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Designing a Monitoring Project for Significant Native Fauna Species

Worksheets and notes to assist researchers/investigators

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Prepared for:

Resource Condition Monitoring – Significant Native Species and Ecological Communities Project

Version 1.2 (July 2009)

Revision History Log

Version #	Revision Date	Author	Changes
1.0	20081125	C. Freegard	Created
1.1	20090615	C. Freegard	Reviewer comments incorporated
1.1	20090619	C. Freegard	Sent to branch manager
1.2	20090721	C. Freegard	Final edits made

Acknowledgements

This guide was written using advice contained in the "Manager's Monitoring Guide – How to Design a Wildlife Monitoring Program" available at http://www.pwrc.usgs.gov/monmanual/ (last accessed 9/12/2008). The authors would like to acknowledge the contributions of the following reviewers in improving the content of this document: Peter Mawson, Teagan Johnston, Vanessa Richter, Amrit Kendrick and Glen Daniel.

Suggested Citation

This document may be cited as:

Freegard, C. and Williams, M. (2009). Designing a Monitoring Project for Significant Native Fauna Species. Version 1.2 (July 2009). Prepared for Resource Condition Monitoring - Significant Native Species and Ecological Communities Project. Department of Environment and Conservation.

Table of Contents

1 Introduction

Planning a monitoring project can be a daunting task. The notes and worksheet available here are designed to help.

It is recommended that project investigators work through the worksheet in Appendix I, record information that is known and flag aspects that require further investigation. Throughout the document there are references to additional information and help on particular topics. These should be referred to when greater clarification or explanation is needed to decide what to include in particular sections of the worksheet.

The guide is not meant to be read from cover to cover, rather the reader should skip to sections of interest to them. There is no set order in which monitoring design decisions should be made. This is because factors influencing decisions are largely interrelated. The reader will find that there are many “chicken and egg” situations where it is difficult to decide what comes first or what should be decided first.

The information provided here is designed to be an introduction only. There are many approaches that may be taken when planning and implementing a monitoring project. It is recommended that project investigators carefully research their options and consult a statistician or biometrician for further advice (where necessary).

2 Background

This document focuses on monitoring projects for significant native fauna species. A significant species is one where a dominant land use and/or threatening processes within the region in which the species occurs place constraints and limitations on the long-term survival of the species. At least one of the following factors must also apply to the species:

- It is identified under Australian Government *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as a threatened species (and relative conservation status);
- It is identified under Australian Government EPBC Act as a migratory species;
- It is listed under the *Wildlife Conservation Act 1950*;
- It is listed as a priority fauna species by the Department of Environment and Conservation;
- It is identified using recognized scientifically valid criteria as of conservation concern in the region but not yet formally recognized under State or Australian Government legislation or as a priority fauna species. This includes species of restricted range or extent (less than 500 000 sq km total area of occurrence) and of low abundance; or
- It is restricted in distribution (narrowly endemic or relictual).

A significant species may also be a species at the limit of its range. Species that are new to science and not yet formally described may also be considered significant using the precautionary principle.

It is important to undertake surveys and implement monitoring programs for significant species in order to: assess conservation status; identify trends; and evaluate management actions. The terms survey and monitoring are frequently used in reference to studies of fauna. In general, the term ‘survey’ refers to the act of collecting information relating to a particular subject. The term ‘monitoring’ refers to the long-term appraisal of a particular subject by means of regular surveys to detect trends and changes usually associated with some kind of management question or hypothesis.

3 WHY are you creating a monitoring program?

3.1 Formulating goals

A clear goal is the first, and most important step in the design and implementation of a monitoring project. The goal is a statement about the purpose of the project. Significant species monitoring project goals can be broadly placed into two categories:

1. Detection of long-term population change; and/or
2. Provision of guidance for ongoing management of populations and habitats.

These two categories are discussed in more detail in the following sections. Additional advice for formulating goals for resource condition monitoring may be found on the US Vital Signs Monitoring website (http://science.nature.nps.gov/im/monitor).

3.1.1 Detection of long-term population change

Population change refers to the rate and direction of change in numbers, health or age/sex structure of a population. Collection of this type of information is the first step in effective management for conservation. Understanding how a population fluctuates and knowledge of long-term trends enables appropriate management actions to be made at the right time, and further research into the cause/s for the observed changes to be proposed and implemented.

Existing monitoring programs may provide useful comparative data. In some cases these data may cover a long time period. Comparing local population trends with regional trends can provide perspective on the scale of the trends and what may be driving them. Regional threats or environmental factors such as weather can influence observations at a local level and therefore bias the conclusions that may be drawn about local threats. Alternatively, threats active at a local level may bias conclusions if the local population changes are not considered in relation to the overall population trends.

Monitoring projects established to identify trends in populations should not be expected to also determine why those changes have occurred. A controlled research project encompassing adaptive management will be needed to establish the cause(s) of any observed changes.

It should be noted that 'documenting the decline' approaches should be discouraged and resources should, instead, be focused on projects that are designed to be sensitive enough for appropriate trigger thresholds to be detected such that actions can then be taken (e.g if a population size falls below a certain level then action is triggered to implement management and/or research actions to investigate why it occurred and how it can be reversed).

3.1.2 Provision of guidance for ongoing management of populations and habitats

To provide guidance for ongoing management it is not sufficient to monitor to detect trends in the population of the species (as in the first category of project goals) but also those environmental factors that are considered most likely to affect the species or influence monitoring results.

If your monitoring project goal is to evaluate, regulate, guide or investigate the success of your current or planned wildlife management actions, you will need to be able to use the collected data to both monitor the success of those actions and to help learn how to improve management over time (i.e. adaptive management). It is important to be aware that the complexity, cost and sample size required for these types of studies may be more than resources will allow to properly accomplish the purpose of the studies. Smart study design, lowered expectation of the sensitivity of results and making all data collection efforts count will help to achieve the goal of these types of studies whilst keeping within resource constraints.

3.2 Formulating measurable objectives

Once the goal of the project has been established, measurable objectives are then formulated as required steps or parts to achieving that goal. Objectives are usually short-term, achievable tasks that contribute to the attainment of the overall goal of the project. They have six components:

1. Species or indicator (Identifies what will be monitored);
2. Location (Identifies the geographic area);
3. Attribute (Aspect of the species or indicator i.e. size, amount, density etc);
4. Action (The verb of your objective i.e. increase, maintain etc);
5. Quantity/status (A measurable state or degree of change for the attribute); and
6. Time bound (The time frame of interest).

EXAMPLE: Increase the number of singing male bunyips (*Bunyipus bunyipii*) at Bunyip Swamp by 25% by 2010.

In the case of significant species of fauna the measurable objectives should be formulated around obtaining information related to:

- Presence or absence of significant species;
- The number of separate populations of significant species;
- Location of populations of significant species;
- Area measurements;
- Degree of connectivity;
- Abundance for individual species;
- Relative abundance; and/or
- Trends in relative abundance.

Before accepting a monitoring objective, ask yourself whether it is:

S – specific
M – measurable
A – achievable
R – realistic
T – time (within the time available)

Additional advice on measurable objectives may be found on the US Vital Signs Monitoring website (http://science.nature.nps.gov/im/monitor).

For further information you may wish to read Section 5.1 on the major approaches to monitoring that broadly cover the techniques needed to be implemented in order to achieve the measurable objectives.

4 WHAT are you going to monitor and measure?

It is important to document at the beginning of the project the rationale for choosing what you are going to monitor and measure. This rationale provides justification for your choice and helps argue the value of committing resources to the project long-term. The decision regarding what to monitor will be influenced by funding opportunities, political decisions, research priorities and management priorities.

