an appropriate fauna survey. Recovery plans created under the Australian Government's Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) are worth a special mention in this regard.

Here are a few examples of the sorts of resources that are available.

Online guides:

- Survey guidance for amphibians
- EPBC Act guidance on surveying birds
- EPBC Act guidance on surveying mammals
- Field survey methods for threatened species

Key reference book:

Sutherland WJ (2006). *Ecological census techniques: a handbook* (2nd ed.). Cambridge University Press, Cambridge.

Journal articles:

Canessa S, GW Heard, KM Parris & M McCarthy (2012). Integrating variability in detection probabilities when designing wildlife surveys: a case study of amphibians from south-eastern Australia. *Biodiversity and Conservation* 21, 729-744.

Garrard GE, SA Bekessy, MA McCarthy & BA Wintle (2008). When have we looked hard enough? A novel method for setting minimum survey effort protocols for flora surveys. *Austral Ecology*, 33, 986-998. (See Decision Point #34, p3)

Heard GW, P Robertson & MP Scroggie (2006). Assessing detection probabilities for the endangered growling grass frog (Litoria raniformis) in southern Victoria. *Wildlife Research* 33, 557-564.

Kelly LT, DG Nimmo, LM Spence-Bailey, RS Taylor, SJ Watson, MF Clarke & AF Bennett (2012). Managing fire mosaics for small mammal conservation: a landscape perspective. *Journal of Applied Ecology*, 49, 412-421.

Parris KM, TW Norton, RB & Cunningham (1999). A comparison of techniques for sampling amphibians in the forests of south-east Queensland, Australia. *Herpetologica* 55: 271-283.

Lindenmayer DB, RB Cunningham, C MacGregor, M Crane, D Michael, J Fischer, R Montague-Drake, A Felton & A Manning (2008). Temporal changes in invertebrates during landscape transformation: A large scale "natural experiment". *Ecological Monographs* 78:567–590.

Tyre AJ, B Tenhumberg, SA Field, D Niejalke, K Parris & HP Possingham (2003). Improving precision and reducing bias in biological surveys: estimating false-negative error rates. *Ecological Applications*, 13, 1790-1801.

Wintle BA, RP Kavanagh, MA McCarthy & MA Burgman (2005). Estimating and dealing with detectability in occupancy surveys for forest owls and arboreal marsupials. *Journal of Wildlife Management*, 69, 905-917.

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