A guide for the use of remote cameras for wildlife survey in northern Australia

National Environmental Research Program
NORTHERN AUSTRALIA HUB

Northern Territory Government

Acknowledgements

This booklet was funded by the Northern Territory Department of Land Resource Management (DLRM) and the National Environmental Research Program, Northern Australia Hub. The booklet represents the culmination of research and development undertaken by the Flora and Fauna Division of DLRM, in partnership with the rangers and Traditional Owners of Warddeken and Djelk Indigenous Protected Areas, Fish River Station, Indigenous Land Corporation, and Kakadu National Park. Substantial information and content was generously provided by the Arthur Rylah Institute for Environmental Research, Victoria. Special thanks to Carli Piltz, Charles Darwin University for assisting with preparation of illustrations and layout.

Cover photos

Front cover - Feral Pig, Arnhem Land; Feral Cat, Kakadu National Park; Northern Quoll, Groote Island; Black Wallaroo, Kakadu National Park.

Back cover - Warddeken Rangers have been working with Northern Territory Government scientists to research the best way to use motion detection cameras to survey wildlife.

The citation for this publication is as follows:

Gillespie, G. R., Brennan, K., Gentles, T., Hill, B., Low Choy, J., Mahney, T., Stevens, A., and Stokeld, D. (2015). *A guide for the use of remote cameras for wildlife survey in northern Australia.* Darwin: Charles Darwin University.

ISBN 978-1-925167-12-2

Printed by Uniprint

Charles Darwin University, Darwin Northern Territory, 0909, Australia.

Contents

Summary

Remote cameras are an efficient and non-invasive survey tool that can be used in a range of research and management applications for wildlife. How remote cameras are used and deployed depends upon the question or the objectives of a project. This booklet provides information on the general uses and application of remote camera technology for wildlife research projects, and the planning and implementation of remote camera surveys in northern Australia, especially tropic savannas. It includes information on camera types, setting cameras in the field, other equipment requirements, targeting different mammal species, the use of baits, and data storage. Information relating to the type of data collected with remote cameras, analytical techniques and important statistical requirements are outlined. Included are recommended standard operating procedures developed by the Flora and Fauna Division, Northern Territory Department of Land Resource Management, for using remote cameras as part of general wildlife surveys and monitoring programs in tropical savannas of the Northern Territory.

1 Background

Remote cameras or 'camera traps' are an efficient means of collecting data over long periods of time (e.g. weeks) with minimal input of labour and minimal stress to the animals being surveyed. They provide a cost effective means of detecting rare and/or elusive species that are otherwise difficult to systematically sample by conventional methods, or high costs and other logistical challenges of operating intensive field sampling programs in remote areas. Furthermore, remote camera traps are a highly accessible tool for a wide range of practitioners to collect wildlife information, including park managers and rangers, Indigenous land management groups, environmental consultants and students and naturalists. The resultant photographs are a valuable resource for interpreting wildlife information to decision-makers and the public.

This booklet explores some of the considerations relevant to the planning and implementation of remote camera surveys and interpretation of the data produced. Practical considerations, such as the type of cameras, the set-up, as well as sampling and statistical design, including the choice of sites for survey and the analysis and interpretation of data, are provided. Carefully planned and executed remote camera surveys can deliver valuable ecological and management-related information, which will not only increase knowledge of the distribution of species, but can be used to answer wildlife management questions related to the evaluation of management activities, such as threatened species recovery programs or pest species control programs.

Remote cameras are not the answer to all wildlife survey and monitoring problems. Careful consideration of the appropriateness of survey methods to the desired aims of a particular survey or monitoring program should always precede the decision to use remote cameras as a survey or monitoring tool. In some cases, other methods may prove more efficient or better suited to project aims, or a combination of methods incorporating remote cameras may be most appropriate. Choice of survey methods should always be guided by objective consideration of the costs and benefits of alternative survey methodologies.

2 Are remote cameras appropriate for your project?

Determining whether remote cameras are a suitable tool for answering particular research or management questions involves consideration of several factors.

2.1 Species of interest

Remote cameras work by sensing objects that move and are a different temperature relative to the background; therefore they are most suited to detecting mammals and to a lesser extent birds, but generally less sensitive at detecting reptiles and frogs.

2.2 Purpose of information collected

When using remote cameras purely as an observational tool, such as for documenting species presence or for collecting photographs of animals for educational/interpretive purposes, only a small number of cameras may be required. Such applications will generally require minimal planning, are easily implemented by a small number of people and in many cases (i.e. where the data are not required to precisely answer a question) do not require formal data analysis. However, the conclusions that can be drawn from such data will be limited compared to a formally designed and analysed sampling program.

For many applications, such as surveying the distribution of species, estimating species abundance, or monitoring changes in these parameters through time, proper attention must be given to study design (e.g. where and how many survey sites, and sampling effort at a site, etc.), camera deployment and how data will be analysed. Poorly designed surveys often result in data which cannot be used to answer the questions of interest.

2.3 Resources required from start to finish

The labour associated with implementing remote camera surveys is relatively minimal compared to surveys using alternative sampling methods, such as cage traps or spotlight surveys. However, extensive remote camera surveys may still require significant staff resources and equipment. Adequate resources must also be available for project planning and data analysis, which may require specialist advice and assistance from a biometrician. Unless the survey data are collected and analysed using appropriate statistical methods then the information generated may not provide reliable answers to the questions of interest, which can lead to inappropriate management decisions or actions.

Remote cameras of reasonable quality are more expensive to purchase than other wildlife survey equipment such as cage traps or hair-tubes. Therefore, adequate financial resources will be required to purchase and maintain the necessary pool of cameras and accessories to support a particular project. Allowance will need to be made for attrition of cameras, as losses due to accident, fire, malfunction, theft and vandalism inevitably occur, and will mean that repair or replacement of affected units will be necessary. In addition to the remote camera, consumables such as batteries, SD cards, and bait stations or lures, must be purchased, which, depending on the number of cameras deployed, can add substantially to the cost of the survey. Advances in digital technology have resulted in rapid improvements in remote cameras, allowing them to become smaller, cheaper and more effective. It is anticipated that further technological advances are likely to result in recently purchased remote cameras being superseded, eventually becoming redundant and in need of replacement.

3 What ecological and management questions can be answered with remote cameras?

Typical applications of remote cameras include:

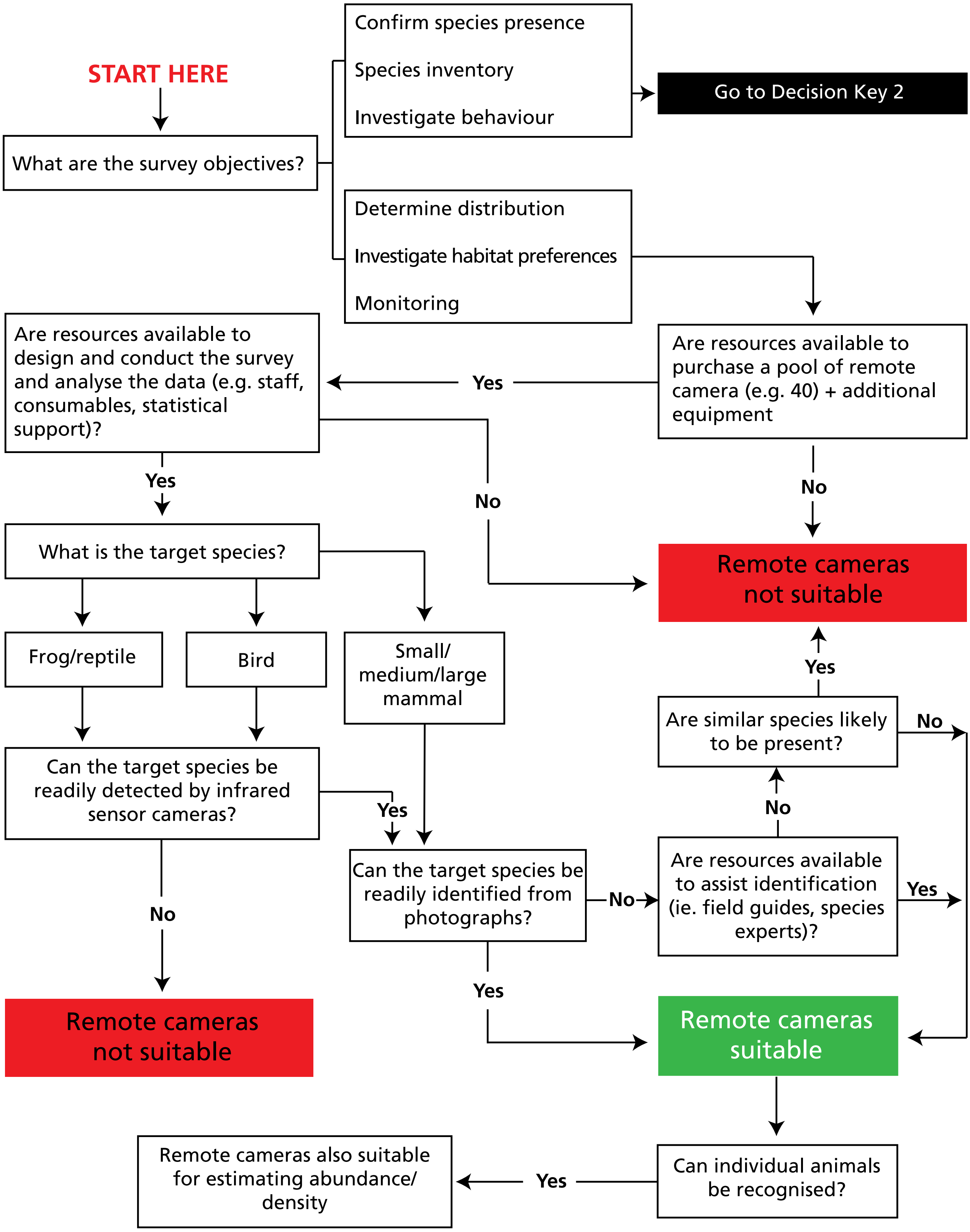
- Simple surveillance, in order to document species that may be visiting one or a few sites of specific interest, such as a watering hole.
- General biodiversity surveys; remote cameras may be used in conjunction with other standardised sampling methods to systematically document spatial patterns of vertebrate biodiversity.
- Targeted wildlife surveys; remote cameras may be used, either exclusively or in conjunction with other sampling methods, to determine the spatial distribution of species known to be amenable to camera trapping.
- Population density estimation, where an array of cameras is used to identify the spatial distribution of uniquely marked individuals of a species.
- Monitoring, in order to document changes in occurrence and distribution of individual species or a suite of species over time.
- Management evaluation, in order to document changes in species occurrence or species composition through time and space, in response to specific environmental management interventions, such as pest management or fire management.

Remote cameras record the presence of wildlife at a particular location and time. Wildlife survey data collected using remote cameras has a number of special characteristics which require careful consideration when determining how best to collect and interpret such data. Important features of typical camera trapping data include:

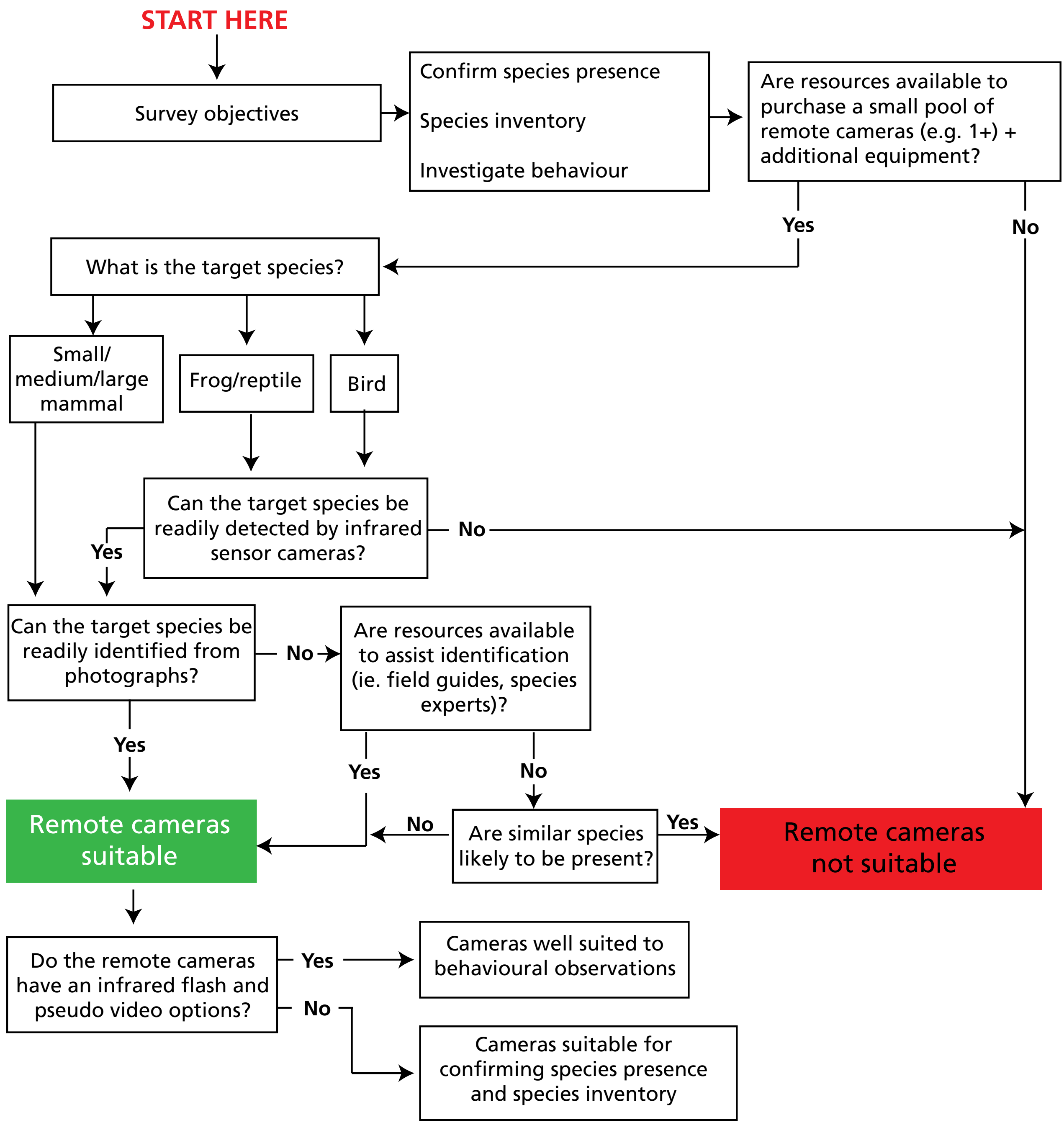
1. Images are collected over the course of a deployment in response to individual animals visiting the camera sites, which are automatically photographed.
2. Images are stored for future reference on the camera's digital media, and are time- and date-stamped.
3. A species of interest may occupy a site at which a camera is deployed during a survey; however there is no guarantee that the species will actually be photographed. This is called a false negative.
4. A species of interest may not occur at a site at which a camera is deployed during a survey; however it may occur there at other times. This is particularly the case for rare species, species occurring at very low densities, or species with large home ranges.
5. In some cases, individual recognition of animals will be possible (e.g. species with naturally variable and distinct markings), but in most cases it will only be possible to determine which species were detected and when, but not to identify individuals reliably.
6. It will be difficult to positively identify some species, either always or in some instances, such as poor-quality photos.

