What data to collect during track-based surveys? Combining expert experience to develop a data collection template

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Contents

Summary

Context: Track-based surveys include a range of sampling methods to record animal presence based on their tracks, scats, diggings or other signs. The method can be used for different objectives; one potential application is to create a nationally consistent approach for monitoring species distributions and trends. Track-based monitoring could also improve our understanding of ecological processes operating across time and space, and allow us to evaluate the outcome of management actions. However, there are several variations of track-based surveys being used across Australia, and the inconsistencies in data recording hinder the collation of data regionally and nationally.

Aims: We worked with tracking experts to develop a standard data recording template for track-based surveys, with advice on data collection, that can be used anywhere across Australia.

Methods: Experts co-designed then filled in a questionnaire that collected perspectives on: the objectives of track-based surveys; which data fields were reliable and relevant (and which were not reliable, or not relevant) for a regional or national monitoring program; and general advice for carrying out surveys.

Results: Track-based surveys are carried out to meet many objectives, and all could contribute to regional or national monitoring if data are recorded reliably. Track-based surveys offer excellent opportunities for skills sharing and inter-generational knowledge transfer.

A new, streamlined data collection template was created, with data fields that were relevant nationally, and that could be collected at a consistently high quality. Data fields that are not relevant for national monitoring, but could be useful for local objectives, are noted; and data fields that are too problematic to continue being used are also noted. Broad conclusions from the review of data collection templates and experience include:

- Streamlining data collection is important because it saves time and energy:
    - Any data fields that can be filled from other national spatial datasets, such as broad vegetation type, soil type, topography, can be omitted from a national data collection template.
    - Any data fields that do not contribute to the survey objective can be dropped.
- Recording some key attributes of the design and type of survey optimises the analysis potential:
    - Recording whether detections were incidental, or made during standardised surveys (and if the latter, using what method) is paramount for enabling data collation and analysis.
    - Recording whether the surveys targeted one or a few species, or recorded all species, is paramount for being able to recognise ‘absences’ as well as ‘presences, and thus allow different approaches to analysis.
- Training in species identification from their sign, aging sign, and in filling out the data collection template are critical.
- The size of tracking teams varies, but keeping tracking effort (the amount of search time across the team) consistent between surveys is important.
- Detectability varies between surveys, but is hard to estimate. Recording the tracking conditions can help understand detectability, but nothing can ‘repair’ collecting data in poor tracking conditions. If conditions are poor, then defer the survey.

Conclusions: Using sign to record animal presence (and absence) is prone to certain biases, but these biases can be managed by collecting data in good tracking conditions, identifying species and the age of sign correctly, and filling in the data collection sheet correctly.

Background

Track-based survey methods have been used by many groups (including Indigenous ranger groups, non-government organisations, government agencies, independent scientists and consultants) from the wet-dry tropics in the Kimberley, the Pilbara, through the western and central deserts and down into South Australia. Track-based surveys include a range of standardised and incidental sampling methods to record animal presence based on tracks, scats, diggings or other signs. The most common standardised method is a 2 ha sand plot survey (sometimes called a sign survey, track survey, 2 hectare plot, cybertracker survey or Tracks App survey). The 2 ha sand plot survey consists of observers searching a 2 ha area for signs of animal presence and recording information about the habitat or tracking conditions (Moseby *et al.* 2012). The method can be used for different objectives; one potential application is to create a nationally consistent approach for recording species occurrence at local, regional and national scale, that would allow for monitoring species distributions and trends, improve our understanding of ecological processes operating across time and space, and allow us to evaluate the outcome of management actions, such as burning or predator control.

Over time, the method of 2 ha sand plot tracking has been altered by several groups to fit with regional or local monitoring objectives. As a result, there are now several variations on the method being used across Australia. These inconsistencies in data recording fields hinder the collation of data regionally and nationally.

The Arid Zone Monitoring Project is working with Indigenous ranger groups and Indigenous organisations, non-government organisations and natural resource management groups, state and federal governments, institutions and individual experts. The project is collating and analysing data collected from almost 15,000 track-based surveys carried across two-thirds of Australia to produce a collective picture of the distributions of desert species and their threats, and whether these are changing over time. The research will also provide guidance to groups on how to improve their monitoring programs, so they are collecting the data they need to help them manage country. More information can be found at: https://www.nespthreatenedspecies.edu.au/projects/arid-zone-monitoring-surveys-for-vertebrates-across-arid-and-semi-arid-zones.

The Arid Zone Monitoring project has many components, covering data collation and analysis, and guidance for improving practice. In the component of the project addressed here, we aimed to work with tracking experts to develop a standard data recording template for track-based surveys (including 2 ha sand plots, other standardised sampling types, as well as incidental observations) with advice on data collection, that can be used anywhere across Australia. To achieve the aim, we:

- Sought consensus on which data fields must be recorded consistently nationally, and which data fields were more relevant for accommodating regional and local differences in ecology and monitoring objectives.
- Highlight where specific training is needed to encourage enhanced consistency in data recording and interpretation.
- Generated an updated/revised data recording template for track-based surveys based on the working groups collective experience.
- Provided general guidance about ways to improve future data collection before, during and after survey.

This work is a foundation step to support the development of a coordinated regional and national monitoring programs. The review of data collection templates also informs the manipulation and analysis of existing data that is being carried out in other components of the Arid Zone Monitoring project.

This report focusses on the data collection from track-based surveys. An equally important aspect of ongoing monitoring is the *design* of data collection; that is, where track-based surveys are situated, how many plots to sample, and how often to re-sample them. Guidance on this aspect is provided in a companion report.