Some important questions to address when justifying your choice are:

- Is the species of local, regional, or national importance?
- Is the species covered by a recovery plan?
- Is the study site/s of particular importance to the species?
- Will monitoring this species provide information to guide management of the species or its habitat?
- Will the data you plan to collect contribute regionally or nationally to the conservation of the species?
- Is this species already monitored sufficiently by existing programs?

Long-term monitoring projects should be considered as long-term investments requiring careful planning. You are laying the foundations from which a large amount of data will be collected, collated and analysed. It is important to realize that once an opportunity has passed, those data cannot be retrospectively collected so it is important to make sure that data collected are useable from the beginning. Your planning decisions will have long-term consequences.

The followings sections will help you decide what to monitor;

3.1 Choosing a species or set of species

3.2 Deciding what types of information to collect about the chosen species

3.3 Choosing species surrogates

4.1 Choosing a species or set of species

This section highlights various factors that should be considered when selecting which species to survey. The choice of species will influence the techniques used to collect data, the number of samples needed, costs and the number and skills of personnel required. As a consequence, thoughtful consideration is needed at this stage to avoid problems later. For example, some species are difficult to survey for a variety of reasons and will therefore limit the amount of information that can be gathered and reduce the power of analyses.

After considering the factors described below, you should have all the information needed to justify your choice of what to monitor. Articulating the rationale behind your choices will strengthen your proposal and arguments to establish, fund, and continue your monitoring program.

If the choice of species requiring monitoring has already been decided e.g. due to a funding requirement, then the following sections should be used to flag cautions and highlight where difficulties may be encountered.

4.1.1 Difficult species to monitor

Species may prove difficult to monitor for a number of reasons. These reasons should be considered before choosing a species to monitor or at least taken into consideration when developing a monitoring for a predetermined species. How difficult your species is to monitor will affect the level of resources required to obtain sufficient data to satisfy the goals and objectives of your monitoring project.

Difficult to monitor species include:

- Difficult to detect or low abundance species
- Species that are highly responsive to environmental conditions
- Poorly known species
- Difficult to identify species

Table 1 summarises the ecological and biological attributes that influence the ease with which significant species can be monitored and provides examples. Knowledge and experience of investigators will lessen the extent to which some ecological and biological attributes will impact survey and monitoring results.

Unfortunately significant native fauna species often fit into one or more of these categories and the following sections should therefore be used to raise awareness of some of the difficulties and consequences.

Difficult to detect or low abundance species
Detectability can be defined as the probability of locating, identifying, and counting each individual of a species if it is present at your monitoring site during a survey. Cryptic or rare species are difficult to observe and therefore difficult to obtain enough information to tell you something meaningful about resource condition. Species for which successful trapping or observation methods have not yet been developed are also difficult to monitor

Rule of thumb: Wherever possible monitor species that are easier to find and more consistently detectable.

Detectability of species also varies between sites and seasons as well as over time. This variation in detectability has the potential to bias estimates and must be considered and accounted for when analyzing results of a monitoring program.

In general, an abundant species (given that it is reasonably detectable) will require less effort to count than a rare one. However, it is the uncommon species that are often of interest for monitoring and need to be directly targeted irrespective of ease etc. Such species are often absent from the sampling sites, causing investigators to increase sampling effort in order to obtain sufficient data to analyse. Datasets for uncommon species often require different analytical approaches that are specifically designed to handle situations where datasets are not ideal. Sampling distributions will almost always be non-normal and statistical transformations may be necessary. Data may need to be pooled across sampling sites. The type of analyses possible will affect the types of statements that can be made about populations.

Rule of thumb: If possible (where the option exists within the hypothesis being tested) make it easier for yourself by monitoring abundant species or employing a technique that permits the observation of a large number of animals.

To further compound the problems associated with the detectability and abundance of species there is the issue of variability. Any monitoring project's ability to estimate change is influenced by the amount of season-to-season or day-to-day variability in that project's monitoring results. High variation or noise in monitoring results will diminish your ability to detect and estimate trends. The variability in monitoring results also influences the sampling effort, the amount of time or effort spent at each sampling site as well as the number of replicates needed to detect trends of the magnitude expected or required by the recipients of the monitoring project's data.

Rule of thumb: More sampling effort must be expended when there is high variability.

Some help on ways to manage and reduce the variability is contained in Section 5.3.2 Count Variation.

Whilst variation in monitoring results has the effect of masking long-term trends, bias in monitoring methods used can cause monitoring programs to reach false conclusions regarding the trajectory of those population changes. Biasing factors include weather and observer differences. For most species there are monitoring methods that are unbiased or there are ways of correcting the common biases. The latter requires the use of covariates.

Rule of thumb: Species that have well-developed, unbiased sampling approaches and techniques should be favoured.

The issues of bias and correcting for changes in detectability are some of the most contentious issues in the fauna monitoring field.

Rule of thumb: If in doubt consult a statistician or biometrician for advice before starting any field work.

Species that are highly responsive to environmental conditions

Species that have variable movement patterns are difficult to monitor because it is difficult to predict where the animals are to obtain a count, and difficult to know if variability in counts is due to true changes in the population or simply a result of the movement of portions of the population. Migratory or nomadic species are examples of such species. To monitor these species it is essential to understand the underlying factors that cause the movement of the animals, whether it be seasonal changes, response to changes food sources or other factors so that these can be monitored in addition to the animals themselves.

Poorly known Species

Some knowledge of a species distribution and biology is required to implement a monitoring program for a species. For species where little is known, it is difficult to know where to monitor and what techniques to use. In these cases it is often best to apply knowledge of similar species and make inferences. Monitoring programs for poorly known species may also have an extended pilot phase to enable techniques and methodology to be refined. Review of monitoring programs for poorly known species should occur more frequently than for well known species.

Difficult to Identify Species

Correct identification is an essential part of a survey. The experience of personnel in species identification can vary and these observer differences can greatly alter the results of a monitoring program. Appropriate training is required to improve consistency between observers. Alternatively, monitoring species that are notoriously difficult to identify or easily confused should be avoided unless sufficient resources are available to improve the rate of correct identification. Species that require expert consultation to confirm species identification may consume more resources than can be justified from the value of the information obtained.

Table 1: Ecological and biological attributes that influence the ease with which significant species can be monitored (adapted from Clarke *et al*. 2003[1]).

Attribute	More difficult	Examples	Less difficult	Examples
Population density and abundance	Very low density and/or abundance	Chuditch (*Dasyurus geoffroii*)	High density and/or abundance	Typically species with specific habitat requirements (eg pools in streams) or restricted geographic distributions (eg island restricted).
Knowledge of distribution	Poorly known	Night parrot (*Pezoporus occidentalis*), Forest black-cockatoos (*Calyptorhynchus baudinii* and *Calyptorhynchus banksii naso*)	Well known	Gilbert's potoroo (*Potorous gilbertii*)
Individual detectability	Highly cryptic	Well camouflaged, trap shy species such as the numbat (*Myrmecobius fasciatus*).	Readily detected	Species that are large, colourful, noisy, 'trap happy' and/or diurnal are easier to observe. Muir's corella (*Cacatua pastinator pastinator*) is a good example.
Movement pattern	Broad	Migratory species such as Carnaby's black-cockatoo (*Calyptorhynchus latirostris*) and humpback whale (*Megaptera novaeangliae*).	Local	Any species that establishes home ranges or territories eg Woylie (*Bettongia penicillata ogilbyi*). Species that are predominantly sedentary such as the tree stem trapdoor spider (*Aganippe castellum*).
Environmental responsiveness	Highly variable or unpredictable	Nomadic species that respond to the availability of food sources such as the Bilby (*Macrotis lagotis*) in arid areas. Species whose activity patterns in response to environmental conditions are not well understood.	Highly predictable	Species that respond to seasonal changes at a landscape level rather than a local level. Long-distance migratory species such as whales and turtles are reasonably predictable regarding arrival time in breeding waters or at nesting beaches.
Knowledge of biology	Poorly known	Marsupial moles (*Notoryctes* sp.). Many invertebrates species.	Well known	Species with well established long-term monitoring programs such as the Western Swamp Tortoise.