The following decision keys will help you determine whether or not remote cameras are suitable to use, based on the nature of the application, available resources and the target species.

Decision Key 1



Decision Key 2



Remote cameras may also be useful for capturing and documenting behaviours of animals that are otherwise difficult to observe or are rare. Whilst perhaps not the primary objective of deploying cameras, resulting images can sometimes provide insights into the ecology and behaviour of species not easily documented by other means (Fig. 1).

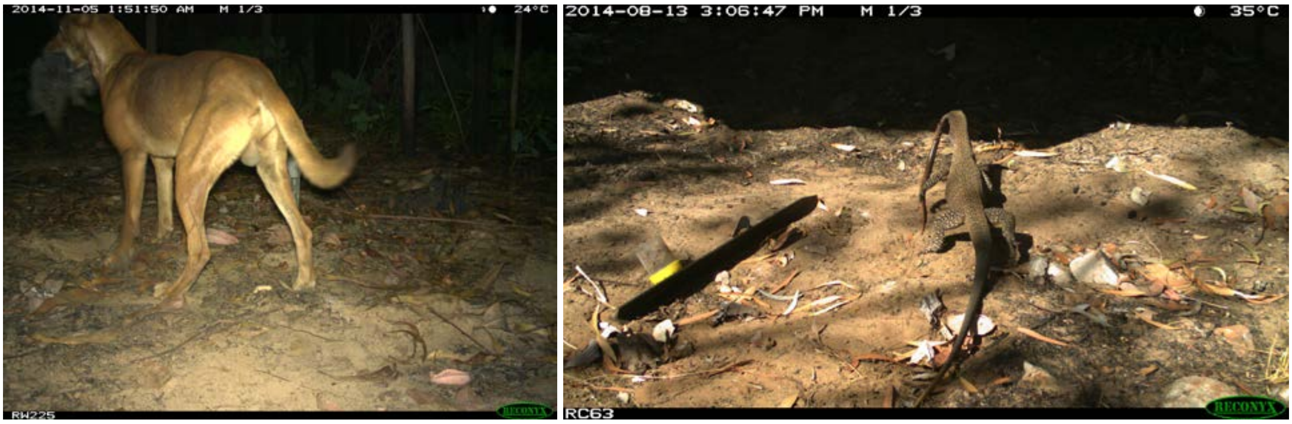


Figure 1: Photos taken with remote cameras of (left) a Dingo (*Canis lupus*) preying on a Common Brushtail Possum (*Trichosurus vulpecula*); and (right) a Black-palmed Monitor (*Varanus glebopalma*) preying on a Northern Small-eyed Snake (*Criptophis pallidiceps*).

Proper interpretation of camera trapping data requires that appropriate statistical methods are applied that account for these features of the data, in particular the likely presence of false negative occurrence records (i.e. instances where the species is present at a site, but was not photographed during a given camera deployment; Fig. 2). Failure to properly interpret data can easily lead to misleading and incorrect conclusions with flow-on effects to management decisions.

Data collected using a properly designed remote camera sampling program is generally analysed to determine the proportion of an area that is occupied by a particular species (i.e. the rate of occupancy). The occupancy rate (and the manner in which it changes over time) is a useful criterion for assessing the status of wildlife populations, and can represent a meaningful target for monitoring and reporting on changes in condition over time. This is particularly the case for species that are difficult to survey, where assessing actual numbers (abundance or density) is often not feasible.

Under some limited and very specific circumstances, remote camera data can be used to infer the abundance or density of a species of interest within a sampling area. It should be noted however, that in most cases camera data will only be useful for measuring rates of site occupancy or proportion of area occupied. Assessments of abundance or density from camera trapping data will only rarely be feasible, and will usually require that individuals of a species are uniquely marked, and can be reliably recognised as individuals from photographs (Foster and Harsen 2011; Ramsey *et al*. 2015). A list of relevant references on methods to infer abundance or density from remote camera data is provided in the reference section.

Further information on interpretation and analysis of camera trap survey data is provided in Section 9.

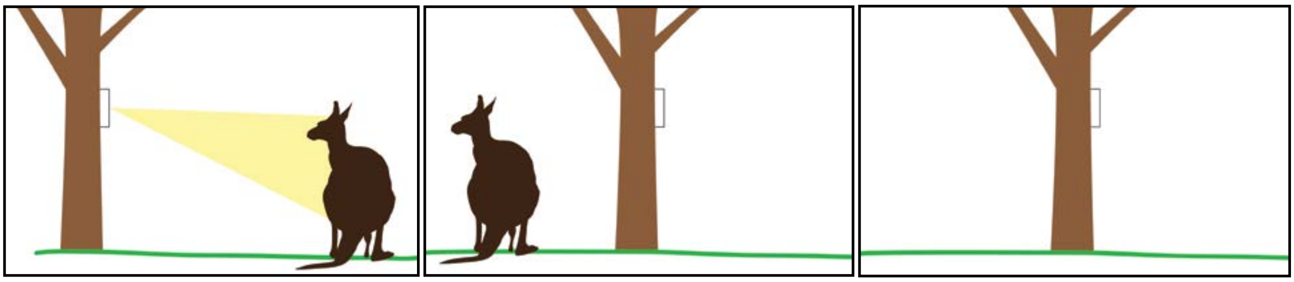


Figure 2: Illustration of the difference between occupancy and detection. In the first picture the kangaroo occupies the site and is detected and photographed by the camera. In the middle picture the kangaroo is present and occupies the site, but is out of view of the camera and therefore not detected. In the third picture the kangaroo is not present so there is no picture taken. This is why detection rates need to be calculated and used in occupancy estimates.

4 Study design considerations

Careful consideration of the aims of the project at the outset is essential, as the design of the sampling strategy will depend on the project aims. Answering ecological and management questions using remote camera sampling will require that sampling programs are properly designed, with appropriate replication, methods of site selection, and experimental design such as use of experimental controls.

It can be very tempting to simply place cameras at locations known to support the species of interest, or to target locations with habitat that is considered to be highly suitable in the hope of obtaining photographic evidence of the presence of the target species. Such an approach is called "convenience sampling". In some limited circumstances, convenience sampling can be a useful approach; for instance when we are only interested in surveying a very specific, limited set of locations, and have no interest in inferring whether the species might be present at any other (un-surveyed) locations. An example of convenience sampling is where the objective is to follow-up on unconfirmed reports of the occurrence of a rare species at one or more sites in a management area. As long as we only wish to investigate these particular sites, and not to make inferences regarding other locations in the management area, then carrying out remote camera surveys only at these sites is reasonable (Fig. 3).

However, if we are interested in drawing conclusions regarding some broader area, then approaches to site selection which are based on randomised sampling are essential. In such survey designs, a statistical population of sites is defined and survey sites are chosen from this population at random. The distance between survey sites depends on the ecology of the target species; a large enough distance is usually chosen so that the likelihood of detecting the same animal at adjacent sites is negligible (i.e. each survey site can be considered independent). However, for wide-ranging species such as cats or dingoes, independence can be difficult to achieve, particularly in small survey areas. In this case sites should be spaced as widely as feasible, and at uniform distances apart.

Figure 3: Northern Brush-tailed Phascogale (*Phascogale pirata*) a semi-arboreal mammal currently rare and threatened has not been caught by live trapping in areas where it was previously known to occur. Remote cameras can be used to improve knowledge of whether the species is now absent from the sites or just not being caught in cage traps. Photo by Kym Brennan.

Choice of the broader statistical set of sites should reflect the area that we are hoping to learn about from the sample data. For example, if we are interested in estimating the overall pattern of distribution, or rate of occupancy, of Black-footed Tree-rats (*Mesembriomys gouldii*) in Fish River Station (Fig. 4), then we might choose as our statistical set of sites all 0.25 km^2 map grid squares located within Fish River Station. Having specified this statistical set of sites we would then choose a random sample of 0.25 km^2 grid squares from this set, and carry out a remote camera survey in each of these randomly chosen sites. Provided a sufficient number of squares are sampled, and at least some detections of Black-footed Tree-rats are made, it will then be possible to make valid statistical inferences from the data regarding the likely rate of occupancy across the whole of Fish River Station (Fig. 4). We can be confident that the same information applies to the grid squares that were not sampled. If there is good reason to presuppose that the target species is more or less likely to occupy particular habitat types within the area of interest, a more precise estimate of occupancy can be obtained using a stratified random sampling approach. Stratified random sampling in such a case would involve selection of random sites from each vegetation type to ensure adequate representation of all vegetation types in the sample.

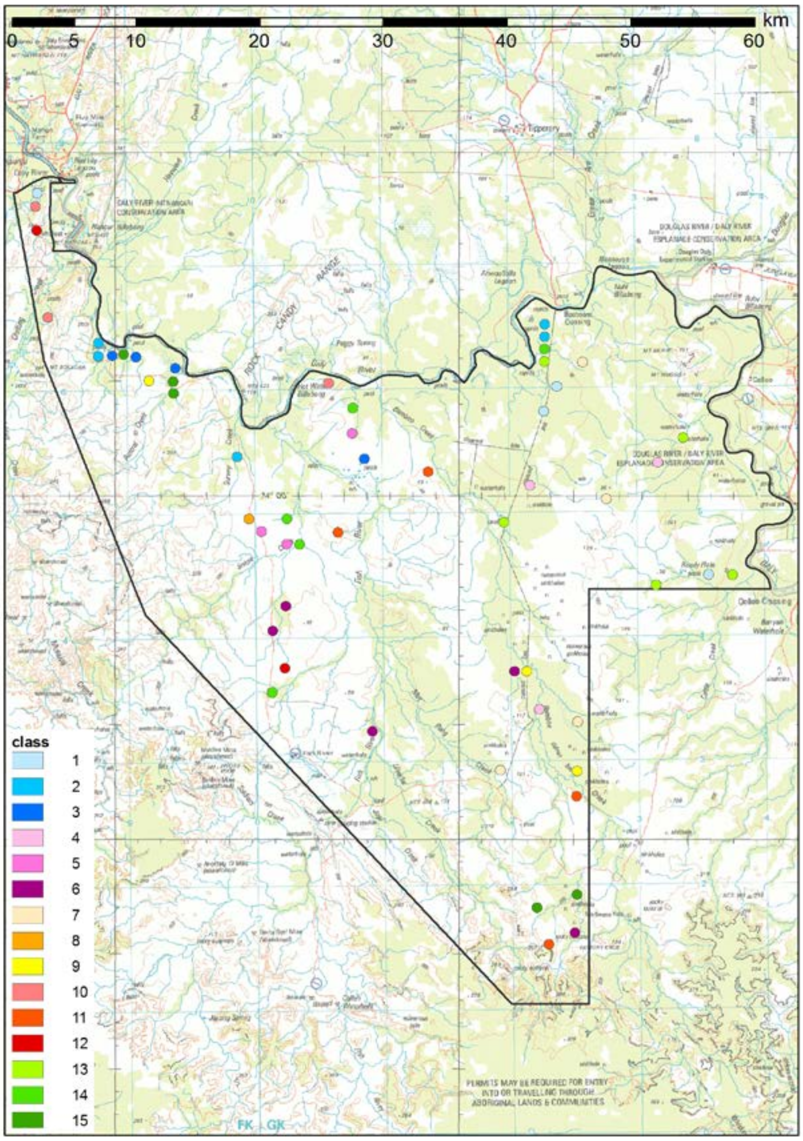


Figure 4: Example of a well-planned sample design for surveying Black-footed Tree-rats at Fish River Station. Different coloured dots represent a random selection of stratified sites that characterise the range of habitat types, fire histories, and feral animal densities across the property.

Where the intention of the remote camera survey project is to evaluate the effect of management actions on a species, then the experimental design considerations of any such study apply. Ensuring a sufficient replicated number of sites is surveyed, and the inclusion of appropriate control sites within the design, will help ensure that the effects of the management action can be distinguished from any underlying changes that apply to all sites.

4.1 What is detection probability?

Whenever surveys are conducted for a species, there is a chance that it will not be detected, even though it is present at survey sites. There are a number of reasons for this:

- The animal may avoid our traps because it is shy and cautious.
- It may be the wrong time of year or day. Some animals like reptiles are less active in the dry season.
- Our trap may be in the wrong place, some animals prefer to move through certain parts of the landscape and not others.

Detection probability is the probability that a species will be detected during a survey if it is present at a site. For example, if the chance of detecting a species is 50% in any one survey, and if we undertook three surveys at the site, the chance that we would fail to detect the species even though it is present is 12.5% (0.53 = 0.125).

If previous surveys indicated that a species was actually present at 1 in 4 sites (e.g. occupancy = 0.25) within similar habitat, then if we were to survey 100 sites we would expect, on average, the species to be present at 25 of those sites (100/4 = 25). If we plan to undertake three surveys at each site, and the chance of detecting the species is 50% in any one survey, then we would expect, on average, to detect the species at only 22 sites ((1 - 0.125) x 25 = 21.8 sites). There is a 4% chance that the species is actually present at a site where we didn't detect it despite undertaking three surveys. Furthermore we would also estimate the following:

- Number of sites the species is not detected but present: 25 – 22 = 3 sites
- Number of sites we expect the species to be absent from: 100 – 25 = 75 sites
- Chance the species is present at a site where we didn't detect it in 3 surveys: 3 / (3 + 75) = 0.038

Therefore, how common or rare a species is in the landscape and the detection probability will affect decisions around how long cameras need to be deployed.

4.2 How many sites should be surveyed?

Often it is not possible to determine the necessary number of sites to survey using remote cameras prior to conducting the survey. In general, when conducting an occupancy type survey, the aim of the survey design will be to make the most precise estimate of the rate of site occupancy, given the available resources. The precision of statistical estimates of occupancy depends on:

- the number of sites that are surveyed,
- the daily detection probability of the survey method,
- and the number of repeat surveys that are carried out at each site (i.e. the number of days of camera sampling) (see Fig. 5).