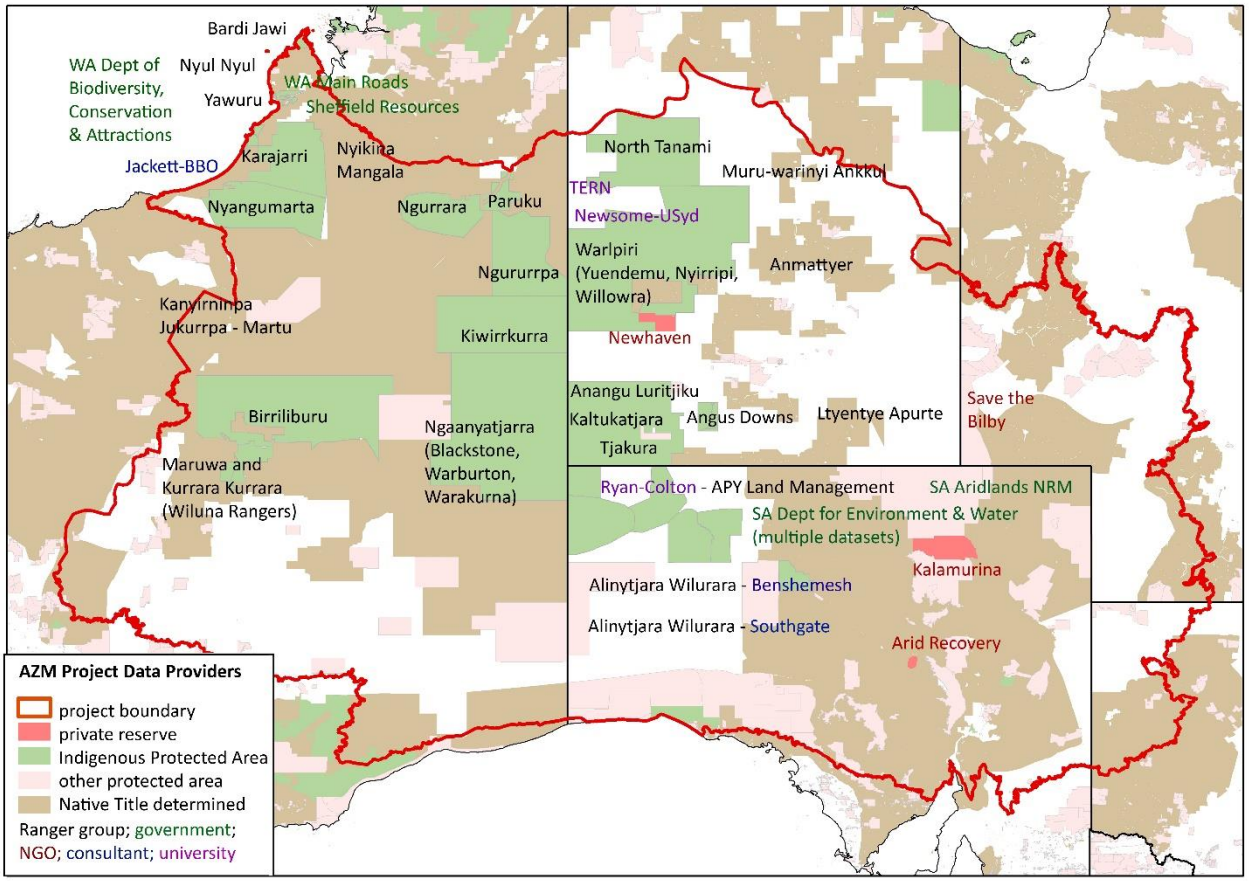

Figure 1: This map shows the locations of all data providers that have contributed data to the Arid Zone Monitoring project, as of June 2021.

Methods

Asking the tracking experts

We held an initial meeting with our collaborators to discuss how we could assess track-based survey data collection, from the perspectives of people who use it. We decided on two-step approach where first an experienced, diverse working group would initially assess data collection templates and data collection practices for utility and data quality. Second, this assessment would be distributed more widely for extra perspectives from our collaborators, before creating an updated track-based data collection template.

The working group

Our working group included six experts who have extensive first-hand experience carrying out track-based surveys, as well as experience using/analysing the data that is derived from them. The experts provided a range of backgrounds and perspectives, representing Government, NGO, Indigenous ranger group, University, Consultant sectors (Table 1). These perspectives span the range of organisations that carry-out track-based surveys in Australia.

Table 1: Perspectives of the contributors to the survey:

Perspectives (sectors) represented in survey	**Tally of responses**
Government	1
NGO	2
Indigenous ranger group	4
University	5
Consultant	2

Assessing the method

We co-designed an excel questionnaire that provided a structured approach to gathering perspectives from the members of the working group. To ensure that all experts had equal opportunity to be heard, each expert worked independently to assess the method, and provide feedback on:

1) The objectives for carrying out track-based surveys at the national, regional and local scale.
2) The utility of the track-based survey data collection method to meet these objectives and to record consistent quality data.

Although we aimed to develop a data collection template to suit the main standardised method – the 2 ha sand plot survey - the intention is that the same template could be used for other standardised methods, as well as for incidental (non-standardised) recording (Figure 2). We therefore included data fields from four existing data template variations on the 2 ha sand plot method for experts to contrast and comment on (Tales in the Sand (Moseby *et al.* 2012), SA BioCollect data, Tracks App (from the Bilby Blitz), and WA DBCA method (Kimberley and WA focused)). The working group were asked to consider:

- Whether data fields were relevant at a national or regional scale (or both).
- Whether data fields could be filled in consistently enough to ensure rigorous and precise data collection.

- If there were alternative data fields between the data collection template variations – whether there was a superior approach.
- Whether there are specific challenges for Indigenous ranger groups that should be considered when designing recording templates.
- Any considerations regarding training.

We combined the information from the experts and present their experience in three sections below:

1) Why do track-based surveys: what do people want to know?
2) Which data fields are relevant and reliable?
3) General advice for carrying out surveys

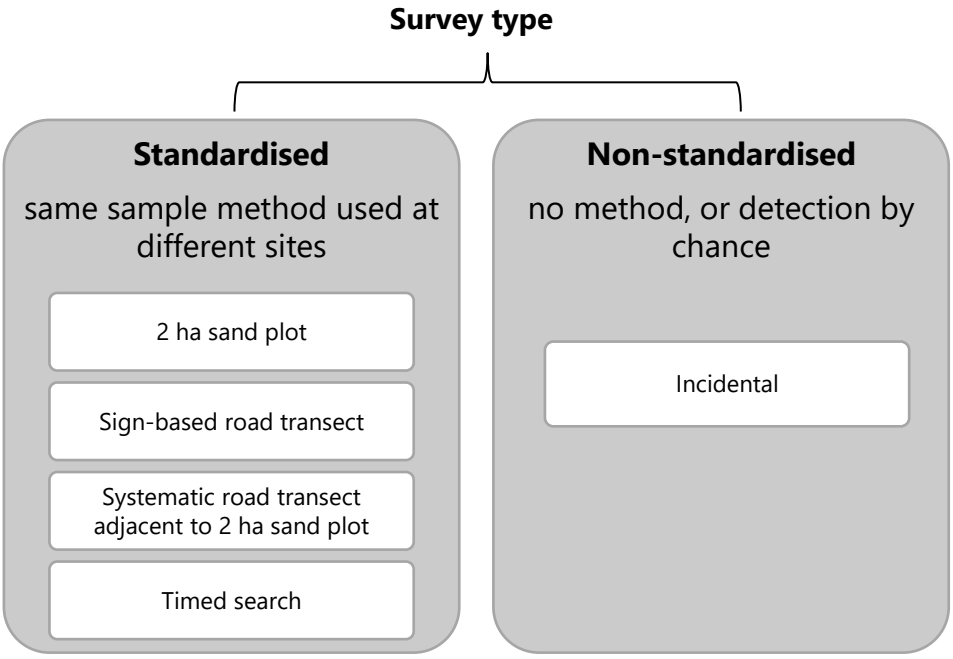

Figure 2: Track-based survey data classified by survey type and sample method. Surveys can also aim to record all species at a site, or they can focus on target species, only recording presence/absence of that target species.

Results

1. Why do track-based surveys - what do people want to know?

Track-based surveys have been used for different reasons, including:

- once-off inventory studies where surveys are carried out once in short-time frame (such as surveys prior to development projects),
- inventory studies over one year or multiple years, where sites are surveyed to describe species occurrence across a property/region,
- multi-year local or regional studies that are focused on specific questions (such as distribution in relation to fire patterns),
- on Country experiences, and
- multi-year monitoring programs to track changes over time, at a range of scales.

A common thread in the justification for the track-based survey method is to carry out ***monitoring*** to answer questions about whether a species is changing in distribution or abundance, and find out the reasons for this change. Monitoring usually requires a set of survey sites to be repeatedly visited over time, and the design of the sampling is critical for answering the question.

Having clearly defined goals (purpose) and objectives (measurable aims) are essential to designing and carrying out monitoring programs that generate data that will be informative and useful (Lindenmayer & Likens 2010). We assembled a list of objectives for using track-based surveys from the expert working group. These objectives are divided into three scales, that have varying objectives, some of them nested (Table 2).

Table 2: Objectives for carrying out track-based surveys.