[1] Reference: Clarke, R.H., Oliver, D.L., Boulton, R.L., Casset, P. and Clarke, M.F. (2003). Assessing programs for monitoring threatened species – a tale of three honeyeaters (Meliphagidae). Wildlife Research 30: 427-435.

Attribute	More difficult	Examples	Less difficult	Examples
Ease of identification	Difficult to identify or distinguish	Species with similar appearance such as Carnaby's (*Calyptorhynchus latirostris*) and Baudin's white-tailed black cockatoos (*Calyptorhynchus baudinii*)	Easy to identify or distinguish	Species with distinctive characteristics that are easy to observe. The colourful plumage of Gouldian Finch (*Erythrura gouldiae*) and their popularity as cage birds make them easily identifiable in the field. The calls of orange-bellied (*Geocrinia alba*) and white-bellied frogs (*Geocrinia vitellina*) are easily distinguishable once taught.

4.1.2 Environmental indicators, bioindicators, indicator species and focal species

Every species requires a range of conditions in order to live, forage and breed successfully. Removal or degradation of any one of the required conditions compromises that species' ability to survive and potentially results in the loss of that species from the area. Therefore the continued presence of a species in an area suggests that those conditions are still being met and can therefore potentially be used as an indication of ecosystem health. Monitoring species that require high quality environments, specialised habitats or specific conditions will help inform land managers of the condition of those particular environments.

Indicator species are described, in relation to birds, as species that are most vulnerable to local extinctions or declines in an agricultural environment. The term focal species has been used to describe those birds that are most sensitive to shortages of resources or threatening processes in a landscape. If resource shortages and threats can be managed at a level that protects the most sensitive species then it is likely that other less sensitive species are also protected. Therefore, if a suitable indicator or focal species is chosen and monitored it will provide information that, in theory, will assist the protection of other species in that landscape.

The health of an environment/ecosystem is often difficult to monitor directly because of the many interacting factors involved. It is easier to monitor the status of a species that requires particular environmental conditions to inform managers about whether or not those conditions still exist. Thus species monitoring has the potential to be a surrogate for ecosystem and/or resource condition monitoring.

However, ecosystems are very complicated and we can only hope to understand a small amount of how the various components interact. This approach makes assumptions that may or may not be correct and circumstances may change during the course of the monitoring project.

Useful reference:

Lambeck, R.J. (1997). Focal species: a multi-species umbrella for nature conservation. Conservation Biology 11: 849-856.

4.1.3 Keystone species and ecological dominants

Within a given landscape or ecosystem there are often particular species that have a disproportionate effect on the ecology of the location through sheer numbers, biomass or ability to control the pattern of other species via predation or habitat modification. Monitoring such species can infer changes or effects on other species because such species are, in effect, managing and controlling the population numbers of other species at the location. These species are known as keystone species, and an example is burrow-nesting seabirds on islands where the guano produced by the birds greatly influences the availability of nutrients to plants and, in turn, other animals.

Understanding keystone species and ecological dominants requires good knowledge of the ecosystem and the interactions between species and the environment over time. In many situations this knowledge is not available or limited such that it would not be advisable to base a long-term monitoring project on a series of assumptions.

4.1.4 Monitoring multiple species

Many monitoring methods enable data to be collected on a range of species at the same time. Such studies provide a more complete picture of the health and status of a range of species in the study area. Collecting data on an entire community allows the comparison of trends amongst species, identification of patterns amongst groups of species and provides greater insight into the interactions of the species with each other and the landscape. This is usually associated with a decrease in the cost of data collection per species. Examples of such projects in Western Australia include cage trapping under the Western Shield fauna recovery program and monitoring turtle nesting beaches where multiple species come ashore. However, when monitoring multiple species the intensity of information collected for each species is likely to be less than what may be collected in an individual species focused monitoring program.

4.2 Deciding what types of data to collect about the chosen species

Data is the raw material or unorganised facts that need to be processed. Information is data presented in a usable form, usually processed, organised or structured in some way such that it is put in context and/or has been interpreted. The purpose of collecting data is to obtain information.

Data can be collected at a variety of levels (Table 2). The purpose of your study (i.e. what kind of information you want to obtain) will guide what kind of data is required and at what level it should be collected. If data is collected at more than one level then a much richer, more detailed picture of what is happening can be developed. For example, gathering data about the juvenile age classes, birth rates, and survival will potentially reveal more information about the health of a population than simple counts of adults, though the costs of collecting such data are substantially higher than collecting basic count data. The type and amount of data collected will be limited by the resources available, techniques available and the degree of bias and variability of those techniques.

It is easier to collect additional data at the time of doing the monitoring, than it is to collect the data in a retrospective manner (if this is even possible). In general it is advised to practice collecting as much data as possible. Even if it is not directly useful to the current study, it may prove of benefit for subsequent studies or objectives.

Table 2: Types of monitoring data that can be collected and the associated information that can be obtained at different levels.

Level	**Attributes that can be measured or observed**	**Examples of information obtained**
Individual animal	Morphometrics (i.e. body measurements)	Growth curve for aging individuals.
	Health	Information on disease, parasites, blood chemistry etc that is normal or abnormal for a species. Changes in health over time (e.g. body condition).
	Reproduction	Information on individual breeding success over time.
	Behaviour	Indicators of breeding activity. Reaction to impacts (e.g. tourism). Home range size.
Population of a species	Size (number of animals)	Changes in population size over time.
	Fecundity (birth rate)	Changes in fecundity over time.
	Survivorship (death rate)	Changes in survivorship over time.

Level	**Attributes that can be measured or observed**	**Examples of information obtained**
	Area of occupancy	Changes in area of occupancy over time.
	Extent of occurrence	Changes in extent of occupancy over time.
	Immigration and emigration	Rate of potential genetic exchange between populations.
Community	Species turnover (i.e. composition of species)	Changes in the composition of species over time
	Number of species	Change in species richness or diversity over time.
	Immigration and emigration	Seasonal changes in species diversity.
Landscape	Habitat characteristics	Suitable habitat features for a particular species. Area of suitable habitat.
	Connectivity of habitat	Assess level of isolation of a population. Identify useful wildlife corridors
Environment	Threats	Influence of a threat on other measured attributes.
(Covariates)	Weather	Ideal conditions for monitoring. Degree of influence of weather variables that affect monitoring data.

4.3 Choosing species surrogates

Fauna monitoring implies that an actual species will be monitored. In some situations this may be difficult to do, especially if the species is uncommon, cryptic, shy or techniques are costly. In these cases surrogates such as habitat, food plants or associated (easier to monitor) species could be chosen.

It is important to exercise caution when using surrogates because you are not monitoring the species of interest and although some correlation between your surrogate and species is expected (otherwise you wouldn't have chosen it), you must take care not to be misled or make too many assumptions. It is important to undertake periodic checks of the actual species to ensure that patterns observed in the surrogate are meaningful to the species of interest.

In general, the surrogate should have similar ecological or biological features to the target species, and be expected to respond to environmental parameters, and especially potential threats, in a similar manner.

5 WHERE are you going to put your sampling locations?

The first step involved in deciding where to put sampling locations is some familiarity with the study area. The following sources of information may be useful when broadly deciding upon sites:

- Maps (topographic, soil, Agricultural Land Systems mapping etc)
- Existing vegetation maps (e.g. Beard, 1974-1981)
- Aerial photographs
- Satellite imagery (e.g. Google Earth)
- Existing literature
- Local knowledge
- Field visit

It is also important to consider any access restrictions such as Disease Risk Areas and road conditions.