In general, surveying more sites a greater number of times using the method with the highest probability of detection, will maximise the precision of the estimate of the rate of occupancy. However, there are usually conflicts and trade-offs between these three aims. For example, if limited numbers of cameras are available for use on a particular project, then carrying out many days of survey at each site will limit the total number of sites which can be surveyed over the course of a survey season. The expected precision associated with a particular sampling program can be calculated if reasonable estimates regarding the occupancy rate amongst the sampled sites and probability of detection are available prior to the survey. This information may be available from a previous study of the same species, from pilot studies, or from expert opinion. MacKenzie and Royle (2005) provide a thorough analysis of these issues, and derived a number of 'rules of thumb' for occupancy sampling program design which are somewhat relevant to the design of remote camera surveys. Bailey *et al.* (2007) describe a freely available computer program (Program GENPRES) useful for exploring the efficiency of alternative occupancy sampling designs, which can be used in the design of remote camera surveys.

4.3 How long should cameras be deployed?

The maximum duration (number of days) of remote camera surveys is usually limited by battery life or, in some cases, by the capacity of the digital storage media to retain many images. If remote cameras are not required for use at other sites, then deploying cameras for a length of time close to the expected endurance of the batteries and/or digital storage medium is probably the best strategy. This is because the cost of leaving a deployed camera out for a few extra days is effectively zero – no additional staff time or resources are required for a 30 day deployment for example, compared to a 10 day deployment. By maximising the length of the deployments, a greater effective number of daily 'surveys' are carried out at each survey site, and hence a longer sequence of detection and non-detection events is accumulated at each site. Statistically, this leads to more precise estimation of both the probability of detection and the rate of occupancy (Fig. 6).

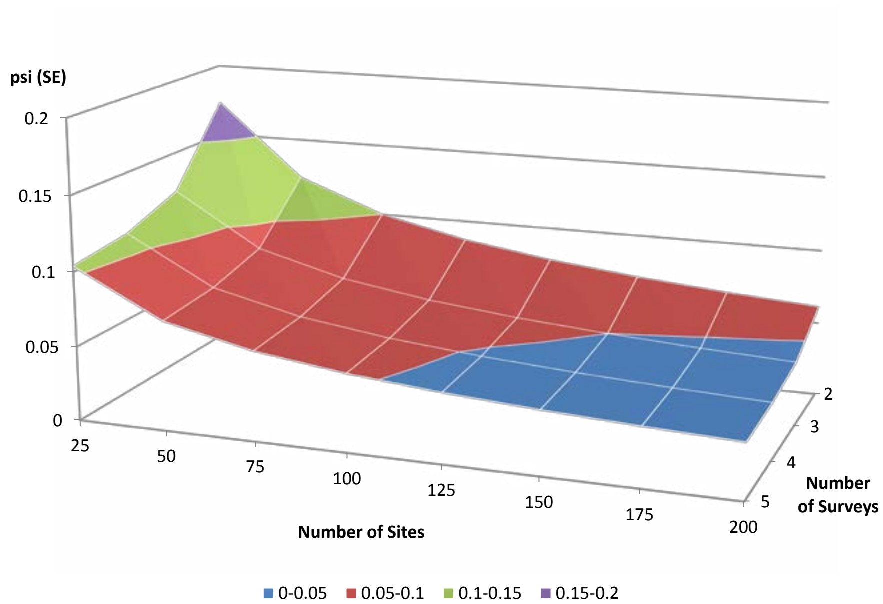


Figure 5: The relationship between the precision of occupancy estimates (the proportion of sites occupied by a species) varies depending on the number of sites surveyed and the number of repeat surveys undertaken at a site (e.g. the number of weeks cameras are deployed). When either the number of sites or number of surveys is increased the precision of the occupancy estimates improves. However, the improvement in the estimate is far better when the number of sites surveyed is increased. The colours on the graph represent the precision (SE = standard error) of the occupancy estimate (psi). Lower values mean the estimate is more precise.

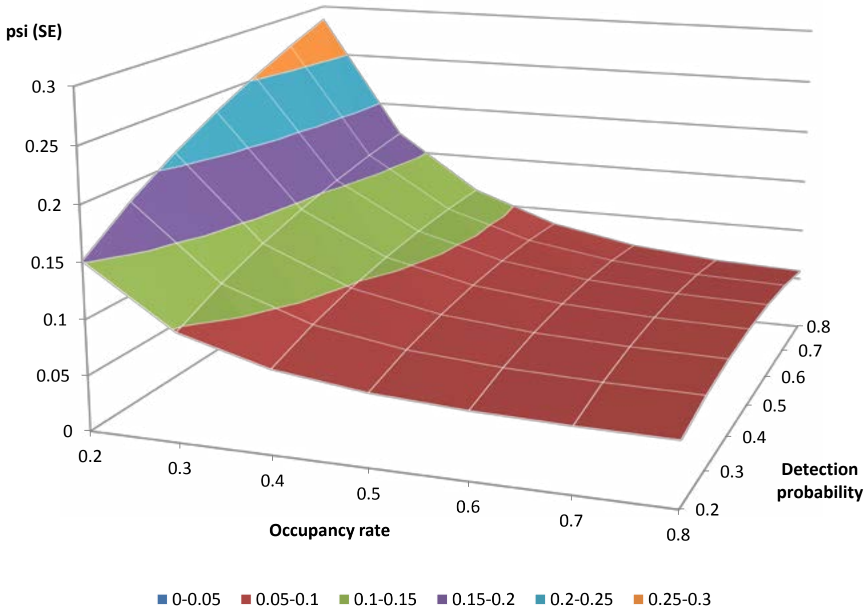


Figure 6: The relationship between species that are rare in the landscape (low occupancy values) or common in the landscape (high occupancy values), the ability to detect a species (the detection probability), and the influence on the precision of occupancy estimates (psi(SE)). The colours on the graph represent the precision (SE = standard error) of the occupancy estimate (psi). Lower values mean the estimate is more precise for a given number of sites sampled. When species are rare in the landscape more sites will need to be surveyed in order to get better estimates. Conversely, when species are common in the landscape less effort is required to get reasonable estimates.

4.4 How many cameras at sites?

Deploying more than one camera at each survey site will usually be expected to lead to an increase in the probability of detecting species of interest. This is because the likelihood that target species will encounter a camera, or be attracted by a lure, is greater when more cameras (and lures) are placed within the site. The distance between the multiple cameras at each site will vary depending on the ecology of target species. For example, for wide-ranging species with large home ranges (i.e. hundreds of hectares), widely spacing the cameras (e.g. 500 m) will sample more of the site but still remain within the bounds of the target species' typical home range. In contrast, for species with smaller home ranges (i.e. tens of hectares), closer spacing (e.g. 100-200 m) is generally selected.

Although deploying additional cameras at each site is likely to increase the probability of detecting the target species if the site is occupied, it reduces the number of sites that can be surveyed at the same time with the same number of available cameras. Unfortunately, there is generally no optimal answer to the question of how many cameras to deploy at each site, as the relative costs and benefits cannot usually be determined before commencing the survey. Previous experience, or a pilot study may be necessary to determine the best number to use, and will require quantification of the detection probability associated with differing numbers of cameras per site, as well as the costs associated with using various numbers of cameras to survey a site.

Deployment of additional cameras at a site provides partial insurance against occasional camera malfunctions or theft, such that a site is not completely written off if a particular camera fails to provide data for some reason. This is particularly important in remote, hard to access, survey areas, where the costs of travelling to and from sites to deploy remote cameras are high. Under such conditions, the cost of loss of data caused by camera malfunction or loss may be higher than the cost of buying and deploying multiple cameras at all sites to minimise the number of sites where no data are obtained. Occupancy modelling approaches can be readily modified to deal with designs where sites (either by design or as a consequence of remote camera malfunction) have unequal numbers of cameras deployed.

4.5 General guidelines

In any study one must assume that at some sites species will be present but go undetected by remote cameras during a survey. Therefore doing more than one survey at a site or surveying for a longer time period will increase the chance of detecting the target species. This can be achieved by:

- Deploying camera traps at sites for longer periods.
- Deploying more than one camera at a sample site.
- Sampling sites in different times of the year to account for seasonal variation in species detectability.

When animals are relatively easy to detect with remote cameras (i.e. detection probabilities are relatively high; > 0.7), using one camera for 20-30 days without malfunction at a site should be sufficient (Hamel *et al*. 2013). When animals are hard to detect (i.e. detection probability is low; <0.5), then cameras need to be deployed for longer periods. Detection probability can also be improved by deploying additional cameras at a site.

If the aim of the study is to get good estimates of occupancy, then Table 1 provides a rough guide to the number of sites and length of surveys when using a single camera per site. Species that are common but hard to find will require more survey days at less sites. As species get harder to find (detection probability decreases) the optimal length of surveys increases. When a species is rare in the landscape (low probability of occupancy) more sites will need to be surveyed to cover a larger area of the landscape.

Table 1: A rough guide to the number of sites and length of surveys when using a single camera per sample site. The minimum number of deployment nights and the number of sites to sample will vary depending upon the nature of target species.

Species is:	Minimum number of weeks deployed	Minimum number of sites to survey
Common and easy to detect	3	30
Common but hard to detect	7	40
Rare but easy to detect	4	150
Rare and hard to detect	7	180

4.6 Pilot studies

A pilot study, or preliminary survey, is a particularly useful means of gathering information prior to embarking on a full survey program that can vastly improve the quality and efficiency of the proposed survey. Statistical advice based on preliminary analysis of the pilot data can help refine aspects of the sampling design, such as the number of cameras to deploy per site, the survey duration and the number of sites to survey, and allow the feasibility of a full-scale survey to be assessed. A pilot study also provides staff a chance to practice using the cameras, refine the methodology, identify logistical problems which might occur and determine the time and resources (e.g. staff, vehicles) required to complete the full survey program.

5 Types of cameras

Most types of remote cameras currently used for surveying wildlife are triggered by infrared sensors. These fall into two categories: passive infrared (PIR) and active infrared (AIR). PIR sensors detect moving objects within the sensor's detection zone that are a different temperature to that of the background environment. PIR systems have a single sensor component, and in most camera units the sensor is integrated into the camera housing. AIR systems are activated when an object breaks an invisible narrow beam of infrared light that extends between a transmitter and a receiver. The transmitter and receiver units of an AIR system must be properly aligned for the unit to function correctly. In AIR camera systems, the transmitter and receiver units are separate from the camera and the infrared receiver is connected to the camera by a length of electrical cable.

The majority of remote cameras that are currently commercially available comprise a compact digital camera activated by PIR sensors. The main advantage of PIR triggered cameras is their ease of use by a single operator with minimal training and experience. Remote PIR cameras detect animals moving within a zone of detection radiating outwards in front of the sensor. As a result PIR cameras typically allow animals to be detected over a wider area than narrow AIR sensor beams. However, wide detection zones are susceptible to false triggers, where by photographs are taken that do not contain an animal. False triggers may occur when the animal is outside of the camera's field of view or beyond the range of the flash. Moving vegetation, passing shadows, or heated ground can also cause false triggers. This can be particularly problematic in open areas or when the remote camera is set very close to the ground. Some PIR systems do not operate effectively in hot climates because the difference between background temperatures and those of moving animals may not be large enough to trigger the camera. Despite these difficulties, the growing availability of reliable, easy-to-use remote PIR cameras with features that make them suitable for extended field deployment (e.g. waterproof housing, high capacity for image storage, long battery life) has led to a marked increase in the use of these systems in a wide range of wildlife applications. The rest of this booklet deals with remote PIR cameras.

Commercially available remote cameras are available with a wide range of features. These include, but are not limited to: either white light or infrared flashes; continuous (i.e. 24 hour) or day or night only operation; a range of delays between successive photographs, and sensitivity settings that allow the sensitivity of the sensor to be adjusted so as to minimise false-triggering. Remote cameras are currently being used throughout Australia for a range of wildlife survey applications and are suitable for surveys and monitoring projects targeting mammals ranging from the size of a mouse to that of a buffalo.

5.1 Camera models

Commercially available camera units vary markedly in price depending on quality and the available features. Key features to consider when purchasing remote cameras include: cost, durability, trigger times, battery life, flash type (infrared or white light) and image quality. Choice of model depends largely on the applications for which it is to be used. For example, the minimal disturbance to target animals provided by remote cameras with infrared flash, together with the ability to take up to 10 photographs at one second intervals each time the camera is triggered, makes this type of unit well suited to the collection of behavioural observations. However, photographs taken with infrared flash are monochrome and of relatively low resolution compared to those taken with a white light flash (Fig. 7). Remote cameras with infrared flash are therefore not well suited to surveys of species that may be difficult to identify accurately from poor-quality images, such as many small mammal species. The possibility that the species of interest might be disturbed by a white light flash or the noises made by cameras and subsequently avoid the camera is also an important consideration. Whilst many animals have been observed to repeatedly visit camera stations and be photographed on subsequent occasions, or remain at the site whilst being photographed multiple times, more research is required to evaluate the actual influence of cameras themselves on animal behaviour and detection (Meek *et al*. 2015).

Figure 7: The black and white image (left) taken with the Reconyx Hyperfire HC600 at night is a rodent, but diagnostic features for species identification are not visible. The colour image (right) taken with an HC550 is a Arnhem Land Rock-rat (*Zyzomys maini*), which can be distinguished from the sympatric Common Rock-rat (*Z. argurus*) by the tail length and thickness, and colour and length of hairs on the tail – details not typically visible in the lower resolution black and white image.

Six commonly used PIR remote camera models readily available on the market, along with features of each unit and their advantages and disadvantages, are outlined in Table 2. These systems vary markedly in their features, image quality, reliability and price. The information in Table 2 should not necessarily be taken as an endorsement or recommendation of any of these units, but rather an illustration of the features and advantages and disadvantages of a selection of typical remote camera systems. Many other remote camera systems are commercially available, and as technology develops new and better systems are likely to become available. It is therefore prudent for those planning to purchase cameras in the future to carefully investigate the systems available in order to make informed choices about the most appropriate units for their own applications.