National objectives	• To describe the extent of occurrence of native terrestrial species and invasive species at the continental scale. • To track changes in occurrence over time, of native terrestrial species and invasive species at the continental scale. • To understand the factors that determine occurrence of native terrestrial species and invasive species at the continental scale, including in relation to landforms, habitat types, other species or threats.
Regional objectives	• To describe the occurrence of native terrestrial species and invasive species at regional scale. • To assess spatial and temporal changes in occurrence, at regional scale • To describe regional-scale occurrence of native terrestrial species and invasive species in relation to habitat and other drivers. • To assess the response of native and invasive species to management changes at the regional scale. • To provide opportunities for skills-sharing and exchange between regional groups.
Local objectives	• To spend time on Country, learn tracking skills, share knowledge and culture, and see what animals are on Country. • To collect information to guide local-scale management of Country (including Healthy Country Planning). • To map/know where species occur and how they are faring. • To understand local-scale habitat associations and use. • To assess the effectiveness of local-scale management. • To identify responses to environmental change (fire, rainfall, introduced predator presence, management).

It is important to note that the scale of a monitoring program's objectives may influence how the information can be used at other scales, for instance:

- A national level monitoring program across all arid Australia can summarise spatial and temporal changes in distributions and relationships between species, but may struggle to identify local mechanisms that drive these changes, while
- Regional level monitoring program can provide more textured insights on ecological processes, but these insights may not extrapolate well to other regions or to a national level.

Depending on the questions that people wish to answer, there are two subsequent key decisions that are required before beginning to collect data:

1. What data should be collected at the sites, and
2. What is the best survey / monitoring design to answer these questions, including location and number of sites, and timing of survey.

This report focusses on the first question. More detailed information to help with monitoring design is provided in a companion report.

2. Combining insights from tracking experts for data collection improvement

Which data fields are reliable and relevant?

We categorised the data fields from track-based surveys into four groups:

a) Survey description
b) Animal description
c) Habitat
d) Detectability

We then compiled the responses of the experts about data field in each group, into tables. The table presented below (Table 3) lists the data fields that experts agree **should always be included** in data collection templates; these data fields were drawn from the survey description, animal description, habitat and detectability data groups. Data fields from the first three groups that experts agreed could be omitted, or only included during surveys with more specific local objectives, are presented in Appendices 1 and 2 respectively. Note that experts believed that the data fields relating to detectability require further analysis of their utility for national scale monitoring before they can be included on a national data recording template, although some detectability data fields may be important for regional or local-scale studies. As an interim step, one data field related to detectability has been included in the revised template. The importance of, and problems with, recording detectability variables are discussed further below, and in Appendix 3. A sample data collection template is provided in Appendix 7.

Table 3. *Data fields that are required to meet national monitoring objectives, and therefore should be retained in data collection templates.*

Question	Data field	Format	Description	Issues with reliability or training
SURVEY DESCRIPTION				
Who	**Recorder**	*First Last Name*	Person who is responsible for the quality of the data.	This person should have relevant training and skills.
	Ranger group or organisation	*Name*	Helps to identify data source.	
When	**Survey date**	*DD/MM/YYYY*		
	Survey start time	*HH:MM*	Helps to manage data and may help with trackability.	Surveys are best carried out in the morning when shadows are longer and tracks are freshest.
Where	**[1]Location latitude**	*Coordinates* *Datum*		Accurate to within 50m if carrying out revisits. Record spatial metadata.
	[1]Location longitude	*Coordinates* *Datum*		Accurate to within 50m if carrying out revisits. Record spatial metadata.
	Property/IPA name			
	Site name/ Plot ID		This can help manage monitoring programs.	Coordinated naming/numbering approach across many groups challenging. Easier to use GPS data.
	Photograph of site	*Photograph*	Photograph to record variables such as habitat type, vegetation, and fire history.	Access to camera may be limited. ID, time, location, and date stamp is crucial for incorporating into data recording- (photographs should have a site name and date visible). Resources are not always available for training with data extraction and data entry.
How ([2]Survey type)	**Standardised or Incidental?**	*Standardised, or Incidental survey type*	Surveys are standardised when data are recorded in the same way each time. Incidental records can be collected using any methods.	Recorder must understand the difference between standardised surveys and incidental survey types.
	Sample method (for standardised surveys)	*2ha, road transect, timed search; road section adjacent to 2 ha sand plot, sign-based transect, sign-based search, timed search etc.*	If the survey was standardised, what method did you use?	Recorder must understand the difference between these survey methods

Question	Data field	Format	Description	Issues with reliability or training
	Survey target	*Recording all species detected?* *Only recording signs from target species?*	Need to know whether species absence (vs non-detection) can be inferred from the data collected. If the survey design is targeted towards one or a few key species, not which species are the targets. (Surveys could record all species present even if they have species targets)	Not knowing the survey focus is a major impediment to collating and analysing data collected to date.
How (Control for effort)	**Number trackers searching**	*Number*	Record number of people actively searching.	This is rarely recorded by methods. Sometime a large group may include some people who search consistently, and others that are intermittent, which is challenging to tally. Probably better to give guidance on the level of effort that should be used consistently across all surveys.
	Survey length	*Length of time (mins)*	Record how long people searched for.	
ANIMAL DESCRIPTION				
Animal detection	**Species**	*Scientific or common name and local language name*		Training essential. Only record when certain of identification. E.g. 'Large hooved mammal' is better than recording 'donkey' if the detection is incorrect (e.g. it was really a horse). Appending local animal lists with photos that are easy to use would help with training and identification of signs in the field.
	Species	*Photograph*	Photographs useful for verification	Need a rigorous system to upload and store photos.
	Species type	*Native mammals, feral mammals, reptiles, birds*		Useful for app-based data collection to reduce the species set. Not useful for printed data collection sheets
Types of sign Helps to identify/validate the presence of species	**Tracks**	*Yes, No*		Challenging for inexperienced trackers.
	Burrow	*Yes, No*		Challenging for inexperienced trackers.
	Animal alive	*Yes, No*		
	Scats	*Yes, No*		Challenging for inexperienced trackers.
	Diggings	*Yes, No*		Hard to get right. Should only be used in combination with other more definitive sign (e.g. tracks).
	Animal dead	*Yes, No*		This may not always confirm occupancy. Good to look for other signs in combination to confirm.

Question	Data field	Format	Description	Issues with reliability or training
	Skin/hair feathers	*Yes, No*		
	Signs of feeding	*Yes, No*	Signs of animals gnawing, browsing or other remains.	Hard to get right. Should only be used in combination with other more definitive sign.
[3]Age of sign	**Age of sign /** **How old is the sign?**	*Fresh (1-2 days),* *Old (3 days to 1 week),* *Very Old (> 1 week)*		It can be difficult to age sign. Fresh sign is most obvious but separating "old" and "very old" is more challenging. Tracks from heavier animals remain longer than from small animals.
HABITAT				
Fire history will influence species presence	**Time since fire/burnt**	Regional categories e.g. ***Desert:*** *Recent (3 months), fresh shoots (3 months - year), mature herbs (1-2 years), old enough to burn, long unburnt* ***Kimberley:*** *< 1, 1-2, 3-5, long unburnt* ***DBCA Kimberley:*** *<1-year, 1 year, > 1year*	This vegetation cycle depends on rainfall and latitude.	Training is needed; and data templates could include a picture card with time since fire categories. Very different patterns across regions depending on rainfall, that need to be addressed in the data field entry options. Data field entry options should relate to Indigenous fire categories. Can be captured using remote sensing data at national scales, noting that resolution of imagery is coarse relative to the size of a 2 ha sand plot.
DETECTABILITY				
Tracking conditions	Tracking conditions	Score from 1 = excellent 2 = moderate 3 = poor	1. Light excellent (morning/late afternoon, no clouds); No wind or rain in the past few days; Lots of soft sand not covered by leaves or grass. 2. Light reasonable (e.g. late morning, partly cloudy); and/or light wind; and/or not so much soft sand to search. 3. Light poor (cloudy); and/or been windy for a couple of hours; and/or not much soft sand (lots of leaves, grass, or hard surface).	Various systems have evolved to record this information, all subject to inconsistencies in scoring, and their use in data screening or analysis remains untested. The description to the left is suggested as a composite between existing systems.