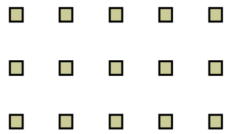
Once you are familiar with the general area of interest you will need to make decisions about:
- Choosing a sampling design
- Choosing sampling locations

5.1 Choosing a sampling design

The actual layout or design of sampling at your chosen site/s will be determined by the target species and the purpose of the survey. Options for sampling design include points/quadrats, grids, transects or trapping webs. In general…

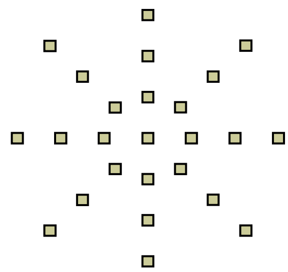
Choose a point or quadrat design if:
- Observing species presence
- Assessing the distribution of a species
- Require flexibility of random sampling

Choose a grid design if:
- Measuring population density and dynamics
- Measuring individual animal movements
- Targeting small, less mobile species
- Sampling a small area (<5ha)



Choose a transect design if:
- Measuring relative abundances
- Targeting wide ranging species
- Sampling a wide range of habitats over a large area
- Require convenience of utilising pre-existing tracks

Choose a web design if:
- Measuring density and relative abundance
- Have good access by foot
- Sampling a small or medium size area
- Have good detectability of species of interest
- Have resources to cope with demanding logistics



Sampling locations or spacings will also depend on the monitoring method and target species. For example, Elliott traps are generally placed closer together than cage traps because they target smaller animals that move over smaller areas. Generally, pitfall traps and small and medium Elliott traps are placed 10-50m apart, and small cage traps are placed 20-200m apart depending on what species are targeted. For example, small cage traps can be placed in lines of five to ten traps, 20-50m apart to target Quenda, or along road transects at 200m intervals to target wider ranging species such as Chuditch and Woylies. More than one trap type can be incorporated into a survey design such as that illustrated in Figure 1.

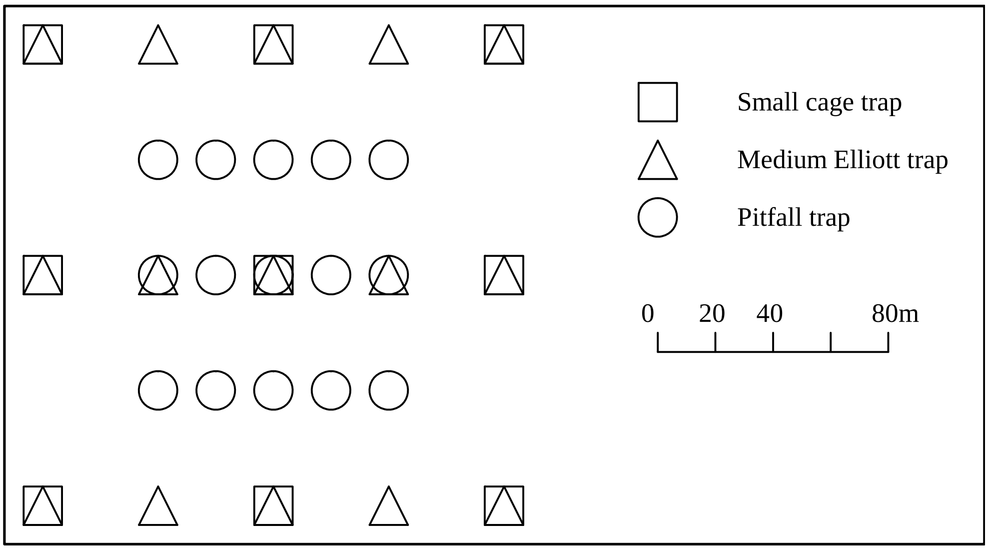


Figure 1. Integrated trapping grid design used during the Kingston Timber Harvesting Study near Manjimup.

5.2 Choosing sampling locations

Exactly how sampling locations are chosen is important. In most cases it is impossible to sample the entire population being studied and therefore it is important that the sampling which is done, is representative of the whole. The following points should be considered when deciding where to put sampling locations:

- **Too few samples over too large an area**. If your study area is very large and you only have resources to sample a few sites in that area then it is reasonable to surmise that trends calculated from your sampled locations may not reflect trends for the overall area. It is difficult to clearly define when you have too few samples from a geographic perspective. However, in most cases pilot study data or data from similar studies usually indicate that sample sizes for monitoring programs need to be large for most species to accommodate the variability inherent in population counts.

- **Pre-determining where to sample**. In general, any individual who chooses their own sampling location without applying some sort of random or systematic sampling scheme, will end up putting samples in sites that are not representative of the study area. The location of the sites becomes influenced by that person's thoughts about what places are attractive and what places should be avoided. This limits the usefulness of the monitoring program, as any analyses of such data can only represent the chosen plots. The solution is to use a random or systematic scheme to select your sampling points.

- **Excluding certain areas from sampling**. There are some situations where it is necessary to exclude certain areas from sampling, such as difficult to access sites (e.g. steep slope, middle of a swamp) or for other reasons such as safety or logistics. These are practical decisions but you must be aware that they can impact the results of your study as they may not be representative of the entire study area.

- **Stratifying on vegetation or habitat.** Stratifying involves increasing or decreasing the density of monitoring sites in certain areas of your study area. This is often done when certain areas are of particular interest and there would be too few samples to calculate reliable trends using the overall sampling method. The boundaries used to create stratification should be related to permanent physical features, such as stream corridors or soil types, that are unlikely to change in subsequent years and boundaries based on vegetation, habitat, or current land use should be avoided.

- **Choosing new points each year or using the same?** To detect long term changes it is important to use the same sampling sites, trap points etc. Using the same sites eliminates variation in monitoring results caused by location. Permanent sampling locations also make logistics easier because you can repeat previous year's efforts. From a statistical point of view it is important to remember that using permanent sampling locations means that you will need to choose tests that account for "repeated measures". It is also important to consider what impact the frequency or intensity of your monitoring is having on the environment and the species you are studying. Impacts such as disturbance and vegetation trampling should be minimised wherever possible.

- **Mapping out all your sampling sites before going out into the field.** By plotting your sampling sites on maps or a GIS system you will be better able to visualise the consequences of your choice of sites and sample sizes. Mapping your points will quickly illustrate any errors that were made in choosing them. Check that it is logistically possible to navigate between the sites within the required time frame. Mapping the sampling sites is a relatively quick task that can save time and prevent a variety of errors from continuing between seasons.

- **Not all points need be visited every year.** It is not necessary to visit all sampling sites each year if circumstances and purpose of the study allow. The frequency of monitoring will be determined by the measurable objectives and the statistical analysis required to report against those objectives. Sampling frequencies that allow monitoring to occur in multiple stages will rotate the number and location of sampling across a number of years and require more complicated statistical analysis.

- **Control and treatment sites.** If your study is investigating the effect of a particular management action then it may be useful to establish control (i.e. non-treatment) and treatment sites. It is important to make every effort to find sites that are as similar as possible so that any differences in results can be attributed to the treatment being applied.

- **Deliberate bias.** In some situations there may be an intentional bias in sampling. This is usually done to test a simple hypothesis or management question. For example you may wish to know if there are proportionally fewer freshwater mussels in the vicinity of a stormwater outlet than the rest of the stream to help determine if the water quality of the stream is being affected by the outlet. Here sampling is biased to sampling in the vicinity of the outlet and comparing it to away from the outlet rather than randomly sampling throughout the stream.