Table 2: Comparison of common brands of motion sensing fauna cameras

Brand	Reconyx PC850	Reconyx HC550	Reconyx HC600	Pixcontroller Digital Eye	Scoutguard KG680v	Bushnell Trophy
Price (US$)	$650	$550	$550	$480	$230	$303
Trigger speed (seconds)	0.2	0.2 seconds	0.2	1.8-3.8	0.8-1.2	0.8
PIR sensor range	30 m	30 m	30 m	24 m	15 m	18 m
Video Y/N	N	N	N	Y, day only	Y	Y
Image type	Colour day and night.	Colour day and night.	Colour day, B&W night.	Colour day and night	Colour day, B&W night.	Colour day, B&W night.
Operating temperature range	-40 to 60 C	-29 to 49 C	-29 to 49 C	-15 to 43 C	-20 to 60 C	-20 to 60 C
Waterproof-ness	Waterproof	Waterproof	Waterproof	Waterproof	Weatherproof	Weatherproof
Warranty and support	2 yr warranty. Includes 'mapview' software for metadata export and image management.	1 yr warranty, includes 'mapview' software for metadata export and image management.	1 yr warranty. Includes 'mapview' software for metadata export and image management.	1 yr warrant.y Includes image management software.	1 yr warranty.	2 yr warranty.
Programming	3 pre-programmed settings with full manual programming of sensitivity, delay, images and more. Programmable via SD card.	3 pre-programmed settings with full manual programming of sensitivity, delay, images and more.	3 pre-programmed settings with full manual programming of sensitivity, delay, images and more.	Some programmable settings via camera and manual switches in unit e.g. sensitivity	Programmable sensitivity, delay and number of images.	Programmable sensitivity, delay and number of images.
Pro's	Very fast trigger, good degree of programmability, highly durable, good data management capabilities, good support. Widely used in wildlife research.	Very fast trigger, good degree of programmability, durable, good data management capabilities, good support. Widely used in wildlife research.	Very fast trigger, good degree of programmability, durable, good data management capabilities, good support. Widely used in wildlife research.	Very high quality optics and images. Has built in image viewer. Used in wildlife research	Good degree of programmability, has built in image viewer.	Price, simple to operate.
Con's	Price, need separate device to view images.	Price, need separate device to view images. Less durable than PC 850.	Price, need separate device to view images. B&W night images. Less durable than PC 850.	Slow and noisy trigger, complex programming required, relatively short battery life, price	Lower image quality, less durable. B&W night images.	Lower optical and image quality, less durable, need separate device to view images. B&W night images.

In the Northern Territory (NT) remote cameras need to operate reliably under harsh conditions, including extreme heat, smoke, dust and wind, heavy rain and high humidity. Furthermore the high diversity of species present in the NT means that remote cameras need to be suitable for detecting a wide range of animal forms under a wide range of conditions. For these reasons Reconyx camera models are used in the Northern Territory by the Flora and Fauna Division, Department of Land Resource Management (Fig. 8). The relatively high cost per unit of Reconyx cameras is greatly offset by their climatic durability, reliability, sensitivity and flexible programming.

Figure 8: A Reconyx Hyperfire camera attached to a tree.

5.2 Other equipment

Remote camera surveys require a range of additional equipment other than the camera units themselves. Camera-mounting equipment, camera accessories (e.g. digital memory cards), tools for site and bait station (if using) preparation, consumables (e.g. batteries, bait) and navigational aids for locating and marking the site are all usually required for carrying out remote camera surveys. Some remote camera units are supplied with accessories such as mounting straps and digital memory cards, while others are not. Refer to the manufacturer's website, and/or user manuals, to determine what is supplied with cameras and to ensure that adequate funds are available for additional equipment required. Some key equipment requirements are outlined below:

1. Memory cards – The internal memory of most digital cameras only allows for storage of a very small number of images, therefore each remote camera needs to be supplied with a digital memory card for storage of images. These cards are identical to the types used in most automatic digital cameras, and are widely commercially available. Memory cards with a large storage capacity (e.g. 4 GB or more) that allow thousands of images to be stored can be purchased at relatively low cost. Buying memory cards in bulk from online retailers may also result in significant cost savings.
2. Mounting straps – Most remote camera units have a bracket or lugs integrated into the enclosure for attaching the unit to a tree or pole. Adjustable elastic straps are ideal for this purpose. Pliable light-gauge wire, rope, cord or cloth webbing can also be used to mount cameras to trees or posts.
3. Anti-theft devices – While it is virtually impossible to prevent theft or vandalism, cable-locking the remote camera unit to a tree will act as a deterrent and is advisable in areas with high human visitation or if setting cameras along vehicle or walking tracks.

4. Batteries – In general, buying the best quality batteries is cheaper in the long-run due to the lower rates of battery exhaustion. Battery life can be markedly reduced in cold conditions: alkaline batteries are more sensitive to cold than are rechargeable nickel metal hydride (NiMH) or non-rechargeable lithium batteries. However, in some circumstances, rechargeable batteries may not last as long as alkaline batteries. Camera manufacturer's websites and user manuals make specific recommendations regarding the preferred types of batteries. Purchasing batteries in bulk can result in large cost savings.
5. Data cables – USB cables for downloading images from the remote camera to a computer are generally supplied with remote camera units that use standard consumer model digital cameras. Alternatively, memory cards can be removed from the camera and the data downloaded using a digital memory card reader.
6. Other general equipment required for setting remote cameras in the field includes:
   - **Navigation** – GPS, PDA, maps, compass.
   - **Site preparation** – Secateurs or pruning saw, leather gloves, shovel, dry-erase boards and marker pens for site identification sign, flagging tape and permanent markers for site marking.
   - **Setting the remote camera** (batteries and memory cards installed and camera settings programmed) – User manual, setup checklist, mounting straps or tie wire, pliers, electrical tape, desiccant (silica gel), cable lock, ant repellent, hand-held camera to check test images.
   - **Installing bait stations** – Bait, rubber gloves, antibacterial hand wash, bait station materials (e.g. pole for attaching the bait, bait container), pliers, hammer, tie wire or zip ties.
   - **Data management** – Data sheets, waterproof field notebook, pencil, PDA.

Cyber Tracker sequences have been created by Indigenous ranger groups for use on rugged PDAs to record geo-referenced camera deployment and retrieval data (See Appendix 3).

A checklist of equipment is provided in Section 10.

6 Permits and ethics requirements

A key feature of remote cameras, in contrast to many other wildlife survey techniques, is that they are relatively non-invasive; animals don't need to be physically captured or handled as part of the survey. From an ethical and animal welfare point of view, remote camera surveys are only minimally intrusive, with impacts on animals limited to minor disturbance caused by flashes and camera noise, and behavioural responses to baits and minor habitat disturbance. For these reasons, animal ethics committee approvals are still required for implementing remote camera surveys in the NT http://www.animalwelfare.nt.gov.au/animal_research_and_teaching. Under the *Territory Parks and Wildlife Conservation Act*, remote camera surveys conducted for the purposes of specific research projects in the NT will require a Scientific Research Permit http://lrm.nt.gov.au/__data/assets/pdf_file/0007/4021/permit_scientific_research.pdf. Projects undertaken in Kakadu and Uluru National Parks also require a permit from Parks Australia http://www.environment.gov.au/resource/researchers. Other northern Australian jurisdictions, including Queensland, Western Australia and island territories, also have permit requirements for the use of camera traps.

7 Practical limitations of remote cameras

7.1 Loss of cameras and data

Remote cameras are easy to use and very little training and experience is required to become proficient in their use. When used correctly they are quite reliable; however, remote cameras can fail in harsh field conditions and may deteriorate over time, resulting in replacement and repair expenses. However, failure of remote cameras during surveys, resulting in wasted survey effort and lost data, are not related to faulty equipment and are either entirely preventable or can be minimised. Some major factors resulting in the loss of data during remote camera surveys and preventative measures that can be taken to minimise them are outlined below.

7.1.1 Operator error

A major factor responsible for the incorrect functioning of remote cameras during surveys resulting in the loss of data is operator error. The camera sensor has defined narrow detection zones. When focusing on a particular area, such as a bait station, the cameras require careful aiming to ensure that animals investigating the lure are within the zone of detection. Setting the remote camera and sensor at the wrong height above the ground can easily result in missed photographs, particularly when targeting small mammals which can pass beneath the detection zone.

Incorrect programming or accidental changing of camera settings during setup and field testing can also cause malfunctions. To avoid loss of data due to operator error it is extremely important to carefully read the instructions provided and to practice using the units before beginning field work. Northern Territory Flora and Fauna Division staff have found testing of cameras behind the office on local wildlife to be a useful means of gaining familiarity with the operation of remote camera units.

If possible, prepare cameras for field deployment prior to going into the field; install the batteries and SD cards, and program the camera and sensor settings. Pay particular attention to setting the date and time, as the accuracy of this information is crucial when analysing the data. Make a checklist of the camera and sensor settings required and take this and the user manual into the field for reference.

Remote cameras usually have a test mode that allows adjustments to be made without taking any photographs. However, these modes are not reliable during hot conditions typical of set up times in northern Australia. A more accurate and reliable method is to take a few test photos and examine these with a small digital camera that uses the same type of SD card as the remote camera. Use this approach during setup to ensure the remote camera is aimed at the target area and that it is set at the correct height for the target species (see Section 10 Standard operating procedures). Once testing is complete and the camera has been switched on, check that the unit's housing is properly closed to prevent moisture entering the housing and damaging the electronics. In areas of high humidity, packets of desiccant (silica gel) placed inside the camera housing can help protect electronics from moisture.

7.1.2 Battery failure

Battery failure is another major cause of lost data during remote camera surveys, as units may stop taking photographs before the end of the survey period. Because camera settings, animal activity, and temperature vary, there is no way to precisely predict battery life or the total number of images that can be taken on a single set of batteries. Camera manufacturers generally provide estimates; however, these must be considered as a guide only. A large number of photographs taken using the flash can quickly drain camera batteries which may be a problem for surveys in areas where there are high levels of animal activity at night. Use of the best quality batteries available is advised, as although they are more expensive they will last longer than cheaper batteries, and the cost of lost data and wasted effort is generally much greater than the savings made using cheap, inferior batteries.

Alkaline batteries are more sensitive to cold than nickel metal hydride (NiMH) or lithium batteries. However, check manufacturer specifications, as not all camera models support all battery types. Ensuring that rechargeable batteries (if used) are fully charged before installation, or that alkaline batteries are replaced with every use, will help ensure cameras continue to function for the duration of a survey. As a general guide (Table 3), NiMH rechargeable batteries should be suitable for camera deployments up to approximately five weeks. However, for longer deployments it is recommended to use lithium batteries. Always use the same kind of batteries in a camera; mixing battery types can damage cameras.

When setting remote Reconyx cameras, the battery charge is indicated in the remote camera as percentage and may read low if the camera is set on the wrong battery type, or if some batteries are not securely set in the camera. If a battery is loose then the unit will still receive charge but it will be low and may run out during the deployment, resulting in loss of data. Check the battery charge readout when setting the remote camera.

Table 3: Comparison of battery types for use in motion sensing fauna cameras.

Battery type	Lithium	NiMH	Alkaline
Pro's	Long battery life in cameras. As high output devices, cameras optimised for use of lithium batteries.	Rechargeable, should get many charges out of batteries. Lower cost and waste in the long term.	Lower purchase cost than Li or NiMH.
Con's	Expensive. Single use means high waste and high overall cost.	High initial cost. Moderate battery life per charge.	Despite higher amp hour rating, battery life in cameras is low. Single use means high waste and high overall cost.

7.1.3 Theft and vandalism

Theft of remote cameras is a possibility that must be considered, particularly in areas of high human visitation or where cameras are set close to roads and tracks. Units with infrared flash are less conspicuous than those with a visible white flash, as a white light flash will quickly betray a camera's location in low light conditions. However, theft can be minimised by setting units away from roads or tracks to reduce the likelihood of discovery.

Securing camera units to trees using a cable and lock will limit the likelihood of theft (Fig. 9). When multiple cameras are deployed it is advisable to use combination locks, or have locks keyed-alike, to avoid having to carry multiple keys into the field. Note that when using bike locks, coil excess cable length up off the ground. This will reduce damage from fire and subsequent difficulty removing the lock and remote camera.

In many cases, people who discover cameras may not disturb them, but will be curious about why they are there. Attaching a small sign to the side of each camera with a brief description of the project and some contact information is likely to satisfy curiosity and may help to limit vandalism or other interference.

Figure 9: Camera secured to a tree with a bike cable lock.

In some instances animals interfere with cameras. Inquisitive crushing from large animals such as buffalo, gnawing of camera casings by rats, and opening and removal of batteries and SD cards by Common Brushtail Possums, have been documented. Larger animals such as cattle, buffalo and dingoes may move the camera position on the tree and in some cases knock the camera from the tree. These problems may be minimised by securing the camera tightly on the tree, securing the door with a cable tie, or placing the camera inside a metal case. Reconyx manufacture sturdy metal cases for their cameras for additional protection if needed.

Bait stations can also be interfered with if not secured or designed properly. Crows and some rat species are notorious for breaking into or damaging bait stations; Dingoes will readily remove bait stations that are not adequately secured (Fig. 10). Saltwater Crocodiles have also been documented removing a bait station (Fig. 11).

Figure 10: A dingo taking a bait station.

Figure 11: A Saltwater Crocodile (*Crocodylus porosus*) taking a bait station during a wildlife survey in Arnhem Land (Djelk rangers, Djelk Indigenous Protected Area).

7.1.4 False triggers

Cameras may be triggered to take photos without animals in them for a variety of reasons. In some cases, false triggers can fill up memory cards and cause batteries to fail, resulting in loss of survey data. Minimising false triggers is also important to reduce photo processing time. Excessive false triggering during the day can result from heated vegetation, passing shadows, warm gusts of wind or from radiating ground heat. A remote camera attached to a small tree that moves in the wind is also an all too common cause of false triggers. Setting the camera on a firm support, such as a tree greater than 20 cm diameter, in a shaded aspect (South in dry season, North during the wet season), and removing or trimming vegetation in front of the camera will reduce false triggers (Fig. 12). Take care to remove the roots of perennial grasses and plants that will experience rapid seasonal growth causing false triggers.

As the passive infrared sensors detect the difference between the background temperature and a moving animal's body temperature, they are able to detect animals over a much greater distance in colder temperatures. However, in conditions when detection zones are large (e.g. PIR sensors may detect moving animals 20-30 m out from the camera unit), animals may be detected either beyond the range of the flash at night, beyond the camera's field of view, or may be obscured by background vegetation, resulting in false triggers. Many remote camera units have sensitivity settings that can be modified. Decreasing the sensitivity of the PIR sensor can reduce false triggers resulting from animals being detected outside the range of the flash at night as well as the incidences of false triggers during the day; however, reducing the sensitivity too much may result in animals not being detected. An alternative method is to set the camera on a downward angle to reduce the field distance of view without adjusting the sensitivity settings (see Section 10 Standard operating procedures). This approach also helps to reduce false triggers from heated vegetation.

When targeting species that are nocturnal, many remote cameras have activation settings that allow the operator to program the unit to function only at night, thereby removing the problem of false triggers during the day.

Figure 12: False triggers caused by a single blade of grass moving in the sensor view.