Further notes on data fields

Survey description

[1]Recording location:

For most survey objectives, it is important to precisely record location data, particularly when the monitoring design requires site finding the site again to re-survey, or habitat modelling that requires alignment with GIS layers. See Appendix 5 for further information, but in brief, we recommend that:

- a geographic coordinate system using latitude and longitude should be used for most purposes rather than projected coordinate system (for instance UTMs),
- when multiple GPS devices are used that they are set to use the same datum (E.g. AGD84, WGS84, GDA2020; which provides the frame of reference for measuring locations on the Earth's surface). Using multiple GPS devices with different datums creates misalignment in the location of sites when mapping (this may not cause issues if the scale of the analysis is coarse – for instance 1 km^2).

[2]Recording survey type:

Experts had differing opinions on the value of recording information on survey type. However, distinguishing the survey type and method is essential to allow for any systematic collation and analysis of data across multiple data collectors. The critical information includes:

- Whether detections were made during standardised surveys, or via incidental observations. In standardised surveys, data are collected using the same sample method over time.
- In standardised surveys, the sample method needs to be recorded (e.g. 2 ha sand plot, road transect, timed search etc).
- In standardised surveys, a data field should note whether the survey recorded information on all species detected, or whether it targeted a focal species and information on other species could have been missed. This will allow surveys with good quality 'absence' data to be separated from other surveys.
- Some species such as cats, dogs and foxes may walk along roads and be more detectable there. Detections on roads adjacent to 2 ha sand plots can be included as data from a standardised survey if these road sections are checked systematically during a survey of the adjacent 2 ha sand plot. However, records from 2 ha sand plots and adjacent roads should be separated and clearly identified to avoid introducing biases. For example, the propensity of predators to use roads may vary between regions, roads may not be representative of the study area, and lumping detections from roads with 2 ha sand plot data could elevate the occupancy of road species.

Experts expressed confusion around the significance of 'absence' data. Absence data is valuable because it indicates the environmental conditions that are unsuitable for a species, at least during the time surveys are undertaken. Absence data, in tandem with presence data, can help narrow down our understanding of what drives species occurrence, and sharpen up estimates of change over time. In general, 2ha plot surveys can supply absence data, and the quality of absence information improves if the same sites are re-sampled over a relatively short time (e.g. 6 months). This is because repeat visits help to separate out 'true' absence from imperfect detection. Imperfect detection happens when tracks are missed by chance. By revisiting sites, we can estimate how often trackers detect a species when we know it really is in the area. See the section on 'Detectability' below for more information on this topic.

Animal description

[3]***Aging of sign:***

Experts had differing opinions as to whether age of sign is important, and what categories should be included. Some recommended reducing the categories to two (1-7 days, or older than 7 days), because knowing what was in the site in the past week is generally good enough, and it can be difficult to discriminate sign between 3-7 days old and > 7 days. The experts suggested there needs to be investigation of how the impact of animal size influences detection. For instance, camels leave tracks that last sometimes for many months (which means they are more likely to be detected during a survey) while other sign, such as hopping mouse tracks, generally lasts for only a day or two. Simplifying the detection windows (i.e. changing 1-2 days to 1-7 days) will favour detections of large animals in the 'fresh' age category because tracks from smaller animals will become hard to identify after just a couple of days. We recommend aiming to age sign into one of three classes, but this recommendation may be revised in future.

Habitat

Data fields for habitat have proliferated in the existing data collection templates, reflecting the challenges of designing data fields that can record information that is relevant at both local, regional and national scales, especially given the diversity of local objectives when surveying. For this reason, experts suggested that most data fields for habitat should not be retained in a national data collection template. Instead, good quality location data from GPS can be intersected with national scale maps of vegetation, soil, hydrology, and so on, ensuring national consistency. If information about habitat is important for answering questions at a local scale, then habitat fields that suit those questions can be added to the template (see Appendix 4 for extra information on habitat information).

The only habitat data field that experts agreed on retaining was one to record the time since fire at the survey site. Fire history data can also be extracted from national remote sensing datasets, but the scale of most remote sensing products is coarser than the scale of the survey site. In addition, fire history data collection is engaging for local people - particularly for individuals involved with fire programs, and most groups want to observe and discuss the fire status at survey sites.

Taking a photograph of the site, in a standardised way (for example, always pointing in a particular direction) may be a helpful record, but photographs need to be clearly labelled and stored to be useful.

Detectability

When carrying out 2 ha sand plot surveys, observers are looking for the sign of animals to tell if a species has been using that site. But this method is not an error-proof way to know whether animals have used a site. This is because sometimes an animal will have used the site but left no detectible signs behind – so we assume the animal is not present, when it actually was. Recording "false absences" will mean that we think the species is less common than it really is.

A detection depends on two processes:

1) that the species was present at the site, and
2) that you found sign of the species in your survey.

However, ***non-detection*** (not finding a species) could be due to:

1) the species not being present at that location (*true absence*), or
2) it was there, but was not detected during survey (*imperfect detection*).

Taking imperfect detection into account may be important for monitoring objectives that require good estimates of an animal's true occupancy, such as investigating the influence of different types of management on occurrence, or closely tracking trends in occurrence. Accounting for imperfect detection requires: 1) the use of occupancy models, and 2) a structured monitoring design with revisits to sites within the year. The idea is that if a site is visited multiple times, this gives you a better chance of detecting the true presence of a species that may be hard to detect with just one visit. Occupancy models can also include information about the conditions at a site that could influence whether a species is found (detectability covariates), and this could improve estimates of true occupancy. However, it is important to note that certain assumptions must be met to be able to carry-out this type of analysis (MacKenzie *et al.* 2005), and advice from a statistician should be sought to help make your sampling design robust.

Expert opinion on the utility and challenges of recording information about detectability was mixed, partly because of logistics (revisiting the same sites is difficult to organise, and local interest can be low), and partly because local objectives often don't require information on detectability. In addition, more analysis is required to tease apart which data fields are most useful for understanding variation in detectability, which means that we could spend time collecting data that turns out not to be that useful. However, the expert discussion on this subject highlighted some key factors related to detectability that should always be considered when carrying out track-based surveys, even if detectability is not being estimated, in order to maintain high standards of data quality. For instance – tracking data should only be collected when conditions for high quality data recording are good, and when the trackers are properly trained to identify sign and record the data correctly. These key factors are integrated into the next section (general advice). The expert perspectives on data fields that may be relevant to informing detectability are collated in Appendix 3.

General advice from experts for carrying out surveys

Training

Many groups across Australia use track-based surveys. These groups differ in their tracking skills, and ability to record the data collected during the 2 ha sand plot surveys (including understanding scientific terms and using apps). It is important to modify training to the needs of the different groups. However, training to ensure that trackers are recognising animal sign correctly, aging sign correctly, and recording all data consistently, is essential for making track-based surveys useful. Training needs to happen before surveys are carried out.