After reading this list you might have some trepidation about where to put sampling sites for your study. Being cautious is a good thing because an inappropriate sampling regime is a common mistake made in creating monitoring programs. Seek advice from a statistician if you would like further guidance.

6 HOW are you going to measure it?

This section covers the nuts 'n bolts of exactly how you are going to measure what you have chosen to monitor. There are many things to contemplate and it is not easy to bring it all together. You need to choose an appropriate monitoring approach, decide on any covariates to collect, decide on monitoring techniques and at the same time think about how you are going to statistically analyse the results. It is difficult to incorporate and account for the inherent variability of populations, the many types of measurement errors that are a part of every monitoring technique and approach, and the bias, risks, and nuances associated with interpreting the monitoring results.

6.1 Choosing a monitoring approach

It is recommended that you read through the following sections outlining the major approaches to monitoring before deciding on a specific monitoring technique. The major approaches are linked to the kind of information or product that they generate, their uses and limitations.

The major monitoring approaches, listed in approximate order of increasing difficulty, are:

- Collating records and observations

- Species map

- Index of abundance
- Estimate of area of occupancy or extent of occurrence
- Estimate of population size

During any of these monitoring approaches additional data can be gathered to help interpret changes or trends in the species of interest. This additional data may be biological (e.g. notes on the health of animals observed) or it might be environmental (e.g. weather conditions). For example weather conditions may be noted to enable correlations to be made between temperature and the number of reptiles observed.

6.1.1 Collating records and observations

Collating records and observations of a particular species is often the first step in understanding a species enough to plan a project to monitor that species. Distributional records can help determine the habitat requirements for a species which in turn assists further surveys. It is also important to note that records of a species absence (with associated survey effort information) are just as important as presence records. Sometimes where a species isn't is more helpful to know than where it is.

Records and observations can be collated from a number of different sources including the following:

- Opportunistic observations;
- Hiring a specialist to search for the species (i.e. presence/absence records); and
- Using standardised sampling.

Opportunistic observations. Records for a species can be collated from museum specimens, literature, notebooks or other documents as well as sightings reported by the public. Generally these will need to be georeferenced to be useful.

A number of databases are available online for searching for records of particular species. Examples of such databases include NatureMap[2] (http://naturemap.dec.wa.gov.au) and Birdata (http://www.birdata.com.au/homecontent.do). A search of the Department of Environment and Conservation's Threatened and Priority Fauna Database can also be requested.

The rate of sighting records being entered into databases can be used as a coarse estimate of the abundance of a species because you would expect the number of sightings to change proportionally to changes in population size. Many factors can affect the rate of sighting reports (especially the uniformity of surveys) and so this is not a reliable monitoring method but does have its place particularly if community involvement in reporting sightings is promoted and encouraged.

Hiring a specialist to search for the species. Using a specialist is the best way to obtain a comprehensive survey for a particular species. A specialist is more likely to have the skills to confirm the presence of rare or unusual species because they have insights into behaviour or habits that enable them to locate species missed by people without specialised skills. For example the burrows of the tree-stem trapdoor spider (*Aganippe castellum*) are very well camouflaged and easy to overlook but to the trained eye they are very distinctive and are often constructed at the base of particular shrub species.

However, the thoroughness of the survey is entirely dependent on the knowledge and skills of the specialist. The results of such efforts are difficult to repeat because specialists themselves do not share the same knowledge base and it is difficult to train personnel to the same standard. Also, the amount of effort put into searching for a species may not have been systematic.

Using standardised sampling. If you would like to compare the detectability, abundance or distribution of a species over time or between sites then it is recommended that standardised sampling be used. This involves keeping the amount of sampling effort constant between sites or

[2] DEC (2007 –) *NatureMap: Mapping Western Australia's Biodiversity*. Department of Environment and Conservation. URL: http://naturemap.dec.wa.gov.au/

between visits by restricting the amount of time spent sampling as well as the area sampled. Standardised sampling enables your surveys to become a monitoring program when it is repeated over time, and uses the same or similar effort and skills. It is possible to utilise the skills of a statistician and a specialist to increase the efficiency of surveys through stratification whilst maintaining a standardized sampling method.

6.1.2 Species map

Maps are useful in the first few years of a project. They allow users to begin to see the results of monitoring efforts and can be produced before sufficient data has been gathered to enable statistical trends to be determined. Species maps are rarely the sole purpose for gathering data and are usually side products, but can be used to complement monitoring efforts. However, it is worth considering mapping at the beginning of your project because it requires specific kinds of data and tools.

To map your data you need:

- **Geo-referenced data**. You need accurate coordinates (lat/long or AMGs) for your sampling points, sighting records etc.

- **Mapping software**. Whilst it is possible to hand plot points on a map it is recommended that you use mapping software such ArcGIS or DECGIS to produce data layers. These layers can then be overlaid onto other management information to help inform decisions.

- **Appropriate data**. Your maps are only as good as the data you have collected so it is important that your data is as representative and unbiased as possible.

Maps are perhaps the most understandable and attractive summaries of data that can be presented to funding bodies, volunteers and supervisors. Statistical trends may require five or more years of data to have been collected, compared to a species map which can be produced within the first few years.

Species maps are affected by biases in monitoring techniques and representativeness of sampling sites. Biases in coverage and techniques will result in biased data and biased maps that do not represent the true distribution and abundance of the species of interest. Discrepancies and bias in your monitoring program are easier to identify when mapped, particularly compared to tables or spreadsheets. Mapping your data should be used as a quality control check.

Collecting data suitable for mapping enables the distribution of records to be plotted and if data is ‘fit for purpose’, extent of occurrence and area of occupancy can be estimated. Such information is useful for assessing the conservation status of a species. The distribution data may also be plotted with other data layers to look at aspects useful for making management decisions, such as the connectivity of habitat which could be used to plan revegetation efforts.

6.1.3 Index of abundance

In most situations it is extremely difficult to accurately count the total number of animals in a population. Animals are often difficult to observe (cryptic or shy), can sometimes be too numerous to count, can be incorrectly identified, individuals can be missed during counts, or some individuals may be counted more than once. An index of abundance is used to provide an indication of population trends whilst recognizing the potential for inaccuracy. An index involves an incomplete count that is thought to be proportional to the population size (e.g. number of birds heard calling at a point, number of reptiles found on a stretch of road at night). An index does not determine the relative detectability of the animals being counted nor does it estimate the missing portion. The biggest difficulty with use of an index is the assumption of a constant ratio between the index and the true population.

In almost all situations this assumption of consistency between counts is false (i.e. you won’t count the same proportion of the population each time you monitor). For example, the number of tammar wallabies seen visiting a feed station will vary from night to night over a week but the actual number of tammar wallabies in the area is not likely to have changed over the same period.

An index is a reflection of both the real numbers of animals present and your ability to detect them. This has consequences for monitoring. Firstly, a change in detectability DURING each sampling period will add variation to your counts (i.e. measurement error). Consequently your monitoring project will have reduced ability to detect changes and you may require a larger sample size or longer time frame to detect change. Secondly, if your ability to detect animals, changes OVER TIME (i.e. you see proportionally more or fewer) then you have created a bias in your counts and your index is no longer an accurate reflection of changes in that population.

Detectability DURING a sampling period can be impacted by factors such as weather. Bad weather will lower counts and so it is advisable to eliminate counts taken during bad weather.

Detectability OVER TIME may be affected by observer differences caused by staff turnover and their relative abilities and experiences. A keen, experienced observer is likely to provide higher counts than a less motivated, less experienced observer with poor eyesight/hearing. The resulting counts will be biased over time and you will see false declines or increases in the counts. These changes would not be due to real changes in the population, but simply due to differences in the two observers' skills.