8 Setting remote cameras in the field

Remote cameras have a range of settings that can be used to alter how the unit operates that may either increase or decrease the likelihood of photographing a particular target species. Prior to commencing a survey the most appropriate settings should be determined and, for consistency, all camera units used in a given study should have the same settings. This is particularly important in studies involving between-site and/or treatment comparisons (e.g. monitoring, impact assessment). However, in circumstances where different settings, or even different camera models are used in a single study, these differences can be accounted for in the analysis (i.e. occupancy modelling). Despite this, a consistent approach to setting all cameras in a study is recommended. Camera model and settings should be recorded onto datasheets and computer spreadsheets as part of the metadata for each project to ensure this information is available during subsequent analyses.

Figure 13: Djelk Ranger Darryl Redford inspecting camera settings and batteries prior to deployment.

8.1 Camera settings

Three settings are common to many remote cameras that can be used to ensure animals are photographed, and false triggers minimised. These settings are: motion sensor sensitivity, activation time and camera delay. For units with limited battery capacity, adjusting these settings can help ensure that cameras remain operational for the duration of a deployment.

Adjusting the sensitivity of the PIR sensor will change the sensor responsiveness by changing the heat sensitivity threshold, therefore being more responsive to the heat differential between an animal's body temperature and the background environment required to trigger the camera. Because this heat difference is larger in cold temperatures, PIR sensors are more sensitive in temperate environments or during cooler seasons. High sensitivity is typically better to detect small-sized mammals.

Reducing the sensitivity may also help avoid the problem of false triggers during the day due to heated vegetation, passing shadows or heated ground. However, by reducing the sensitivity there is a risk that some animals may not trigger the camera, especially in warm environments experienced in many parts of northern Australia where there is less difference between an animal's body temperate and that of its surroundings. For cameras with SD cards that have the capacity to retain large numbers of images on a single set of batteries, large numbers of false triggers are less problematic and the maximum sensitivity setting is recommended to avoid missing animals.

Activation time settings allow cameras to be set to operate continuously, only at night, or only during the day. Some cameras can also be programmed to operate between particular times (e.g. 0500-0800 hours). When targeting species that are strictly nocturnal, setting the camera for night operation only will eliminate many false trigger events during the day and reduce the number of images of non-target species. Reliable knowledge of the activity patterns of the target species and testing of cameras to determine the level of light required will aid in determining whether this is an appropriate setting for nocturnal animals that may also be active at dawn and dusk.

Trigger speed: the speed with which the camera takes a photo relative to when the sensor detects the animal can be varied in some cameras. This function is useful for optimising detection of different species that may move through the picture frame at different speeds.

Photo delay option: many remote camera units include a feature that allows for a pause (e.g. 15, 30 seconds, 1 minute, 5 minutes) between successive triggers. This will reduce the number of photographs taken of the same animal (e.g. if animals linger for long periods at bait stations), and may be useful in areas where there are very high levels of animal activity, especially of non-target species (e.g. where macropods are common). The appropriate length of the delay will depend largely on the target species; a minimal delay will maximise the chances of obtaining multiple photographs of rare or cryptic species, while a longer delay would be appropriate when targeting slower moving animals that may travel in groups, such as macropods or feral herbivores.

Multiple trigger options in some cameras, such as Reconyx, allow programming of cameras to take several photographs in quick succession each time the camera is triggered. This capability increases the likelihood of multiple photos of the same animal, aiding in accurate identification.

Time lapse settings allow programming the camera to take photos at predetermined time intervals, without being triggered. This function may be useful for recording the presence of species that do not readily trigger infra-red sensors, such as frogs, or for monitoring environmental conditions, such as sunshine.

Video: some cameras can also be set to capture video when they are triggered, which may be useful in behavioural studies, or individual identification in mark-recapture studies.

8.2 Site preparation and site requirements

For many applications remote cameras are placed in the field at predetermined locations, using a GPS or PDA for navigation. However, when choosing the exact site for the camera, careful attention to where the unit is located and to site preparation can significantly reduce the incidences of false triggers and facilitate species identification. On approaching the site, keep a look out for a suitable place to set the camera. The ideal location is a flat or gently sloping area that is relatively clear of shrubs, ground vegetation, rocks and logs (Fig. 14), but is shaded by trees or rock over-hangs. If deploying cameras in a rocky or densely-vegetated habitat, think carefully how animals might access the site; if access is limited then this will influence the likelihood of detecting animals.

Select a solid tree that will not move in the wind (diameter greater than 20 cm; Fig.15), with a relatively straight trunk and with a clear area to the south, for attaching the camera. A wooden stake hammered into the ground or a purpose-built camera post can be used in areas where there are no suitable trees. It is recommended that the camera is set facing a southerly direction as this will minimise false triggers from sun glare and reflection, especially in the dry season.

Clear all vegetation (ground vegetation, shrubs, tree branches, leaf litter etc.) between the camera and the bait station, 2 m either side of the bait station and 1 m behind the bait station, to ensure an uninterrupted view of animals inspecting the bait from behind (Figs. 14 and 15). Also clear the vegetation around the base of the tree to which the camera is attached to minimise the risk of fire damage to cameras. Use a shovel to level large grasses, or if deployment will overlap with periods of rapid vegetation growth (September – May) then make sure that perennial grass and shrub roots are also removed, as these will grow and cause false triggers. Use secateurs to remove branches on the camera tree or surrounding vegetation that may move into the field of view in windy conditions.

In northern Australia vegetation regrowth can be prolific. For prolonged deployments it may be prudent for operators to return to the camera sites periodically and undertake site maintenance, particularly if the site has been recently burnt.

Figure 14: The image on the left shows a poorly prepared camera station; vegetation has not been cleared, the bait station is not centred and the base of the station is not in frame. The image on the right shows a well prepared set up.

Figure 15: Djelk Rangers demonstrating how to set up a camera at a workshop in Darwin in November 2014.

As far as possible remove rocks and logs that on heating up during the day could cause false triggers or obscure the view of animals.

Save the camera's exact location as a GPS waypoint and record the coordinates onto a site datasheet for future reference, and for purposes of relocating the camera at the end of the survey period.

8.3 Targeting different species

Remote cameras can be set up in ways that maximise detection for particular species of interest, or to optimise detection of as wide a range of species as possible.

In most remote cameras, the detection zone of the PIR sensor is a wedge-shaped area of sensitivity spreading outwards in front of the sensor. As a result the detection zone increases in size with increasing distance from the sensor (Fig. 16). Setting remote cameras so that the sensor is at different heights above the ground and at different distances from the target area (e.g. a bait station) allows different sized animal species to be targeted. Adjusting the sensitivity of the PIR sensor also helps target different sized animals and can reduce the incidences of false triggers. However in hot environments, reducing the sensitivity may result in too low temperature differentials between animals and the background environment.

NOTE: Detection zones differ between 1080 pixel images (below) and 3.1 megapixel images (right)

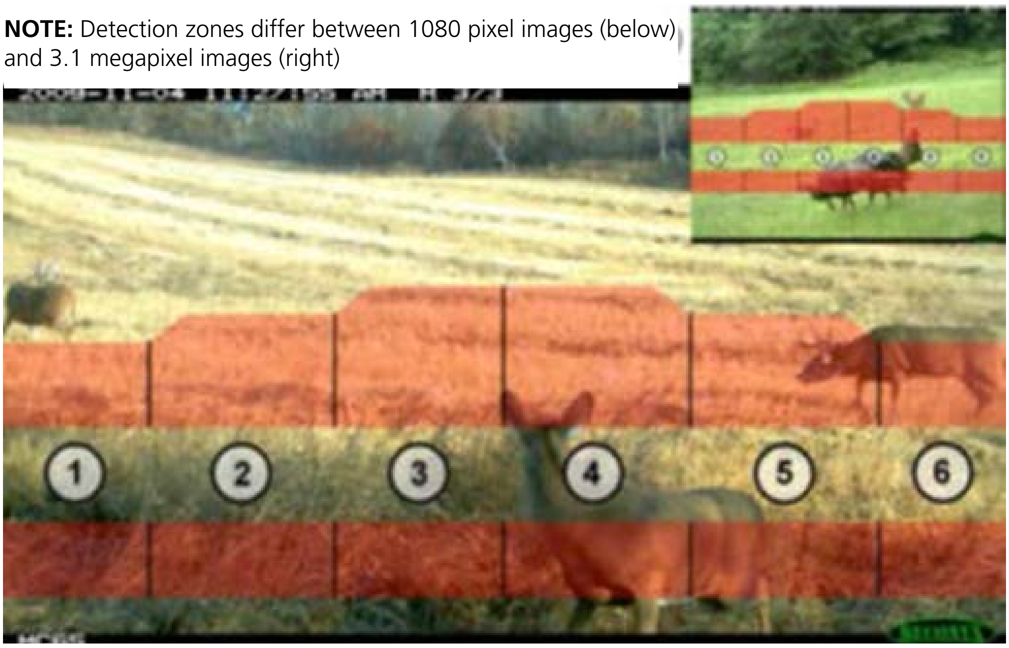


Figure 16: Positions of the sensors field of view superimposed within the photo image frame for Reconyx Hyperfire cameras. An object must move between two sensor sections in order to trigger the camera (Image provided by Reconyx).

Setting remote cameras close to the ground (i.e. 15-20 cm), or angled so that the camera points down to the ground, will record the greatest size range of mammals, as sensors will be triggered by both smaller animals and the legs of larger animals (Fig. 17). The camera's field of view is generally wider than the sensor's detection zone, so although only the legs of an animal may trigger the sensor the photograph will contain more of the animal. Detection zone area varies widely among camera models (see Meek *et al.* 2012). Cameras with a narrow detection zone (i.e. smaller than the camera field of view) have usually fast trigger speeds and will take the photo when the animal is well within the field of view.

- When targeting large animals, such as kangaroos, set the unit so that the sensor is at the height of the animal's shoulder (e.g. approximately 1 m above the ground). This will reduce the number of photographs of smaller non-target species, as these animals will be underneath the zone of detection.
- For medium-sized mammals (e.g. quolls, bandicoots, possums and cats), set the sensor so that it is approximately 50 cm above the ground.
- Some studies have found that when targeting small mammals (*Antechinus* spp., small rodents), a sensor height of approximately 20 cm above the ground increases detection of these species.

Depending on the background temperature and the sensitivity of the remote camera's PIR sensor (sensitivity varies between models), large mammals, such as kangaroos, may be detected when they are 20-30 m from the camera. However, for night photography, the range of the unit's flash will limit the distance over which an animal can be identified. In addition, background vegetation may obscure even large animals that may only be a few metres from the camera.

Reducing the sensitivity of the PIR will limit animals triggering the camera that are outside of the flash range, thus helping ensure that animals photographed are adequately lit for identification at night. However, reducing the PIR sensitivity may also reduce detection of small species. Furthermore, lower sensitivities are not recommended for warmer climates due to the reduced temperature differential between subject animals and the background environment. This problem can also be resolved by angling the camera down from its point of attachment, to face the bait station or target detection area. In this way, maximum PIR sensitivity can be maintained without distant animals triggering the camera.

In Reconyx cameras the flash range is adjustable, via the shutter speed setting. A slow shutter increases the flash range but also increases the potential for a blurry image. A fast shutter reduces flash range but results in a cleaner image. For smaller and faster moving animals, a faster shutter is recommended.

- For large mammals, a maximum distance of 5 m between the camera and the target area (e.g. a trail along which an animal may be walking) should allow adequate illumination and reduce the likelihood of animals being obscured by vegetation.
- For medium-sized mammals, 3 m between the camera and the target area (in most cases this will be the bait station) will ensure the animal is in the foreground of the photograph and is clearly illuminated by the flash.
- When targeting small mammals set the remote camera close to the target area (e.g., 1.5 m between the camera and bait station, Fig. 17). Although small mammals are detected by remote cameras targeting medium-sized mammals, setting the camera close to the target area will capture the fine detail required for identifying certain small mammal species.

Irrespective of the type of cameras and setup used, some species may be very difficult to differentiate and identify confidently from camera photos. In many cases most species identification problems arise with species having very similar size and photographed at less than ideal angles for capturing other diagnostic features. Multiple photos of the same individual will greatly assist with identification. Incorporation of measurement reference points may also aid in identification of species that look similar but vary in size. The dimensions of bait stations may provide useful reference points, and graduation marks can be placed on bait station posts. More reliable estimation of the size of animals in front or behind the plane of the bait station can be achieved in the following way: Draw up a 50 mm grid on a large sheet of paper (say 2 x 2 m); hammer a bait station into the centre of this and take reference shots with cameras set up at the standard height and the standard distances used in deployment. This procedure can be undertaken in the laboratory or office. Assuming that cameras are set up consistently, subsequent comparisons of field pictures with the appropriate reference photo may enable more accurate size estimates of animals that are 'side-on' in the image, without having to go through the set up process repeatedly in each camera deployment.

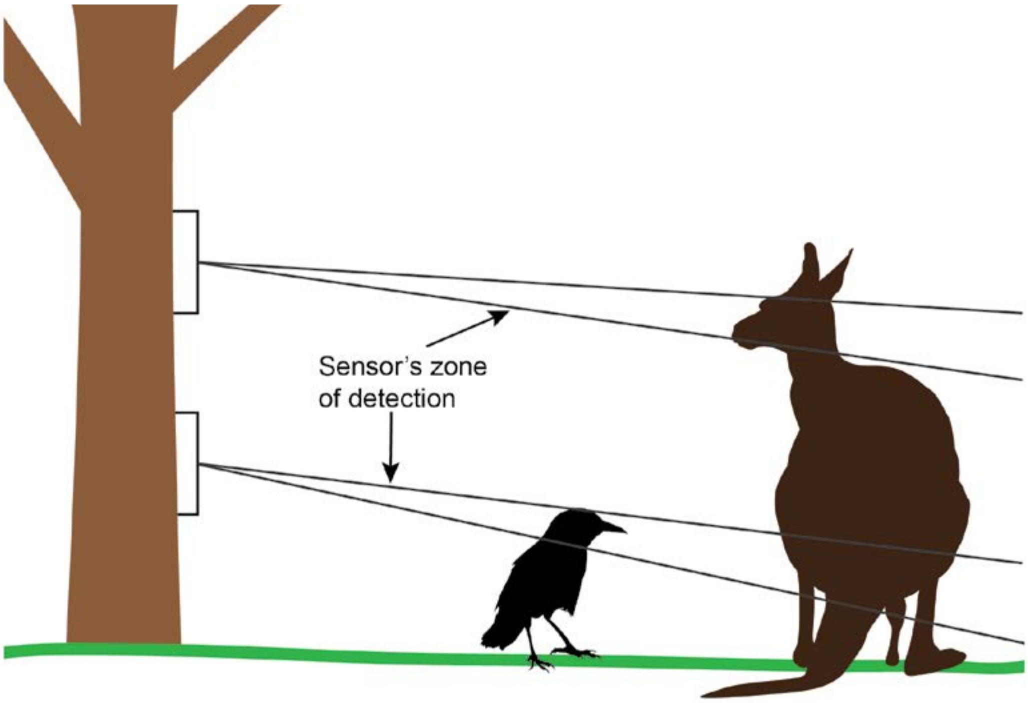


Figure 17: Setting the remote camera sensor height to target different sized mammals. (Modified from Swann *et al.* 2004.)