For Indigenous rangers, in some communities it is good to get the old people to help the rangers learn how to track. Expert trackers may need to go out with the rangers several times to help with learning, and

expert trackers may teach without using standardised survey methods such as the 2 ha sand plot. Such inter-generational knowledge transfer may be a primary objective of some tracking surveys.

Carrying out surveys

- Check GPS accuracy and settings (correct datum, and set to geographic coordinate system) before marking waypoints, and ensure satellites are loaded, to accurately estimate the site location. Record relevant GPS meta data (Appendix 5).
- Regional or local lists and photos of species and their sign can help make data recording easy in the field, and will help ensure that absence records as well as presence records are good quality. Having a bank of photos of sign for species recorded regionally would help.
- Conditions should be good for tracking. Data quality will be better if there is slanting sunlight (in the morning of afternoon), it is not raining, the ground is not wet, and it is not or has not been very windy in the past few days. Nothing can make up for missing species occurrence data because the conditions were poor for tracking.
- Sites should be positioned in places that are good for tracking: that have the right type of soft sand or soils for animals to leave tracks behind (not hard rocky soils), and sites that are not completely covered in thick vegetation, or leaf-litter, as it will be hard to find tracks.
- It is most important that people only record the animals that they are certain of. **If not sure – then leave it out.** This is because a false positive affects data integrity, more so than a false absence.
- It is important to try and keep the effort to find sign at each survey plot as consistent as possible.

Controlling tracking effort – how far and long to search?

Experts have differing opinions about whether time spent searching 2 ha sand plots should be varied based on the number of people searching. Different groups have used different approaches, including:

- Always 20 mins regardless of number people searching.
- 1 person = 30 mins, 2 people = 20 mins, 3 people = 10 mins.
- 1-3 persons = 20mins, 4-6 persons = 10 mins.
- Large team = split into 2 x 2 ha plots side by side.

These are not equivalent in total time spent searching a plot, or in the amount of area covered.

It was noted that people spend more time at sites when they see more animals. When people are recording animals as they go, each detection takes time away from searching (to enter data, or to ID tracks). Sometimes the search party assembles to look at an interesting find. So, sites with many detections could take longer to account for recording time.

Recording lots of extra information at a site, such as about bushfoods or fire information, will potentially reduce the number of sites that can be completed in a day. This is an important trade-off, because collecting quality data from many different plots is likely to lead to better information. Collecting extra information can be important for addressing local objectives, but the general rule is do not waste time collecting data you won't use. For example, recording of age of species (adults or juveniles) may be relevant to key species such as bilby or great desert skink, but measuring track lengths in the field for all tracks adds time spent at each site, so only include this if the information is useful to your monitoring objective.

A proposed approach: keep the plot size is set at 2ha - mark out a 2ha area based on landmarks or with a GPS as you walk (100m x 200m). Observers should spend the time needed to thoroughly search this area. If there are more people who are spread out, it may be quicker to search the area, but *aim to keep the search effort similar across survey sites.*

Extra data relating to focal species

Learning more about threatened or culturally significant species may be a strong motivator for carrying out track-based surveys, and monitoring may be tailored to one or more focal species. In the arid zone, popular focal species include the bilby, malleefowl, great desert skink, and mulgara.

Surveys that focus on focal species can be designed to meet local objectives and simultaneously provide information that informs a national picture of species distributions in the arid zone. Extra data can be collected on local habitat conditions (i.e. long unburnt grass tussocks, food availability etc.), potential threatening processes (i.e. cats, too many hot fires, no rain etc.) and management needs of the focal species. The most relevant extra data will depend on the ecology of the species and the specific local research question. Although the surveys focus on specific species, continuing to collect detection data on non-focal species will also contribute to national-level objectives.

Focusing on important species could affect the quality of data collected on other species. Examples of trade-offs that need to be considered include:

- Observers who are concentrating on detecting focal species may be more likely to miss detections of other species.
- Placing sites within a focal species' habitat may mean the set of sites does not represent the range of habitats that other species prefer, and therefore these other species may mistakenly appear absent in the area.
- Recording additional site data (for example, extra habitat information to understand the distribution of focal species) will increase time required at the site, and therefore decrease the number of sites that can be surveyed.
- There may be specific training needs to allow for recording targeted data for focal species.

The general principle is that collecting extra data can be valuable for species-specific work, but the decision on what data fields to collect should be made carefully, because the collection will entail more survey time, and training may be needed to ensure data quality is maintained. Examples of extra data fields that can be collected in surveys that aim to understand what drives bilby occurrence are in Table 4. These are examples only, the actual data fields required will depend on the species and questions being asked.

Table 4. *Examples of extra data fields that can be considered for surveys that target bilby-specific or cultural objectives.*

Data field	Format	Description and issues with reliability or training
Food plant	*Grass seeds, yakirra grass, witchetty grub shrubs, bush fruits, bush onions, yams and potatoes*	Important for people and bilby, plus other targeted species. The availability of bush foods may be correlated with bilby presence. Good information to indicate previous rainfall conditions or potentially suitable habitat (if currently unoccupied) but a target animal species needs to be specified.
Digging into roots of plants	*Y / N*	Helps to validate the presence of bilby. But needs other sign to prove presence.
Digging for ants	*Y / N*	Helps to validate the presence of bilby. But needs other sign to prove presence.
Juveniles present?	*Yes, No*	Needs measurement sheet.
How old is the animal?	*Big adult, small adult, young*	Needs measurement sheet.
How much bilby sign?	*Lots of bilby sign, little bit bilby sign, no bilby sign*	Subjective measure but may be of local interest in mapping bilby activity.

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Appendix 1 - Data fields to omit from national data collection template

This table summarises the perspectives of experts on data fields that are present in one of more existing data recording templates, but that should be omitted from a revised, national data collection template.

Question	Data field	Format	Description, and issues with reliability or training
SURVEY DESCRIPTION			
Where	**Distance and direction from nearest named place**		Not often recorded. Can be hard to know in the field. Can measure using GIS.
When	**Sample sequence, Plot sequence**	*Initial, repeat, unknown*	Redundant when plan is in place. There should be a monitoring design that dictates where people survey. Field workers don't always know if initial or repeat. Whether repeat can be sourced from GPS analysis, or Year and site name. Revisiting sites can be challenging – the statistical purpose is not accessible to most, and it is less interesting than visiting new locations.
When	**Survey finish time**		Not often recorded. Only useful if using amount of time as a variable.
ANIMAL DETECTION			
Animal abundance [1]	**Abundance score**	*1 - signs in all quarters* *2 - signs in half to 3/4* *3 - one individual or sign in 1/4*	Not recorded often. This can be hard to estimate. This data is challenging to use in analysis, and challenging to achieve consistency. The experts identified problems with estimating abundance correctly and questioned whether abundance scores related to density or activity. The original rationale behind the abundance score was that it could indicate if a site is "core" habitat or a place where an animal is "passing through". However, if how an animal uses the site is of interest, this may be more evident from the types of sign (tracks, vs burrows, vs diggings etc). Where the bilby is the focus, a category for "lots of bilby sign" or "small amount of bilby sign" may be of interest for some ranger groups to increase engagement with the method.
HABITAT			
	Distance from water		Could use GIS to determine if high quality data are available. Confusion about what type of water body in question, and whether this changes with rainfall. Not generally used. Challenging to achieve consistency.
	Distance from road		Could use GIS to determine. Not recorded often. Not really a habitat feature.
	Habitat type other	*Observer's description*	Little consistency in descriptions therefore difficult to analyse.
	Vegetation description understorey; Main perennial understory	*Observer's description*	Little consistency in descriptions therefore difficult to analyse. All habitat descriptions need ecological relevance