Another detectability bias that can slowly impact over time is changes in habitat. If the vegetation becomes thicker, denser or higher it may affect your ability to observe the animals resulting in changes in counts that do not reflect population changes but simply your ability to observe them. Vegetation changes may also make habitat more or less suitable for a species and so animals will move into or out of areas adjacent to your study site depending on favourability. The overall population size for the study area may not have changed but you will observe a trend where you conduct your counts.

Changes in technology can also create problems. Anything that improves your ability to capture, hear or see an animal is likely to bias monitoring results. You may perceive an increase in abundance when no change has actually occurred.

The problem of not being able to measure or correct for biases is the biggest drawback of using an index as a means of monitoring populations. Bias is less of a problem if the types of trends you are trying to detect are long-term (10+ years) and large (>50% change). The decision regarding whether or not to use an index of abundance will be based on the amount of potential bias in counts, the feasibility of minimizing bias and the comparative benefits of other alternatives.

It is generally easier and less time consuming to collect, store and analyse index data compared to population size estimation data. Estimation data often requires multiple visits to the same site, may require time-consuming marking methods and usually has greater information requirements.

6.1.4 Estimate of area of occupancy and extent of occurrence

In some circumstances it is more appropriate to monitor changes in the area occupied or extent of occurrence of a species than actual trends in population size. Changes in area of occupancy (AOO) or extent of occurrence (EOO) can reflect changes in population size. This might occur if a particular species retreats to high quality habitat or refuge patches when population size is small and/or stressed. However, if the species simply becomes sparser over the same distribution then monitoring the area of occupancy or extent of occurrence will not provide an indication of trends in population size. It is still useful information for assessing conservation status.

Estimates of area of occupancy and extent of occurrence and any trends in these parameters may be required in assessments of the conservation status of a species against IUCN criteria.

Estimates of occupancy and occurrence are usually based on presence/absence data. However, few species are conspicuous enough for you to be confident that they will always be detected when present. This means that a recorded absence may be a true absence or it may mean that the species was not detected although it was present. The consequence for imperfect detectability on estimates of AOO or EOO is that they are likely to be underestimates of the true number of occupied sites. It is also important to consider that if comparing AOO or EOO estimates over time it is important for your ability to detect species to be kept as constant as possible.

This issue of imperfect detectability can be addressed by taking repeated samples from at least some of your sampling sites so that both AOO/EOO and detectability can be estimated. The questions of how many sampling sites and how many times to repeat sampling are difficult to answer and will generally require advice from a statistician. In general the number of repeat surveys should be sufficient so that if a species is present at a site, there is at least a 70% chance of detecting it at least once. For example, even if the species is moderately detectable (say it is detected 5 out of 10 surveys) then 2 or 3 repeated surveys of a site may be acceptable, with the number of required surveys increasing as detectability decreases.

There is some flexibility regarding how repeated surveys might be conducted. They could be repeated once a week, on consecutive days or multiple times during a single site visit and they may conducted by a single observer or different observers. However, consideration must be given to the biology of the species and assumptions of statistical models to ensure the results are valid.

The number of sites required to estimate AOO/EOO will depend on the size of the species distribution and the resolution or precision at which you would like it to be measured. For example, determining presence/absence for 1km square grid cells will give a more accurate estimate than 10km square grid cells.

The advantages of estimating AOO and EOO are relatively low-cost options because:

- individual animals do not need to be identified;
- the issue of detectability can be addressed; and
- there are a number of statistically robust models to use for data analysis.

Disadvantages of AOO and EOO include the difficulty in identifying changes in abundance of a species if there is no corresponding change in distribution, and the requirement for repeated surveys to achieve precise estimates.

6.1.5 Estimate of population size

Population estimation techniques combine a count of animals with an estimate of the portion that were missed. This produces an estimate of the total number of animals in the population with a set of statistically determined upper and lower bounds.

Population size is most commonly estimated through mark-recapture experiments. Such experiments require animals to be individually marked and to be recaptured (or at least identified) throughout the study. In general, large numbers of animals need to be marked or a high recapture rate is needed. These techniques are quite costly in terms of time, resources and impact on the animals but the resulting information can be valuable. This is enhanced if additional information is gathered whenever each marked individual is captured such as reproductive status and body condition.

Newer approaches used for estimating population size have been designed to be less invasive and intensive. These techniques involve taking measurements whilst observing animals that help to estimate the accuracy of the count, detectability of the species or observer differences. For example the time between observing animals may be recorded or the distance between the observer and the animal might be estimated (i.e. distance sampling). These techniques do not require the handling of animals and the associated potential for injuries/trauma but can be applied to many observation (visual or aural) monitoring methods such as point counts and transects.

Although these techniques require less time in the field than mark-recapture experiments they require more time than a comparable index. It should be noted that for many small monitoring projects there may not be sufficient samples to enable calculation of useful estimates of detectability. Finally, as with using an index, each population estimation technique comes with a series of assumptions that must be met in order to produce a valid estimate.

There are many population size estimate techniques and an extensive amount of literature available on the topic.

Useful reference:

Driscoll, D.A. (1998). Counts of calling males as estimates of population size in the endangered frogs *Geocrinia alba* and *G. vitellina*. Journal of Herpetology 32: 475-481.

6.2 Choosing a monitoring method

All monitoring projects that aim to obtain an estimate of population size or produce an index of abundance will involve the use of some kind of count (e.g. number of numbats seen over a set transect, number of birds detected from a point etc). There are several counting techniques that are suitable for any given species or group of species. Each counting technique may be modified by altering the sampling time, equipment used etc to suit local situations. However such modifications to general techniques can reduce the usefulness of the data especially if comparisons between sites or over time are desired. Standard Operating Procedures (SOPs) should be utilised wherever possible.

To be useful for detecting trends these monitoring methods must have the following characteristics:

- Able to regularly detect the targeted animal;
- Must be located randomly or uniformly throughout the study area;
- Must detect a constant proportion of the individuals (or estimate the differences); and
- Be precise enough to detect the type and level of changes that you want to detect.

Fauna monitoring methods can be divided into three major categories:

1. Remote observation
2. Observation
3. Capture

6.2.1 Remote observation

Remote observation involves monitoring fauna without the presence of a person to take the sample or observation. Two common examples are the use of cameras triggered by sensors and the collection of hair using hair cones or tubes. These methods generally have low impact on the study species. The data gathered can be limited to presence/absence however individual identification may be made through genetic analysis in the case of hair tubes/cones or distinctive markings in the case of remote sensing cameras. They have the advantage of being able to cover a large area whilst using minimal resources to maintain.

6.2.2 Observation

Observation methods require a person to be present to make the observation. Observations can be made of the signs left by animals (tracks, scats, scratch marks etc) or of the animals themselves. Observations over small areas may be made on foot. If larger areas require coverage then the use of a helicopter or aeroplane may be employed (e.g. survey of large feral animals in remote areas). Night time observations are commonly made with the assistance of a spotlight either from a vehicle or on foot. Observation methods require competent animal identification skills because there is often limited time to make identifications and less opportunity to obtain photographs or specimens for referral and confirmation.

6.2.3 Capture

These techniques involve the physical capture, handling and restraint of the animal. Capture techniques are generally the most invasive and require careful consideration to firstly decide whether capture is necessary to obtain the desired information and secondly, if capture is necessary, to ensure that everything possible is done to reduce the level of impact of capture on the animals (e.g. adequate trap covering, checking traps frequently etc).

The exact method of capture depends on the species of interest. A variety of Standard Operating Procedures have been developed by the Department of Environment and Conservation (DEC) and endorsed by the DEC Animal Ethics Committee for the most common capture methods used for fauna monitoring in Western Australia.