8.4 Targeting a wide range of species

Setting remote cameras to optimise detection of a wide range of species will require a balanced/trading off of factors; there is no one size fits all. One approach is to maximise the sensor sensitivity and the picture frame; set the camera up so that it is angled down towards a lure or bait station such that the field of view covers an area of ground from the foreground of the bait within 1.5 m of the camera - to several metres beyond the bait station. For single camera deployments, the bait station to camera distance should be 2.5 m. However, by deploying multiple cameras at a site, variable setups can also be incorporated, such as varying the bait station distance from 1.5 – 2.5 m.

The NT Flora and Fauna Division currently deploys five cameras at a site with two units at 1.5 m and three at 2.5 m from bait stations. The high number of cameras per site has been determined as necessary to detect rare and cryptic species. This arrangement also allows different deployment combinations within a site. Furthermore, it compensates for situations where one camera fails to operate properly (See Section 10 Standard operating procedures).

Before commencing a field survey it is important to practice using remote cameras. Establishing the limits of the sensor's detection zone, determining the range of the flash and experimenting with different sensitivity settings are all worthwhile. Be mindful of the effect of temperature on the sensitivity of PIR sensors and test cameras in similar conditions to field conditions. Determine the camera delay and activation time that will best suit your survey objectives and target species. Overall, familiarising yourself with the remote cameras before starting field work will save time, reduce the likelihood of losing data due to incorrect setup, and ensure data is collected consistently and reliably.

8.5 Targeting different features

Remote cameras can be set to target particular features, such as den sites (e.g. tree hollows, nest boxes, ground burrows), watering points, or animal trails. How the camera is set will vary depending on the target feature. Set the camera close to the target area and carefully aim the sensor at the correct height to ensure narrow target areas (e.g. burrow entrances, nest boxes) are in the centre of the PIR detection zone. Cameras can be placed several metres off the ground either on a tree opposite, or a purpose-built pole, to target nest boxes or tree hollows. Using remote cameras with very fast trigger times will markedly increase the likelihood of obtaining photographs of animals as they leave den sites. For cameras with wide detection zones, tape placed across part of the PIR sensor can be used to narrow the detection window. In contrast, cameras with wide detection zones are well suited when target areas are wide (e.g. a waterhole). Set the camera back as far as possible (depending on the range of the flash) to increase the size of the detection zone and the area within the camera's field of view.

When targeting animals moving along animal trails or vehicle tracks, cameras are usually set at a slight angle to the track to increase the likelihood of obtaining multiple photographs of animals as they move past the camera. Remote cameras with fast trigger times will reduce the chances of missing moving animals. For large animals, set the camera back from the track (e.g. 2 m from the centre) to help ensure full photographs are obtained of the target species.

8.6 Baits

Remote camera surveys often use baits to lure animals to the camera station, thereby maximising the likelihood of detection. This is particularly important when targeting wide ranging species that occur at low densities and that do not use predictable travel routes or habitats where cameras can be set. Without the attractive effects of bait, the likelihood that such species will happen to pass by the remote camera and be detected may be very low.

The choice of bait depends on the food preferences of the species being targeted. When targeting carnivores meat baits have generally been used elsewhere in Australia, such as chunks of raw chicken, rabbit or fish (e.g. pilchards, tuna log, perforated tins of cat food) and fish oil. However, meat and fish putrefy very quickly in northern Australia, which may in fact act as a deterrent to some species. Trials by the NT Flora and Fauna Division have found no evidence that feral cats are more attracted by specific bait types in the Top End. However further research and development is required on this issue.

Standard mammal trapping bait of peanut butter, rolled oats and honey has been successfully used in surveys targeting a wide variety of small and medium-sized native mammals, such as quolls, bandicoots, possums and rodents. Lucerne hay has been used as bait in surveys targeting Brush-tailed Rock Wallabies in south-eastern Australia (Nelson and Scroggie 2009).

Placing baits inside containers (e.g. small cages, tea infusers, perforated PVC pipes) suspended above the ground will protect baits from removal by target and non-target species, and ensure that the attractiveness of the bait persists for as long as possible. In the Top End, crows, rodents, dingoes and ants can interfere severely with baits. Baits can also be wrapped in layers of chicken wire (meat baits) or hung in hay nets (lucerne hay). Attaching the bait container to a pole (e.g. star picket, fence post, wooden garden stake, recycled plastic pole), rather than attaching it to a tree, provides greater flexibility in positioning of the bait in relation to the camera. Finding a suitable tree for the camera that is the right distance and direction from a second tree on which to hang the bait cage can be difficult and time consuming.

The NT Flora and Fauna Division has devised a bait container that is suitable for most baits and deployments and can be quickly constructed from readily available materials. The bait holder is constructed using a short (80 mm) length of 50 mm PVC pipe with a wire-mesh ventilated end cap, an overhanging cover on the top and slit-ventilated bottom cap (Fig. 18). The plumbing descriptions for the end caps are 'vent water/insect proof PVC 50 mm' for the top and 'vent insect proof PVC 50 mm' for the bottom. The holder is secured to a post (e.g. star picket or fence dropper) 30 cm above the ground.

Figure 18: Bait station device used by the Flora and Fauna Division.

Ant visitation can interfere with the effectiveness of baits. This can be a severe problem in northern Australia where the abundance and diversity of ants is very high. Ants can eat bait and deter some target species, thus reducing detection rates. To reduce this problem, ant granules or Coopex ant repellent can be applied around the base of the bait station.

For some species, instead of using baits, the probability of detection can be increased by targeting areas or features of the landscape that animals predictably use. When targeting dingoes for example, cameras may be placed along vehicle tracks. Setting cameras in areas where there is 'sign' left by the target species (e.g. scats or tracks) may also increase the probability of detection. Care is needed in using such targeted approaches to site selection, to ensure that such targeting does not conflict with the sampling design used to select sites, with flow-on biasing effects on the results of any statistical analysis.

9 Data management

9.1 Image interpretation

Digital photographs are the raw data of remote camera surveys. Photographs are saved as JPEG digital image files, which also encode metadata associated with each image. All remote cameras store the date and time that photographs were taken as part of this metadata. Other image metadata stored within image files varies between units but may include information about the camera model and settings, exposure, aperture and ISO settings, flash settings, trigger and sequence information, moon phase and ambient temperature.

Once the images have been downloaded from the remote camera to a computer, they can be viewed using standard image viewing software. Each image should be carefully scanned for the presence of animals. Not all photographs will contain animals. The animal detected by the sensor may have moved out of the camera's field of view before the picture was taken. Photographs without animals could also be the result of a 'false trigger' event caused by moving heated vegetation or passing shadows. To facilitate interpretation, images can be enlarged to focus on the animal and the contrast and brightness altered. Field guides can be invaluable in helping to distinguish similar species. Consulting species experts, and other wildlife researchers who have used remote cameras to target particular species will also facilitate accurate species identification. If doubt remains as to the identification of species it is better to conclude that the species was not detected, rather than to risk erroneously concluding that it was. Avoidance of 'false positives' (i.e. mistakenly concluding that a species was detected when it wasn't) is particularly important when the data are to be used for occupancy modelling. Estimates of rates of occupancy will be severely biased by the occurrence of false-positive records (MacKenzie *et al.* 2005).

9.2 Data management

Remote cameras are capable of collecting large volumes of image data, particularly when arrays of cameras are deployed for several weeks at a time. Keeping track of which images came from which camera and from which site can easily become confusing. Careful management and storage of data will minimise confusion, and facilitate interpretation and analysis of accumulated data.

Prior to deployment, ensure that all remote cameras have the same settings. When setting up cameras at each site, record the project name, site code, camera code, and date onto a data sheet. Other important information to record onto site data sheets at each camera station includes: the GPS coordinates, and type of bait used. Remote camera settings such as the time delay between photographs (e.g. 30 seconds, 1 minute, 5 minutes), activation period (e.g. 24 hour operation, or day/night only) and sensitivity setting should also be recorded. An example of a remote camera site data sheet is provided in Appendix 1. It is important that downloaded images can be linked to the survey, camera and site they originate from. A sign (a small whiteboard or blackboard is convenient) specifying the site code, date and camera code can be placed into the camera's field of view during field setup so that it is photographed. Storage of this image with the other images subsequently accumulated during the survey will help keeping key meta-data with the images for later reference, providing a useful backup to paper data sheets.

When recovering cameras after deployment, record the date the camera was retrieved, and whether the camera was functioning on retrieval (i.e. a 'pickup' photo was taken). Good record keeping will help ensure that remote camera survey data are collected consistently and enable valid comparisons between locations and/or survey occasions. Reconyx cameras allow a label to be programmed that is visible on all images taken. We recommend that the site name is programmed as the label, thus ensuring that every photo has the site name visible with time and date.

When images from remote cameras are downloaded to a computer for storage, it is important that the images from each camera are kept in separate folders labeled with a unique site code. For each new project create a folder on the computer drive where the images are to be downloaded with an identifying label. Create additional sub-folders for each site labeled with the site code. At sites where two or more cameras are deployed, separate folders for each camera, labeled so that the images from each distinct camera can be easily distinguished (e.g. SITE12A, SITE12B) should be created. Make sure the images from each camera are downloaded into the correct folders. Crosschecking the test shot image of the sign containing the site and camera information taken at the beginning of the survey is a worthwhile error-correcting procedure. Images should not be deleted from digital memory cards until it has been checked that they have been downloaded successfully into the correct project, site and camera folders and a backup created.

Regular backups of accumulated data are essential, and will avoid unnecessary and costly losses of valuable data. Large numbers of digital images can take up a substantial amount of disk space on computer hard drives. For large projects consideration of computer storage space is required. Careful consideration of what photos are kept long term for future reference, and deletion of unnecessary photos (e.g. false triggers) will help reduce unnecessarily large storage requirements.

Image management software is provided with some remote camera units, or is readily available elsewhere, for organising and managing digital photographs (e.g. Reconyx Mapview Professional). Photo database software allows images to be marked with multiple tags, such as the site codes and species names. Searches for these tags can then be used to query accumulated data to locate images associated with particular species, locations or projects. Each image containing an animal should be recorded onto a spreadsheet together with the site code, which camera (if multiple cameras deployed), date and time it was taken, and the species recorded. Summary information, such as the species detected at each site and from the overall study area, can then be easily extracted.

In most cases analysis of the data collected during remote camera surveys will require specialist advice and assistance from a biometrician, which must be included in the project costs. When preparing data for statistical analysis (i.e. occupancy modelling) spreadsheets with a separate column for each day of the survey (i.e. a site that was surveyed from the 23 June to 14 July will have 22 columns), and a separate row for each camera are required. For each target species enter '1' in the columns for dates when the species was detected and '0' into columns for dates when not detected (see Appendix 2 - Data analysis spreadsheet). If one of the cameras at a site failed after 5 days of a 14 day deployment, place a dot in the columns for days 6-14 to indicate no data were collected. Use a separate row for each site and for each camera; surveys consisting of 40 sites each with two cameras will have 80 rows of data for each target species. For sites and/or cameras where there were no detections of the target species, enter a full row of zeros. Storage of detection data in this format will greatly facilitate subsequent occupancy analysis using programs MARK or PRESENCE, which require similar, but slightly different data formats which can easily be derived from spreadsheets constructed in this manner. Consulting with a data analyst or biometrician prior to entering data into spreadsheets is highly recommended, as the spreadsheet can then be constructed to closely match any special requirements of the data analysis procedures, saving time and effort during analysis.

9.3 Inferring rates of occupancy using remote camera data

The proportion of an area of interest that is occupied by a species can be a highly useful statistic for land and wildlife managers, and can be readily inferred from properly collected remote camera survey data. In remote camera surveys, there will be instances when the species of interest is not detected (i.e. not photographed) at some of the surveyed sites even though the species is in fact there. For this reason, interpreting the proportion of sites where a species was detected by remote cameras as a measure of the rate of occupancy will mostly lead to under-estimation of the proportion of sites that are actually occupied.

For remote camera data, each day of a camera's deployment at a survey site can be treated as a distinct survey, during which the target species was, or was not, detected. The resulting sequence of detections and non-detections at each site is referred to as a 'detection history'. The set of detection histories collected during a remote camera survey can be analysed using a statistical modelling framework developed by MacKenzie *et al.* (2002, 2005) to infer the probability of detection associated with each survey. The likelihood that the target species will be detected by remote camera at occupied sites. The probability of detecting the target species is then incorporated into the final occupancy estimate to account for sites where the target species may have been present but was not detected during the survey. These analyses, and more sophisticated extensions thereof, can be readily carried out using the freely-available software packages MARK (White and Burnham 1999), or PRESENCE (MacKenzie *et al.* 2005).

MacKenzie *et al.* (2003) provides an important and potentially very useful extension of the basic single-season occupancy model which allows for season-to-season changes in the occupancy status of sites. This model termed a 'dynamic occupancy model' extends the basic occupancy model to allow for local extinction and colonisation processes which lead to changes in the prevailing rate of occupancy over time. Where a set of survey sites are monitored using remote cameras over the course of multiple years, the dynamic occupancy model can be used to determine how occupancy rates change over time. This is particularly useful for monitoring studies, where knowledge of changes in the status of a species within a defined area is required, or for assessing the effects of management actions over time (e.g. the effect of control of an introduced predator on rates of site occupancy by both introduced predators and their prey).

Some research and management questions for animals that can be addressed using data collected by remote cameras and analysed using occupancy estimation include:

- Distribution – where species occur in the landscape (e.g. within a park, geographic region)
- Habitat preferences – which habitats are occupied by a species (e.g. age-classes of forest, vegetation communities)
- Monitoring and impact assessment – e.g. the response of introduced predators and their prey to predator control programs, assessing changes in small mammal communities after fire, evaluating the success of a reintroduction program
- Surveillance - evaluating changes in patterns of occurrence of species through time.

10 Standard Operating Procedures for Remote Cameras in the Top End of Northern Territory

The following procedures have been developed by the Northern Territory Flora and Fauna Division to provide a standardised methodology for the effective and consistent use and deployment of remote cameras as part of general vertebrate biodiversity surveys in northern Australian tropical savannas. These procedures have been developed based upon extensive trials conducted by the NT Flora and Fauna Division, and project partners, and through consultation with a range of expert practitioners. The procedures are designed to optimise detection of as wide a range of mammal species in northern Australia as possible, including cryptic and elusive mammal species such as feral cats.