Question	Data field	Format	Description, and issues with reliability or training
	vegetation type		
	Vegetation structure	*Shrub land, open woodland, dense woodland, open grassland*	Too coarse to be useful.
Vegetation cover is correlated with habitat suitability	**Percent cover overstorey**	*Recorded as either categories or percentage*	Subjective estimation of percentages is inconsistent. Estimating percent covers is difficult to do in a robust way.
	Percent cover understorey	*Percentage*	Subjective estimation of percentages is inconsistent. Estimating percent covers is difficult to do in a robust way.
	Vegetation thickness	*Open (easy to walk through)* *Thick (very hard to walk through)*	Specific to bilbies. Could be subjective/bias. May not be particularly relevant

Appendix 2 – Data fields that may be useful to help meet local or regional monitoring objectives

This table summarises the perspectives of experts on data fields that are present in one of more existing data recording templates, that should be omitted from a revised, national data collection template, but that may have value for helping achieve local survey objectives.

Question	Variable	Format	Description, and issues with reliability or training
SURVEY DESCRIPTION			
Email and phone number		This can help manage monitoring programs.	
Team members	*Names* *Accreditation of skill level*	This can help manage monitoring programs.	These people should have relevant training and skills. It is not common that all team members are recorded (needs space on datasheet or apps).
ANIMAL DETECTIONS			
Types of sign (Helps to identify/validate the presence of species)	**Digging into roots of plants**	*Yes, No*	Generally digging into roots is the bilby.
	Digging for ants	*Yes, No*	This can be highly error prone and not a good way to determine if bilby.
Age of animal - adult /juvenile	**Juveniles present?**	*Yes, No*	Not relevant for all species. Requires training to use measurement method.
	How old is the animal?	*Big adult, small adult, young*	Not relevant for all species. Requires training to use measurement method.
Amount of activity	**How much focal species sign?**	*Lots of sign, little bit sign, no sign*	Subjective measure may be of local interest in mapping species activity, as long as the measure is standardised.
HABITAT			
Habitat may correlate with species occurrence	**Country type / Landform type**	*Creek line, drainage line, sand dune (dune field), sand dune (isolated), sand plain, laterite (red rocks), salt-lake country, clay pan, hills, breakaways, granite country, mulga-woodlands-on-finer-textured-soils*	Broad habitat categories for national-scale arid zone habitats that are of ecological relevance to species distributions. Habitat options are inconsistent in different regions. Data recording can be inconsistent between observers. Could be extracted from GIS data although GIS layers may be course, and ground truthing required. Experts had differing opinions about whether this is important to record nationally as collection of habitat data should be associated with a relevant research question.
	Vegetation Type	*Spinifex grassland, mixed grassland, buffel grassland, mixed shrub land, open woodland, dense woodland (e.g. gidgee, coolibah, mallee, desert oak, bloodwood,*	Little consistency in descriptions therefore difficult to analyse. Vegetation categories can be inconsistently recorded. Consider using GIS, these categories could be used for ground truthing. Consider including vegetation categorisation at a regional scale

Question	Variable	Format	Description, and issues with reliability or training
		ironwood, whitewood, kurrajong), mulga	
Availability of bush foods correlates with species occurrence.	**Food plant**	*Grass seeds, yakirra grass, witchetty grub shrubs, bush fruits, bush onions, yams and potatoes*	Training is needed. This data can be engaging for local people. Important for people and bilby, plus other targeted species. Good information to indicate previous rainfall conditions or potentially suitable habitat (if currently unoccupied) but a target animal species needs to be specified.
Some species are associated with ephemeral vegetation.	**Ephemeral vegetation present**	*Yes, No*	Indicates whether there has been recent rainfall and vegetation growth associated with boom times. Could use NDVI to determine in some instances. The term ephemeral is challenging. Better to use “green pick”?
Ecologically relevant vegetation differences	**Vegetation**	*Relevant local parameters*	Local vegetation parameters that seek to monitor ecologically relevant vegetation patterns. Based on defined local objectives.

Appendix 3 - Detectability

Carrying out surveys when conditions for tracking are good is critical for collecting quality data and is more important than recording variation in conditions that could affect detectability. In addition, there was little expert consensus on whether these detectability covariates are important, if tracking was always carried out when conditions are optimal. More analysis of repeated surveys is needed to further assess the usefulness of these tracking covariates. The table shows the different trackability variables that have been used by groups, with feedback and comments on their utility. Data field are broken into two sections.

Question	Variable	Format	Description	Comments on reliability or training
1. Intrinsic quality of the tracking surface at the site				
The size of tracks that could be left at the site based on soil surface type. Hypothesis: softer substrate means that smaller animals are available for detection.	**Version 1: How good is tracking surface?**	*1 - if present you could distinguish 2 + 3 plus hopping mice etc.* *2 - if present you could distinguish all of 3 plus fox cat rabbit etc.* *3 - if present you would be able to distinguish camel human dingo etc.*	This tells the quality of the ground surface for leaving tracks. This should stay the same over time for the site.	Current language of categories is confusing. Sites where only large/heavy animals will register, may not be suitable to survey.
	Version 2: How soft is the ground for leaving tracks?	*Soft (lots of little tracks),* *Bit hard for little animal tracks,* *Hard (only tracks of big animals)* *Soft (mouse and small lizard tracks clearly visible)* *Bit hard (unlikely to see tracks of anything smaller than a cat)* *Hard (too hard for tracks smaller than a kangaroo)*	This tells the quality of the ground surface for leaving tracks. This should stay the same over time for the site.	Current language is ambiguous. Sites where only large/heavy animals will register, may not be suitable to survey.
Hypothesis: Plots with a score of 1 will be most worthwhile to revisit and with repeat visits have high detectability.	**Version 3: What tracks can you expect to see on the majority of the plot (under the best conditions i.e. no wind, no vegetation cover)**	1- Tracks of little animals (mice, insects) and medium sized animals (cats, rabbits etc) and large animals (like kangaroos, emu, dingoes, humans) 2- Only medium and large animals 3 -Only large animals 4 -Difficult to see any tracks of anything	The description reflects the innate suitability of substrate to register tracks over the majority of the plot i.e. sandy or soft is best; hard is bad. Important to be able to identify whether a plot location is worth resampling.	
Consensus: Experts are split equally on the value of the two versions above, but agreed that sites where only large/heavy animals will register may not be suitable to survey.				
How much of the plot had exposed, and good (soft / fine) tracking surface.	**Version 1: % of plot suitable for tracking along path taken?**	*Cat4Track: no tracks distinguished*	Describes whether the substrate has become temporarily degraded and likely to produce false negatives.	Percentages can be hard to estimate little consistency between observers. Current language of categories is confusing. Needs to be used with a variable for how innately good the tracking surface is.