6.3 Statistical Considerations

6.3.1 Number of samples

A dilemma at the beginning of any monitoring program involves balancing the need to obtain sufficient data for analysis with the resources available to collect it. How to determine the minimum number of samples required to adequately monitor a species is difficult and affected by a number of factors including:

- Project goals;
- How you plan to analyse your data (i.e. what statistical tests are you going to use);
- How variable your data are likely to be;
- How precisely you want to measure change or trend;
- The number of years over which you want to detect a trend;
- How many times a year you will sample each point; and
- How much money and resources (e.g. personnel) you have.

It is recommended that project investigators obtain information related to the above factors before considering calculating an appropriate sample size.

The actual factual information that you will need to set a minimum sample size is as follows:

- An estimate of the mean and standard deviation (i.e. the coefficient of variation or the variation of your counts) (obtained via a pilot study or using results of a similar study);
- The smallest number of years over which you would like to detect a change;
- The smallest percentage change you would like to be able to detect over those years;
- An alpha (significance) level that you will use to determine if a change is real and not simply variation;
- A power level (the proportion of the time you would like to detect a trend if one were occurring); and
- A statistical test (your analytical model).

The mean and standard deviation (a measure of the amount of variation of your counts) are determined by the traits of the animals being sampled and are best obtained from pilot data for your study. If this is not available you may use data from similar studies with an appropriate amount of caution. You can avoid problems when you calculate estimates of the variation of your counts by:

1. Using data collected over time, not space (i.e. do not use data from several monitoring sites for a single monitoring season, rather use data from a single site over several seasons).
2. Using data from studies with similar counting techniques and sampling units to the ones you plan to use.
3. Use means that come from the same data you used to calculate the variance.

All other pieces of information required for setting sample size are decided based on your need for precision and the smallest amount of change you would like to detect. The higher your expectations of the results of your monitoring project the more effort and cost will be involved in getting sufficient data to be able to provide the desired information. In general, higher expectations will mean that a larger number of samples will be required and this is rarely possible with available resources. It is therefore useful to keep in mind that sample size requirements can be lowered by:

- Aiming to detect only long-term changes.
- Setting your analytical tests (alpha level) to 0.20 or 0.10 rather than the usual 0.05.
- Lowering the variability of your counts using techniques such as standardising the dates and weather conditions when data are collected and also by using consistent observers to collect the data.

Any calculation of how many samples are required for a monitoring program should be treated as an educated guess. There are too many variables involved that cannot be accounted for or known at the beginning of a project. It is also recommended that the adequacy of the number of samples is reviewed at least every five years.

Note: Throughout this document the terms variance, variation, and variability have been used interchangeably and as a quick reference to the general concept of the variability of counts. It is important to understand that the actual mathematical calculation of variability could be any one of several measures such as standard deviation, standard error, variance, or coefficient of variation and each of these has a specific statistical meaning.

6.3.2 Count variation

Count variation is a measure of how your counts fluctuate from year to year. This variation is caused by three elements: the variability in the animal populations from year to year, the imprecision of the counting technique itself, and the variability of population trends from site-to-site (if more than one site is being included). The level of variation affects your ability to detect trends. Data that fluctuates greatly will mask the trends that you would like to observe.

Rule of thumb: The more variable your counts, the more samples you will need to detect a change or trend of a given magnitude.

To calculate an estimate of the sample size required you will need an estimate of count variation. This can be obtained from your own pilot data (the mean and standard deviation) or from estimates taken from other similar situations. Note that these are calculations for fluctuation **over time** not over space, which means that you calculate a mean and standard deviation of counts across several years at one point and not a mean and standard deviation among several points.

Be careful when using counts from other studies because count variances are specific to the counting technique and how the original study pooled their samples. Count variances will differ between studies and between sites even if using the same counting techniques on the same species in the same region. However for an individual site the variability in counts is usually reasonably stable over time. It is useful to check it is still consistent every 5 years or so. It is recommended that estimates of variability of counts from other studies are used only as a general guide at the beginning of a project and that this is reviewed when you have collected sufficient data to estimate the variability for your own study.

There are several ways of reducing count variation and these should be attempted wherever possible.

Rules of thumb for decreasing your sampling variability:

- Choose species whose populations and associated monitoring methods have low variances;
- Use a precise monitoring technique (i.e. a technique that measures close to the 'true' value and this accuracy can be repeated);
- Monitor during the appropriate season under the appropriate weather conditions;
- Measure other things during monitoring that might explain some of the variability (covariates); and
- Train the observers well and use the same ones each year.

Species Choice. If possible, you may wish to choose a species that, based on biological characteristics and ease of survey, will result in lower count variability. Of course, the choice of species is constrained by what you are attempting to measure.

Counting Technique. Counting techniques vary greatly in their precision and accuracy. For example, in general, mark and recapture studies are more likely to provide accurate population size estimates than spotlighting counts for cryptic species.

Choosing When to Count. All species have optimum times and conditions when they are more easily detectable and counts less variable. Counts should usually be taken when detectability is highest and/or most consistent. Data included from less optimal time periods will increase the variation in the results and should therefore be avoided. Weather conditions usually have a strong effect on detectability and so limiting data collection to only favourable weather conditions will also decrease the variability in the counts.

Covariates. Factors that might influence the detectability of the animals being counted (e.g. temperature, wind, cloud cover, habitat) that can be easily measured whilst conducting counts should also be recorded. These data can then be used during statistical analysis to adjust estimates to account for the influence of these factors on the results and thereby help extract the true trend from the overall variability in counts.

Observers. Observers can be one of the largest sources of counting variability within a monitoring program. If possible, the same observers should be used throughout the monitoring project but this is rarely possible for long term projects. When new observers are required, training is important to limit the variability. Training must be provided to ensure that all observers are undertaking counts the same way and with equal skill. It is recommended that observers are regularly tested, preferably in a field situation by an experienced observer. This may be done by setting a group of observers the task of counting animals at a particular site at the same time without communication and comparing the results. Differences in identification skills and counting skills will quickly be identified and remedial action can then be taken. It may also be possible to account for observer differences by including observer identity as a covariate.

6.3.3 Trend detection

Trend can be simply defined as change over time and usually includes a measure of the rate of change over a specified period of time. The detection of a trend is usually associated with the goals and/or objectives of a monitoring project for significant native fauna species and will often specify minimum or maximum rates of change over a specified time period. These in turn are associated with assessing the success of a recovery plan and also triggering the implementation of appropriate management or research actions. Trends are also important for assessing the conservation status of a species against IUCN criteria.

Rules of thumb: for detecting trends:

- The smaller the population change you would like to detect, the greater the number of samples you will need to detect it.
- The fewer the number of years over which you would like to detect a trend, the greater the number of samples you will need.
- The smaller the degree of change that is required to be detected over the shortest time frame, the greater the cost of implementing the monitoring project.

You will need to decide how precisely you would like to measure changes to detect trends i.e. how small a change over what time frame. Imprecise measurements are not going to be very satisfactory to base management decisions on whereas very precise measurements are unlikely to be possible given the time and resources required to obtain them. It is appropriate to consider your willingness to risk being wrong about the population change you are trying to measure with the relative costs and consequences of obtaining the data and making the decision.

Rule of thumb: The lower the precision, the lower the number of samples you will need. Conversely, the higher the precision the larger the number of samples needed.

Precision is controlled by using two statistical settings:

1. Alpha (significance) level
2. Power level

Alpha Level

Animal populations and their counts will vary for numerous known and unknown reasons and therefore monitoring results are unlikely to produce nice, clear linear graphs. Instead, you are likely to find a scattering of points that may or may not show a trend. From this scattering you may decide that a trend is present, and that action is appropriate, but there will always be a level of uncertainty. The level of uncertainty in your conclusions that you are willing to tolerate at the risk of being incorrect is the alpha level.