Depending upon the specific objectives of a project, these procedures can be used in conjunction with standard biodiversity survey methods or on their own. However, we recommend that for general biodiversity surveys, the consistent application of a combination of sampling techniques will yield the best results for the widest range of species. Correct use of these procedures also means that your data will be consistently collected and therefore directly comparable to that of others, which will greatly increase the interpretative power and value of the data.

It is important to note that these operating procedures do not replace the need to develop and refine alternative methods for other specific wildlife research and management questions, such as targeted surveys for particular species, or monitoring programs to evaluate management outcomes. However, these methods provide a general starting point for pilot studies, from which more specific methods can be devised that meet specific project needs. Irrespectively, the same principles of study design, planning and data analysis outlined in this booklet should be considered, and professional advice sought where needed.

10.1 Cameras

The NT Flora and Fauna Division only uses **Reconyx Hyperfire** cameras and it is recommended that other practitioners use these for data consistency and comparability. For these operating procedures and most other applications, Reconyx HC550 or PC850 models should be used, as these have white flash capability, which significantly improves species identification capability.

10.2 Deployment

The NT Flora and Fauna Division uses a standard 50 x 50 m quadrat for undertaking general fauna surveys (http://www.nretas.nt.gov.au/__data/assets/pdf_file/0018/125361/Terrestrial-Fauna-Surveys_NT-Guide-for-EA.pdf). The camera deployment procedure has been designed to be used in conjunction with these survey methods; however remote cameras can also be used without any live trapping.

When undertaking a standard 50 x 50 m trapping quadrat, five camera traps are placed in and around each of the quadrats. One camera is placed in the centre of the quadrat and four cameras are placed in a diamond configuration surrounding the trapping quadrat (Fig. 19). As a standard, the outer cameras are placed 50 m from the centre camera; this creates a total area of coverage of 0.5 Ha. In order to accommodate situations with more restricted access (e.g. rocky areas) or habitats that are narrow (e.g. riparian zones) the shape of the diamond can be flattened by deploying some cameras closer to the centre camera, to a minimum distance of 30 m (Fig. 19). However it is important to maintain a consistent area of coverage, so in such instances the distance to the outer cameras must be extended. A guide to different shaped deployment areas and camera distance combinations is provided in Table 3. Cameras are always placed at least 30 m apart from each other, including the centre camera. A GPS unit can be used in most instances to measure the distances between camera stations. This approach ensures that the sampling area or 'footprint' is consistent between sampling sites.

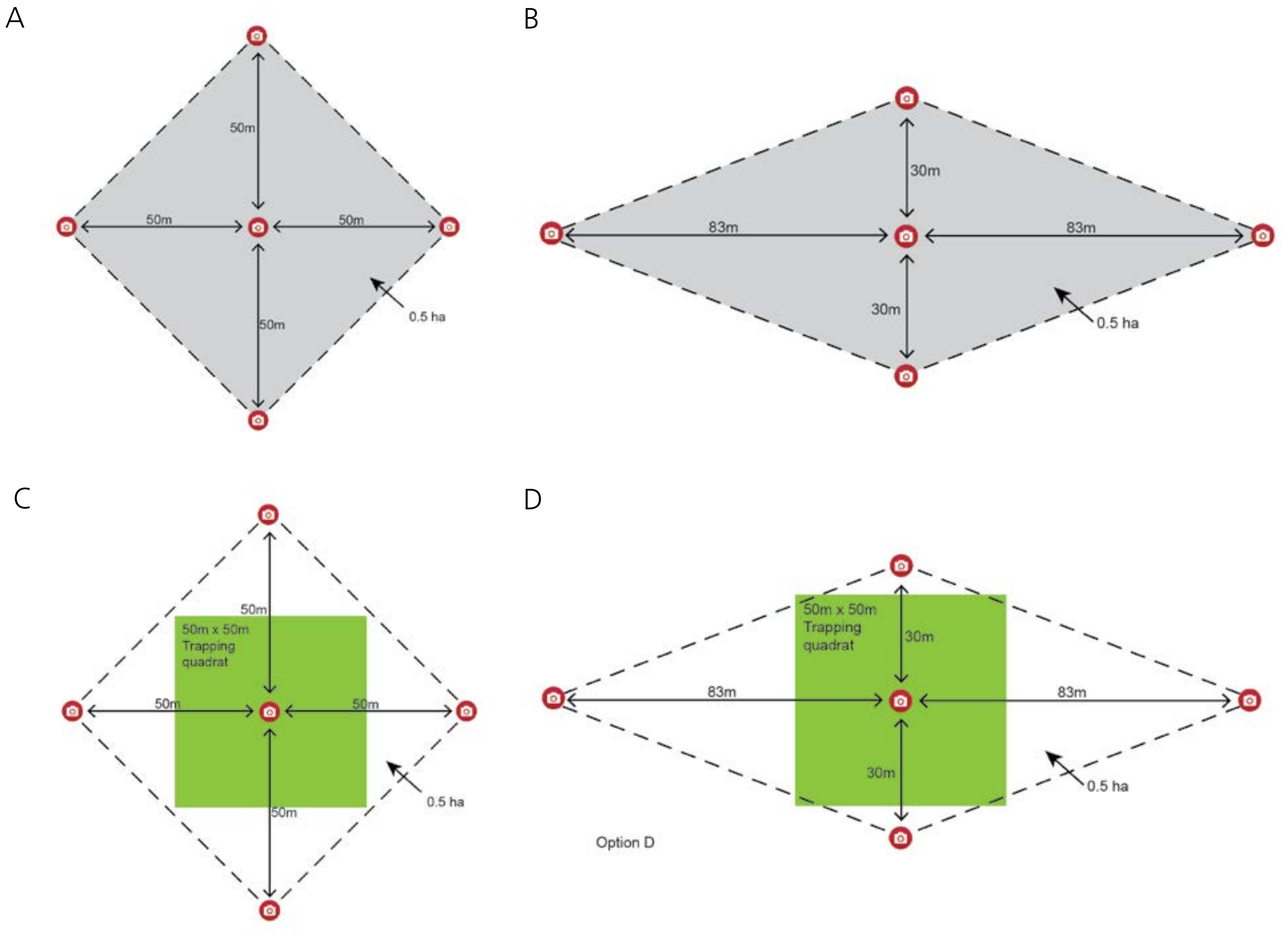


Figure 19: Arrangements of five-camera set up. A) standard placement without other trapping methods; B) narrow deployment without other trapping methods; C) standard placement with standard ground trapping grid; D) narrow deployment with standard ground trapping grid.

Table 4: Dimensions and camera distances of different shaped deployments. As the width of the 'diamond is reduced to a minimum of 60 m, the length increases accordingly. Use this table as a reference guide in the field.

Width (m)	Length (m)
100	100
90	111
80	125
70	143
60	167

Where possible cameras should be placed in a variety of different micro-habitats and situations within the survey area, as different species will use different parts of the landscape. Look for signs of animal paths, or natural openings through the area, such as adjacent to rock ledges or creek beds; also place camera stations in areas with contrasting vegetation structures, such as densely vegetated versus open areas. Avoid deploying cameras in areas where there is a risk of inundation during the deployment period.

Set cameras so that they are facing south to prevent glare and sun damage to the camera lens and sensor. Avoid deploying with east and west-facing orientations to reduce false triggers from the rising and setting of the sun.

Deploy cameras for a minimum of 5 weeks, preferably encompassing the time period that ground trapping is undertaken. Cameras may be deployed 3-4 weeks before ground trapping occurs and collected upon completion, or deployed during ground trapping sessions and recovered several weeks later. If this is not possible, then the camera trapping session should take place within 4 weeks of the ground trapping session.

10.3 Storage and transport of camera traps and bait stations

Cameras, bait stations or lures should be stored in a safe location and transported in sealed containers to prevent:

- accidental damage
- water damage
- dust damage
- theft.

10.4 Site preparation

Equipment

Secateurs

Fire rake or shovel

Leather gloves

Procedure

Careful site clearing is important to minimise false triggers, maximise identification of animals and reduce fire risk to equipment. Using a rake or shovel, clear all vegetation (any low hanging vegetation, grass, sticks, leaves, etc.) between the camera and the bait station, and at least 1 m behind the bait station. Ensure that all vegetation around the camera is also cleared to a minimum of 1 m to mitigate fire damage. Consider the field of view of the sensor and ensure that vegetation is cleared at least 1.5 m to either side of the bait station. Determine what other vegetation outside this area may cause false photos, such as overhanging branches, or plants nearby that may grow into the sensor field during deployment, and remove with secateurs or rake as necessary. If deployment will extend over the period September to May dig out perennial grass and shrub bases of the cleared area. Avoid piling cleared material right next to the camera station area as this may just blow across the field of vision, triggering false images, or impede animal access.

If in doubt regarding vegetation clearing, set the camera and trigger it to take a couple of photos, then remove the SD card and put it into a digital camera to check field of view.

10.5 Installing bait stations

Equipment

Bait

45 cm star picket or fence dropper

Bait container

Cable ties

Tie wire

Tape measure

Hammer

Coopex or ant granules

Procedure

Standard small mammal bait mix (i.e., peanut butter, rolled oats and honey) should be used for general surveys. If alterative baits or lures are used for specific projects or target species, record on the data sheet which type of bait or lure was used at deployment.

Bait containers are an 80 mm length of PVC pipe with a ventilated end cap on each end to allow scent to escape. A ventilated end cap with an overhanging cover on it is recommended to reduce dehydration and water diluting the bait in the wet season (Fig. 18).

Bait containers should be placed approximately 30 cm above the ground on a secure stake that cannot be easily knocked over by animals. Bait stations should be either 1.5 or 2.5 m from the ground point below the camera.

Where ants may be a problem, spray the base of the star picket with Coopex ant repellent.

10.6 Setting the remote camera

i. Install fresh batteries, an empty memory card, and silica desiccant in wet season.

ii. Check that the camera trigger settings are properly programmed. The quickset function provides three pre-programmed trigger configurations in all Reconyx models, as well as an advanced setting where you set any desired configuration. These are:

- ~ Normal (PC850) or Trail (other models) - 3 pictures per trigger, 1 second interval between pictures, zero quiet period between triggers. Recommended for standard operating.
- ~ Aggressive (PC850) or Scrape (other models) – 5 pictures per trigger, takes pictures as fast as memory card can save (rapidfire), zero quiet period between triggers.
- ~ Conservative (PC850) or Feeder (other models) – 3 pictures per trigger, 5 seconds between picturess, 15 seconds quiet period between triggers.
- ~ Advanced – Overrides other settings and allows setting manual combinations.

iii. Check that the image resolution is set to 3.1 megapixels using the 'Advanced' function.

iv. Check that the sensor sensitivity is set to High using the 'Advanced' function.

v. Ensure that the battery type is set to match the batteries being used, using the 'Advanced' function (Lithium for non-rechargeable or NiMH for rechargeable batteries).

vi. Ensure that the label represents the camera code or the site code.

vii. The camera should be set either 1.5 or 2.5 m from the bait station. Any two cameras should be set 1.5 m from bait station, and the other three cameras should be set 2.5 m from bait stations. For consistency, these distances should be determined by tape measure (Fig. 20). Record the distance that each camera is set from its bait station on the datasheet.

viii. The camera should be placed on a tree or mounting post such that the top of the camera casing is 70 cm above the ground.

ix. The camera needs to be attached to a secure support. Avoid trees less than 20 cm in diameter as they move in the wind causing false photos. Avoid dead trees.

x. Ensure that the camera is facing roughly in a southerly direction. This requirement can be relaxed where there is a rock wall or ledge blocking sun interference.

xi. Ensure that the camera is the right way up, with the LED globes on top and the PIR sensor on the bottom.

xii. Angle the camera slightly downward so it captures the base of the bait station in the middle of the frame, to ensure a consistent field of 'detection' as a function of the camera to bait station distance. The base of the bait station should be centre-frame or just below centre frame in order to maximise detections of small species. Use wedges or objects such as short sticks or rocks wedged behind the camera to aide in adjusting and securing the camera position and orientation.

xiii. Ensure that the sensor screen and camera lens are clean. Check that there are no obstacles in front of the sensor, flash unit or camera lens, such as branches, straps or flagging tape.

xiv. Record the location of the camera with a GPS or CyberTracker unit AND write the coordinates (not the waypoint) on the data sheet.

xv. To test if the camera is positioned correctly, arm the camera, move your hand from side to side several times in front and behind the base of the bait station, and to both sides of the bait station. Turn off the camera, remove the SD card and view images in a hand-held digital camera. Re-insert the SD card in the remote camera, delete the images, adjust the camera position and repeat the exercise as necessary (see Fig. 21).

xvi. Record the camera number and SD card number on the data sheet, and the date and time that the camera was set.

xvii. Secure flagging tape above the camera with the site and station number recorded. Ensure flagging tape is long enough to see from a distance but not positioned to trigger the camera.