Question	Variable	Format	Description	Comments on reliability or training
Hypothesis = more soft/sand more tracks will be available for detection.		*Cat3 track: can distinguish camel, human, emu, dingo, kangaroo etc.*		Current language of categories is confusing.
		Cat2 track: can distinguish fox, cat, rabbit echidna, goanna as well as cat3track.		Current language of categories is confusing.
		Cat1 track: can distinguish cat3 & cat 2 as well as hopping mice, rodents, birds, insects.		Current language of categories is confusing.
	Version 2: What percentage of the plot is suitable for tracking (e.g. Sand or dirt)?	*0-25%, 25-50%, 50-75%, 75-100%*		Percentages can be hard to estimate little consistency between observers. May be better to use words half, and quarter.
		numerical estimate 0 -100%		Look at size of species detected for further analysis.
	Version 3: How much clear ground for tracking?	*Lots of clear ground, some clear ground, little or no clear ground*	Clear ground does not always equal good tracking surface.	Needs to be used with a variable for how good tracking surface is.
Hypothesis: Detectability will be compromised if observed scores < expected scores	**Version 4: At the time of sampling, what tracks can you expect to see on the majority of the plot**	1 Tracks of little animals (mice, insects) and medium sized animals (cats, rabbits etc) and large animals (like kangaroos, emu, dingoes, humans) 2 Only medium and large animals 3 Only large animals 4 Difficult to see any tracks of anything	Important to identify if the conditions at a plot were likely to have caused detection problems (to in aid data checking etc).	Rain, wind, sodden ground or thick litter and vegetation cover can wipe away tracks or prevent the registration of tracks. This causes false negs on plots with innately good tracking surface.
Consensus: There is little expert consensus on the above covariates, but experts agreed that sites that have very little exposed tracking surface are not really suitable for track-based surveys.				

Question	Variable	Format	Description	Comments on reliability or training
The size of patches that are good for tracking. Hypothesis = the larger the sand patch more likely that animals that leave sparse sign will be detected.	**Version1. How continuous is the tracking surface?**	*1 - Majority of sandy patches <1m width,* *2 - Majority of sandy patches >1m width,* *3 - majority of sandy patches 1-3m width,* *4 - majority of sandy patches >3m width.*	Accounts for how much tracking surface is available due to vegetation or leaf-litter.	This may not be needed. There should be a cut-off for amount of exposed sand/soil required for tracking.
	Version2. How big are the majority of the sand patches?	*3. less than 1m in width,* *2. 1-3m in width,* *1. more than 3m in width* *4.no sand patches*	This covariate has proved to be a strong and useful in SA.	The question is better here (rather than using word continuous)
Consensus: There is little expert consensus on the above covariates, but experts agreed that sites that have very little exposed tracking surface are not really suitable for track-based surveys.				

Question	Variable	Format	Description	Issues with reliability or training
2. Conditions at the time of survey				
Detection due to influence of shadow	**Visibility**	*No shadow, slight shadow, distinct shadow, not recorded*	Tracking is improved in high light, long shadow conditions.	Possibly circumvent this by looking to see whether tracks of small animals are visible – if so, tracking conditions are fine. But experts disagree on this approach.

Question	Variable	Format	Description	Comments on reliability or training
	Shadow length (as percentage of your own actual height)	*Metres 0 - 1000*		Problematic.
	Weather	*Cloudy, bright sun, windy, calm*		Can it be multiple of these at once – windy and bright sun?
	Shadow (look at own shadow)	*Distinct, slight, no shadow*		Look at own shadow is a good prompt
	Shadow (look at your own)	*No shadow, Slight shadow, distinct shadow* *Or* *Cloudy, patchy cloud, bright sun*	Cloudy or bright, could be coupled with time of day to know shadow length.	Doesn't account for patchy cloud. A question about how much of the sky has clouds may be better
Has weather wiped away tracks recently? Hypothesis= If it rained/windy tracks are removed.	**Time since weather event** **Time since rain that would clear animal tracks** **Time since strong wind that would clear animal tracks**	*time in days, weeks, months*	Adverse rain or wind remove tracks.	***Problematic.*** Time since weather event is rarely known. This is only useful if it rained or was windy in the last few days and that is the reason for why tracks are not evident, or why only camel and no small tracks are evident. Need to be very good tracker to say from tracks whether wind removed tracks (without knowing weather).
	Have tracks been disturbed?	*Wind, rain, car, no recent disturbance*	The cause of disturbance to tracks on site	Confusing
Consensus: UPDATED VERSION	**Has rain or wind wiped tracks clean in the last few nights?**	*Yes / No*		Support from multiple experts for change to question.

Appendix 4. Example extra fields to consider including in surveys for meeting local objectives

SURVEY DESCRIPTION		
Email and phone number		
Team members	*Names* *Accreditation of skill level*	
ANIMAL DETECTIONS		
Types of sign	Digging into roots of plants	*Yes, No*
	Digging for ants	*Yes, No*
Age of animal - adult /juvenile	Juveniles present?	*Yes, No*
	How old is the animal?	*Big adult, small adult, young*
Amount of activity	How much focal species sign?	*Lots of sign, little bit sign, no sign*
HABITAT		
	Country type / Landform type	*Creek line, drainage line, sand dune (dune field), sand dune (isolated), sand plain, laterite (red rocks), salt-lake country, clan pan, hills, breakaways, granite country, mulga-woodlands-on-finer-textured-soils*
	Vegetation Type[1]	*Spinifex grassland, mixed grassland, buffel grassland, mixed shrub land, open woodland, dense woodland (e.g.: gidgee, coolibah, mallee, desert oak, bloodwood, ironwood, whitewood, kurrajong), mulga*
	Food plant	*Grass seeds, yakirra grass, witchetty grub shrubs, bush fruits, bush onions, yams and potatoes*
	Ephemeral vegetation present	*Yes, No*
	Vegetation	

[1]Vegetation type

Including habitat and vegetation profiles may be useful for some monitoring research questions. Consistency in records is required to ensure these data are useful. Vegetation may be recorded broadly (plant community) or at finer scales (e.g. dominant species present in understory/overstory). For local projects, these data may be helpful in retrospectively improving survey design (it may become obvious a medium sized gecko has an association with *Triodia pungens*, for example).

If broad vegetation descriptions are adequate for the project objectives, then rather than recording habitat information at a site, consider using the National Vegetation Information System (NVIS) framework. This is currently the best available nationally consistent vegetation classification system that includes pre-European vegetation distribution (pre-1750), and extant (current extent) vegetation. It is based on contemporary vegetation mapping and can be downloaded and used in spatial software. There are 85 Major Vegetation Subgroups (MVSs) types across Australia, describing the structure and floristic

composition of dominant and secondary vegetation stratums (e.g. canopy and mid-storey species). However, less-dominant vegetation groups are not always represented, and the vegetation information is of variable resolution and scale.

Major vegetation communities found in the AZM project boundary include (and are not limited to):

- Hummock grasslands.
- Mulga (*Acacia aneura*) woodlands and shrublands +/- tussock grass +/- forbs.
- Saltbush and/or bluebush shrublands.
- Mulga (*Acacia aneura*) open woodlands and sparse shrublands +/- tussock grass.
- Other Acacia tall open shrublands and shrublands.

Appendix 5 - Recording precise location data

Having accurate location data is important to meet many survey objectives. There are two aspects of location data that need to be consistently used to create accurate maps:

1) The datum (frame of reference for measuring the location on Earth's surface).
2) The coordinate system (reference of horizontal and vertical distances on a map).

Integrating datasets with different datums and coordinate systems will result in outputs (maps, images etc) that are inaccurate or misaligned (Lowry 2004). It's important, when recording tracking data, to take note of the datum, coordinate system and projection associated with a dataset, and to use these consistently on different devices.

What datum to use?