The setting of an alpha level is a balance between not wanting to 'cry wolf' (saying a trend exists when it really doesn't) and missing an important trend by being too conservative. If the monitoring project is designed to provide information to trigger remedial action if, for example a threatened species declines below an acceptable population size, then you may want to increase the alpha level above the usual 0.05. This would increase the likelihood of falsely triggering action when it is not needed but would also reduce the likelihood of missing an important change that may not have been "statistically significant" at a lower alpha level.

Rule of thumb: The less willing you are to be caught 'crying wolf' (or the smaller you set the alpha level) the more samples you will need to detect a given level of population trend.

Power

Power may be defined as your ability to (or the probability of) detecting a trend given that your population of interest is actually undergoing a change.

Rule of thumb: A power of 80% is reasonable for most monitoring programs.

Useful reference:

Seavy, N.E. and Reynolds, M.H. (2007). Is statistical power to detect trends a good assessment of population monitoring? Biological Conservation 140: 187-191.

6.3.4 Statistical testing

There are numerous methods and packages available for analysing monitoring data and so it is difficult to provide even a basic introduction.

However, if you have managed to set your goals and objectives, decided on a species to monitor, found a suitable monitoring site/s, determined the most appropriate monitoring approach and determined which methods you plan to use to monitor your species of interest, then you should be in a good position to match this information to an appropriate statistical model. Ideally you should have considered what statistical models will be used throughout the design phase of the project but if not, then it may be necessary to make adjustments to the project design to ensure it fits the requirements and assumptions of the model.

It is very important to know how you intend to analyse your data **before** you begin collecting it. If you have already collected data without considering its analysis, you will more than likely find that it is only possible to undertake less powerful statistical analyses. This will therefore compromise your ability to detect trends and draw conclusions.

6.3.5 Review by a statistician or biometrician

Finally, it is highly recommended that you obtain a second opinion on your proposed monitoring project. The advice contained here is a starting point but there are many alternatives and a minefield of options to negotiate. In particular, we recommend showing the results of your worksheets to a statistician for review. The experience will make your project more robust and more likely to succeed. Small adjustments to thinking or methodology at the planning stage of a project can prevent bigger problems later in the project. Remember, you can never go back and collect new data once the opportunity has passed.

7 What next?

After reading these notes whilst filling in the worksheet in Appendix 1 you will hopefully have a much clearer picture of what is required to carry out your monitoring project successfully. You will also be aware of just how much work can go into designing a fauna monitoring project. There is great value in documenting the reasons why a project was designed the way it was so that future personnel involved in the project can understand these reasons. Without documentation it is inevitable that shortcuts will be sought if it is not obvious why a task must be performed in a certain way. If data is not collected in the same way it cannot be compared over time and this greatly reduces the usefulness of the data for monitoring i.e. the purpose for which it was collected!

Monitoring Protocols are detailed study plans that explain how data are to be collected, managed, analysed and reported. They also document the rationale for choosing what you are monitoring and the sampling design. It is recommended that you take your worksheet and convert it into a Monitoring Protocol.

Useful references:

Fancy, S.G., Gross, J.E. and Carter, S.L. (2009) Monitoring the condition of natural resources in U.S. national parks. Environmental Monitoring and Assessment. 151: 161-174.

Hurford, C. and Schneider, M. (2006). Monitoring Nature Conservation in Cultural Habitats. A Practical Guide and Case Studies. Springer Netherlands.

Oakely, K.L., Thomas, L.P. and Fancy, S.G. (2003). Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31(4): 1000-1003.

Appendix I Worksheet

Fauna Monitoring Project Design Worksheet

Use this worksheet to gather thoughts and ideas regarding what you intend to monitor and how. Getting the ideas down and sorted into a rough project plan format will greatly assist in clearly articulating your intentions when it comes to writing a Monitoring Protocol, funding proposals and reports. It will also create a document that can be sent for statistical review to ensure that the study design and proposed statistical analyses are going to provide the desired information.

Background and Objectives

What is the overall **GOAL** of your monitoring program? (See our help on WHY are you creating a monitoring program?).

Describe the conservation, management or policy decision that will be informed by the monitoring program.

What are the **MEASURABLE OBJECTIVES** of the monitoring program? (See our help on Formulating Measurable Objectives)

Relate the objectives to the alpha level, power level, degree of change and time frame that is decided in the Data Handling, Analysis and Reporting section of this worksheet. E.g.

Our objective is to achieve __% power to detect a __% change over __ years with an alpha level of ___.

What **SPECIES** will you monitor? (See our help on WHAT are you going to monitor and measure?)

Explain the reasons why you chose those species and not others.

What **TYPES OF INFORMATION** (e.g health, reproduction, geographical extent, threats etc) are you going to collect about the chosen species and at what scale (i.e. individual, population or community)?

Sampling Design

What **SAMPLING DESIGN** will you use (i.e. quadrat, grid, transect or web) and why? (See our help on WHERE are you going to put your sampling locations?)

Where will you locate your **SAMPLING LOCATIONS**? (See our help on WHERE are you going to put your sampling locations?)

Provide a map or otherwise define the boundaries of your **STUDY AREA**.

Will you sample once every year or at some other **TIME INTERVAL**?

What **TIME OF YEAR** will you place your samples?

Why did you choose that period of time?

Explain which **MONITORING APPROACH** you have chosen and if you have chosen an index approach explain why you feel that changes in species detectability over time are not an issue or problem in your situation. (See our help on Choosing a Monitoring Approach)

What **MONITORING METHODS** will you use to monitor your animals (i.e. remote observation, observation or capture)? (See our help on Choosing a Monitoring Method)

Why did you choose that monitoring method over other ways of monitoring your species? Are there any standard operating procedures or other published source that documents the proposed technique?

In what way(s) will you measure **DETECTION PROBABILITY** (if applicable)? Is this method appropriate for the monitored habitat?

What other sources of **BIAS** may affect survey results? Which ones can be addressed and how? E.g. observer skill level, weather conditions etc

What **ALPHA LEVEL** are you going to use? (See our help on Trend Detection)

What level of **POWER** are you going to use? (See our help on Trend Detection)

Justify both the alpha and power levels you chose.

What is the **SMALLEST NUMBER OF YEARS** over which you want to detect changes?

What is the **SMALLEST AMOUNT OF CHANGE** that you would like to detect?

What method will you use to calculate **SAMPLE SIZE**? (See our help on Statistical Considerations)

If using power analysis, what mean and standard deviation will you use in those calculations (or **COEFFICIENT OF VARIATION**)? (See our help on Statistical Consierations)

What was the source of that mean and standard deviation?

What **SAMPLE SIZE** did you settle on?

By what means did you determine that sample size?

Field Methods

Outline the sequence of events during a field season.

What measurements will be taken and how?

Data Handling, Analysis and Reporting

What technique will be used to **ANALYSE** trends? (See our help on HOW are you going to measure it?)

Why did you choose that analysis technique over other approaches?

How often will you analyse the data?

Personnel Requirements and Training

HOW MANY OBSERVERS will be needed?

Field personnel (include time and wages):

Office personnel (include time and wages):

HOW MANY DAYS will field collection take each year?

How will bad weather, weekend, and holidays be factored in?

What sort of **TRAINING** will the observers need prior to starting?

What **STATISTICAL SUPPORT** will be required?

How much time will analysis take?

Who will be doing the analyses?

Operational Requirements

Current equipment:

Required equipment purchases (include expected costs):

Equipment parts:

Replacement parts:

Transportation costs (include likely kms travelled):

How will the proposed monitoring be incorporated into the annual workload and field schedule?

Approvals and documentation

Does the project require approval from the DEC Animal Ethics Committee?

Do personnel require licenses to undertake the project (e.g. Regulation 17)?