A 'datum' provides a frame of reference for measuring locations on the Earth's surface that identifies the position of latitudes and longitudes (and altitude) (Lowry 2004). There are many different datum types which are created by different mathematical models of the Earth's surface. Using a different datum can create differences between the data and recording of precise location (Iliffe & Lott 2008). In Australia, there are several widely adopted geodic datum types:

1. The Australian Geodetic Datum (AGD) in use since 1966 and 1984 (AGD66 and AGD84),
2. The World Geodetic System (WGS) in use since 1984 (for WGS84),
3. Geocentric Datum of Australia (GDA), in use since 1994 (for GDA94), and
4. Geocentric Datum of Australia since 2020 (current datum GDA2020) (Australia 2020).

The choice of datum influences how coordinates are recorded on the GPS device and used for mapping. Using the most up to date datum (GDA2020) provides the most accurate data because the Australian continent has moved (tectonic movement of up to 1.8m) since 1994, and the GDA2020 datum better defines the shape of the Australian continental crust (Australia 2020). Not assigning datums correctly, can create mapping mismatches of 1.8 to 200m in Australia (this level of error may be fine for analyses at a coarse scale – e.g. 1 km^2).

We suggest picking and using one datum on all devices and recording the datum in the metadata associated with the surveys. This best to use are GDA2020, GDA94 or WGS84, as they are more equivalent. The datum should be recorded to help with managing and using spatial data.

What coordinate system to use?

A 'coordinate system' is a reference system used to measure horizontal and vertical distances on a map. There are two broad types of coordinate systems:

1. Geographic Coordinate Systems use latitude and longitude (expressed either as decimal degrees or degrees-minutes-seconds)
2. Projected Coordinate Systems typically use Cartesian coordinates, such as eastings and northings. One of the more commonly used of these projections is the Universal Transverse Mercator (UTM) system. Within continental Australia, there are 8 UTM Zones, numbered 49-56 going from west to east, and it's important to use the Zone appropriate for your location, to record accurate location

data. A limitation of the UTM projection is that error and distortion increase for regions that span more than one UTM zone (Lowry 2004).

a. In Australia, the standard projection used with projected coordinate systems is the Map Grid of Australia (MGA94) which utilises the Geocentric Datum of Australia (GDA).
b. MGA94 is divided into 8 equal zones across Australia.

We suggest using a geographic coordinate system to record latitude and longitude. Alternatively, if a projected coordinate system is used, the relevant map zone for the location of the survey site should be recorded within metadata.

Table A4.1: Checklist for creating and using spatial datasets (Adapted from: (Lowry 2004)).

Task	**Recommendation**	**Further recommendation**	**Metadata to collect**
Select the datum	GDA 2020 should be used. If this does not appear in the GIS or GPS system, then select WGS84, as this is compatible with GDA.	If data is being integrated with another dataset confirm that they use the same datum. If a non- GDA datum is in use, convert the data to GDA datum.	Datum type (e.g. GDA (94, 20) or WGS (84)).
Identify which type of coordinate system to use	Choose a geographic coordinate system (GDA94/ GDA20) Only use a projected coordinate system (MGA94) if dataset lies within a single UTM zone. Do not use if dataset extends across two or more UTM zones.		Coordinate system type (GDA or MGA).
If using a projected coordinated system, identify the most appropriate projection to use	MGA94 is most appropriate projection to use for sites in single zone projects.	Select appropriate zone to project data into e.g. If in Darwin region, Zone 52.	Map zone (if using MGA (Map zone 49-56)).
Create metadata record for the dataset	Metadata records can be created in GIS programs or extracted manually and saved in notepad programs or Microsoft Excel.		Save metadata with tracking data. Use a system to ensure easy tracing and correlation of data sets (i.e. label or headings referring to location/date/tracking survey where metadata was collected).

Appendix 6 – Best way to set up databases for storing data

Data manipulation, cleaning and ingesting were significant tasks for the AZM project team, because data had been recorded idiosyncratically both across and within datasets. Datasets were structured differently, and many different naming conventions were used even within the same datasets. To combine datasets, we needed to bring all the data into a consistent format. Storing data in agreed formats would make data collation much easier in the future. Below we have suggested a best-practice template for inputting survey monitoring data, prior to submitting to the national database.

Dome data providers send data are collected via an app or automated system whereby data are organised via the standard app format or in the way that is specified depending on the app set up. Whatever configuration data are entered, consistency is key.

If data are entered onto excel spreadsheets or into Access databases manually, there are two preferred data configurations:

- PER SITE: one row per site, with species records arranged in columns
- PER SPECIES: one row per species, meaning multiple rows per site

Some 'rules of thumb' and suggestions for collecting and storing data

- If using paper datasheets to record data in the field, consider pre-populating them with a list of the species you might detect. This is the easiest way to make sure you collect absence data as well as presence data, as it prompts you to record that a species was not detected.
- Make sure that all rows have similar items in the same column.
- Make sure there is only one variable per column – don't use one cell of a column to record multiple types of information. Split the information across columns, even if it means there are lots of blank cells. Otherwise, information will be lost or mis-coded when datasets are merged.
- Stick to one expression of each variable when recording data - for example if there is an option such as "Standardised" or "Incidental" pick one option only.
- Decide how the group will record species before the survey. For example, you could record presence by noting the age of sign (1, 2, 3) or by using 0/1 for absence/presence. Without being clear on the recording method, information could get scrambled.
- If you're ever unsure what to record - leave the cell blank.

Examples of preferred data entry templates in excel, for inclusion in the AZM national database.

Appendix 7 - Data recording template for track-based surveys

Before you begin, check that

- *Trackers are trained*
- *Site has good tracking surface (areas of soft dirt, not too much grass or leaf litter)*
- *Tracking conditions are good (sideways sunlight with good shadows, no wing or rain in the last few days)*
- *You will search about the same across each site (for example, 4 people for 20 minutes, per site)*

Describe the survey and survey site

Who	Ranger group or organisation	
	Name of person recording *(optional)*	
	Number of trackers in the group	
When	Date	
	Start time	
Where	Lats (northings)	
	Longs (eastings)	
	Property/IPA name	
	Site name/ Location/ Plot ID *(optional)*	
	Photograph ID *(optional)*	
How	What sampling method was used *(circle one)*	2 ha sand plot Road beside 2 ha sand plot Transect Timed search *Or describe in words:* *Or* Incidental observation (not from a standard method, you just came across the sign but didn't complete a full survey)
	Survey target *(circle one)*	Recording all species Recording only target species
	If recording only one or some species, what were they? *(e.g. Bilby, Tjakura)*	
Fire	How long ago was the last fire *(years, or local fire categories)*	
	Did the fire burn hot or cool?	
Data quality	Tracking conditions *(circle one)*	1. Light excellent (morning/late afternoon, no clouds); No wind or rain in the past few days; Lots of soft sand not covered by leaves or grass. 2. Light reasonable (e.g. late morning, partly cloudy); and/or light wind; and/or not so much soft sand to search. 3. Light poor (cloudy); and/or been windy for a couple of hours; and/or not much soft sand (lots of leaves, grass, or hard surface).

Species Animal name	**Language/ local name for animal**	**Tracks**	**Burrow**	**Scats**	**Diggings**	**Skin/hair feathers**	**Animal alive**	**Animal dead**	**Other**
can pre-fill with species you may detect		*In each cell, write **F** if Fresh (1-2 days), **O** if Old (3 days to 1 week), **VO** if Very Old (> 1 week), **NR** for not recorded*							
Tracks or sign in the plot, along the transect, or in the timed search; or the incidental observation									
For a 2 ha sandplot, or transect, or timed search surveys carried out *off* the road, if you *also* searched the road next to survey site, record that information below									