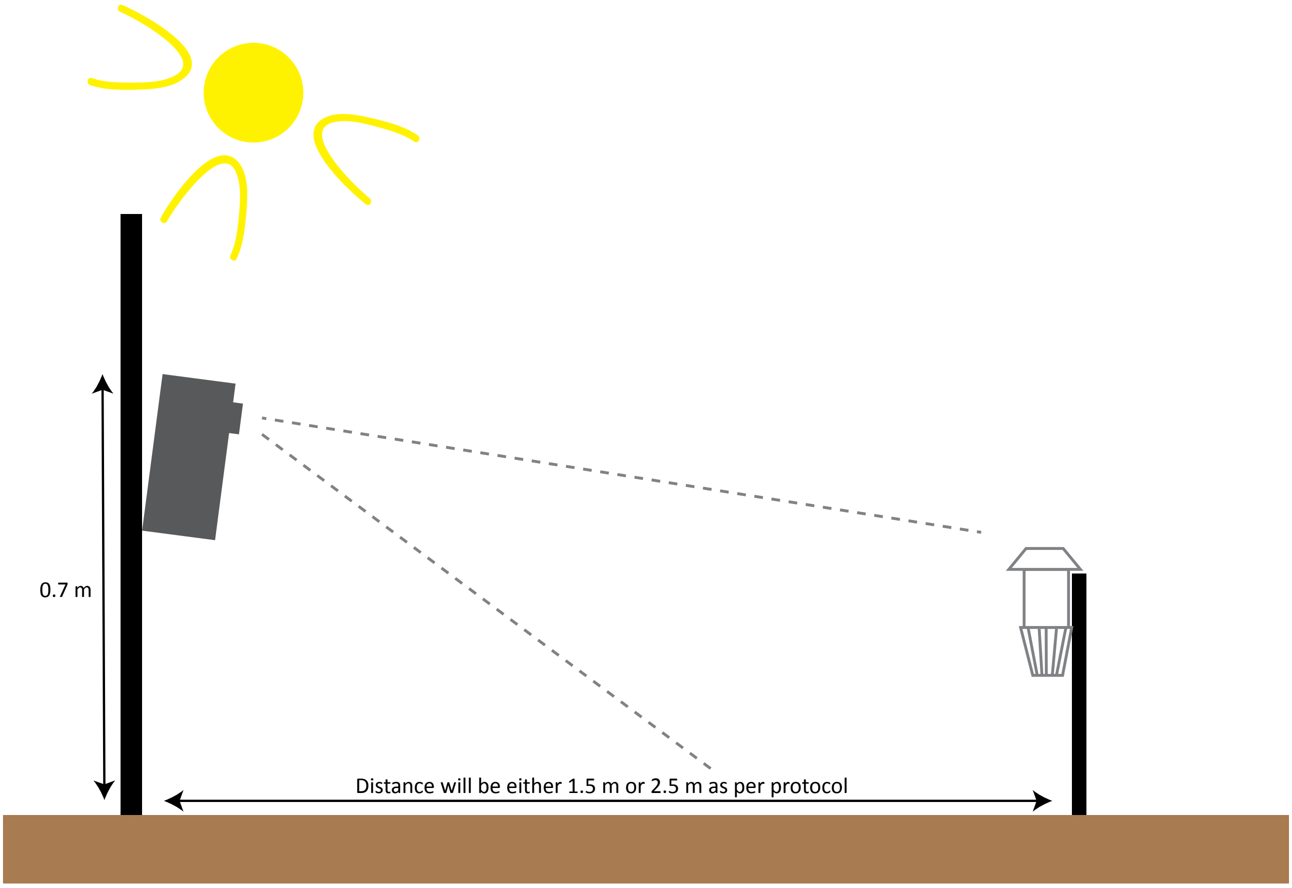


Figure 20: Set-up of a remote camera and bait station.

Figure 21: Examples of a correct and incorrect positioned camera and bait station. In the left image the site is well cleared of vegetation and the base of the bait station is in the centre of the frame, ensuring that any small animals approaching the bait station will be photographed. In the right image the bait station is not centred, resulting in the base of the station being located outside the sensor zone. The large rocks in the field of view will potentially impede detection of animals. However, note the Kimberley Rock Monitor (*Varanus cf. glauerti*) in the bottom-right corner of the right image.

10.7 Remote camera operation for Reconyx Hyperfire Camera

i. Open the remote camera unit.

ii. On the right hand side there is an 'on/off' switch. Flip the switch to the 'on' position. Watch the screen, check that batteries are charged, that battery type is correct, and that the SD card is empty, then wait for 'ARM CAMERA' to be displayed.

iii. If you wish to test the field of view press the '>' button to access the 'WALK TEST' option. Test the field of view by moving either a hand or warm object from both sides of the bait station and behind it watching for the red light on the camera to indicate when you are within the field of view.

iv. Press the '<' button to return to 'ARM CAMERA' or leave on WALKTEST and it will automatically ARM after 2 minutes.

v. Press the 'OK' button.

vi. A countdown timer will start (from 10 seconds).

vii. Before closing the camera check that the rubber seal is clean.

viii. Close the unit ensuring a waterproof seal, and move away from the front of the unit. The camera is ready to take photographs.

ix. In some instances animals may interfere with cameras and even open them. Cable ties can be used to secure the camera control panel doors.

10.8 Recovering the remote camera

i. Approach the camera from the front to trigger a 'capture' sequence. This indicates the end of the sampling period when analysing the camera photos back at the office.

ii. Open the remote camera unit and check the display for the current capture sequence. If the screen is blank move your hand in front of the sensor to trigger a sequence. If the display is still blank, switch the camera off and on again to determine whether the camera is operational, or otherwise the batteries may be flat. It is important to confirm whether or not the camera was operational for the whole survey period. If there is no capture sequence on recovery of the camera it makes it impossible to know whether the camera was operational for the full deployment period. For example if the last image occurs in week 4, this could reflect either no animals at the site post week 4 or a camera malfunction sometime post this time.

iii. Cross check that the camera, SD card and site information match the deployment data sheet.

iv. If the camera is to remain at the site, swap batteries, SD card and bait. Record camera operational status and new SD details card on the data sheet.

v. If the bait station is missing have a look around (up to 20 m from original position) to recover the bait station. Record any site conditions that may have changed from setting the remote camera.

vi. Switch the camera off and remove from the tree. Ensure that the camera, bait station and picket are packed appropriately for transport. Cameras may become damaged if they are left in a vehicle or backpack. In particular the PIR sensor can rub against other field equipment and become damaged.

10.9 Equipment checklist

Camera traps

Mounting posts (where trees may not be available)

Cable ties, tie wire

Digital memory cards (4 or 8GB SDHC cards)

Spare batteries for cameras (12 per Reconyx remote camera)

Hand held digital camera

Bait – peanut butter, oats and honey

Container for mixing bait

Navigation - compass/GPS/PDA

Secateurs

Fire rake – optional, depending on ease of access

Shovel

Leather gloves

Flagging tape

Permanent marker pen

Mounting straps (cable lock straps in high risk areas)

Silica UniSorb sachets

Occy straps

Stake for bait station

Bait receptacle

Hammer for installing bait station stake in hard ground

Ant poison

Tape measure

Field note book and pencils (or pens)

Data sheets and folders.

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Appendix 1 - Example data sheet for camera trapping

Project name:__________

Location	Site no.	Camera no.	SC Card no.	Bait type	Camera-Bait Distance	Lat	Long	Site Description	Date set	Set By	Retrieval date

Appendix 2 - Example of remote camera data spreadsheet

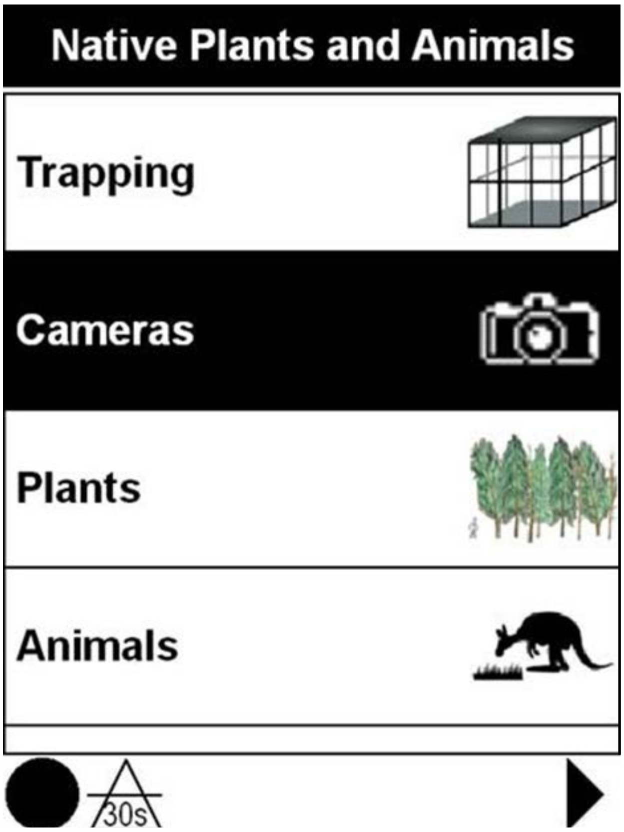
Project name	Site no.	Camera no.	Camera type	Day no.	Date	Total no. photos	Observation time	1st photo no.	Last photo no.	No. of triggers	Antilopine Wallaby	Agile Wallaby	Euro	Bandicoot	Northern Quoll	Black-footed Tree Rat	Delicate Mouse	Pig
NERP	1	RW42	Whitelight	1	13/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	1	RW42	Whitelight	2	14/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	1	RW42	Whitelight	3	15/10/2014	435	0638	36	38	3	0	1	0	0	0	0	0	0
NERP	1	RW42	Whitelight	4	16/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	1	RW42	Whitelight	5	17/10/2014	435	1215	39	40	2	0	0	0	0	1	0	0	0
NERP	1	RW42	Whitelight	6	18/10/2014	435	1131	45	45	2	0	0	0	1	0	0	0	0
NERP	1	RW42	Whitelight	7	19/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	1	RW42	Whitelight	8	20/10/2014	435	0230	49	51	1	0	1	0	0	0	0	0	0
NERP	1	RW42	Whitelight	8	20/10/2014	435	0435	52	75	8	0	2	0	0	0	0	0	0
NERP	1	RW42	Whitelight	9	21/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	1	RW42	Whitelight	10	22/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	1	RW42	Whitelight	11	23/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	2	RW42	Whitelight	12	24/10/2014	435	2217	85	90	2	0	0	0	1	0	0	0	0
NERP	2	RW54	Whitelight	1	13/10/2014	435	0536	94	123	10	0	1	0	0	0	0	0	0
NERP	2	RW54	Whitelight	2	14/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	2	RW54	Whitelight	3	15/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	2	RW54	Whitelight	4	16/10/2014	435	0658	127	135	3	0	1	0	0	0	0	0	0
NERP	2	RW54	Whitelight	5	17/10/2014	435	0811	139	147	3	0	1	0	0	0	0	0	0
NERP	2	RW54	Whitelight	6	18/10/2014	435	2126	148	153	2	0	0	0	0	0	1	0	0
NERP	2	RW54	Whitelight	7	19/10/2014	435	0732	154	168	5	0	1	0	0	0	0	0	0
NERP	2	RW54	Whitelight	8	20/10/2014	435	2109	169	183	5	0	0	0	0	0	0	0	1
NERP	2	RW54	Whitelight	9	20/10/2014	435	2244	184	204	7	0	1	0	0	0	0	0	0
NERP	2	RW54	Whitelight	10	21/10/2014	435				0	0	0	0	0	0	0	0	0
NERP	2	RW54	Whitelight	11	22/10/2014	435	0048	205	207	1	0	2	0	0	0	0	0	0
NERP	2	RW54	Whitelight	12	23/10/2014	435	2127	208	210	1	0	1	0	0	0	0	0	0

Appendix 3 - CyberTracker data collection

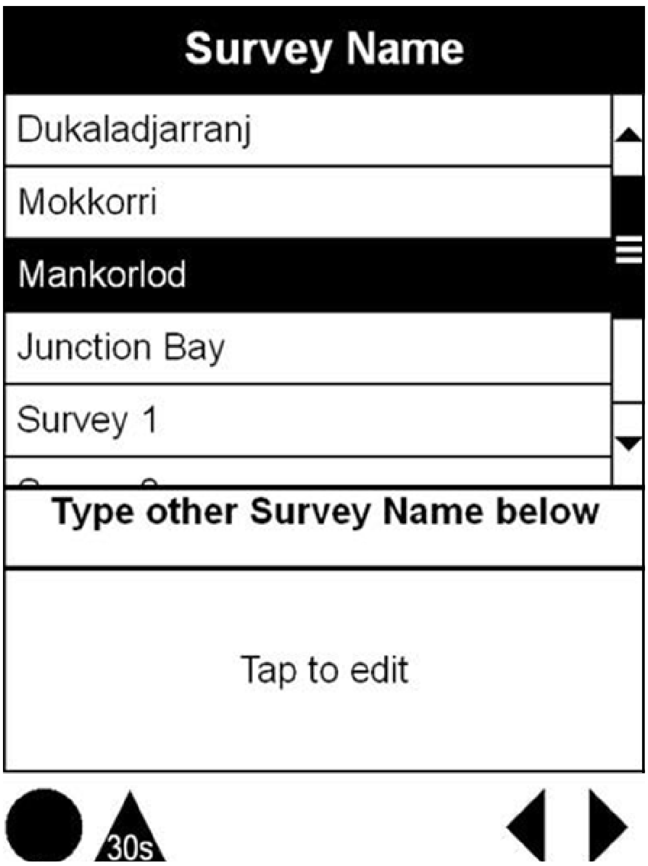
The NT Flora and Fauna Division has undertaken various trials with the rangers of the Djelk and Warddeken Indigenous Protected Areas to create a CyberTracker sequence for use on rugged PDAs to record geo-referenced remote camera deployment and retrieval data. Much of the metadata required for further analysis is captured in this way. The sequence is set up to be amenable to various camera deployment designs, ranging from large survey efforts with multiple cameras per site, to single use sentinel cameras. The sequence can be further manipulated to suit specific study requirements. Maps and 'Go To' points for remote camera collection can be created for the field PDAs and for viewing within the database. The Cyber Tracker remote camera sequence is part of the NAILSMA I-tracker project's Land Patrol Application, which is freely available from their website (http://www.nailsma.org.au/i-tracker/download-i-tracker-land-patrol-application). CyberTracker software and global support is available at http://www.cybertracker.org/.

Figure 22: Djelk Ranger Ivan Namarnyilk inputting remote camera collection data, 2013.

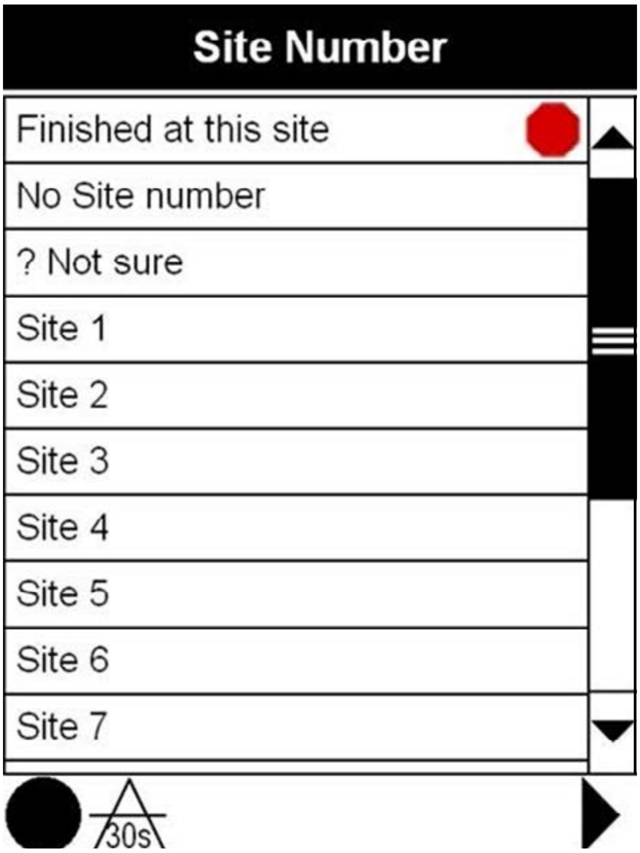
The following diagrams show the CyberTracker screen sequence for remote camera trapping. Note: selected fields are blacked out.



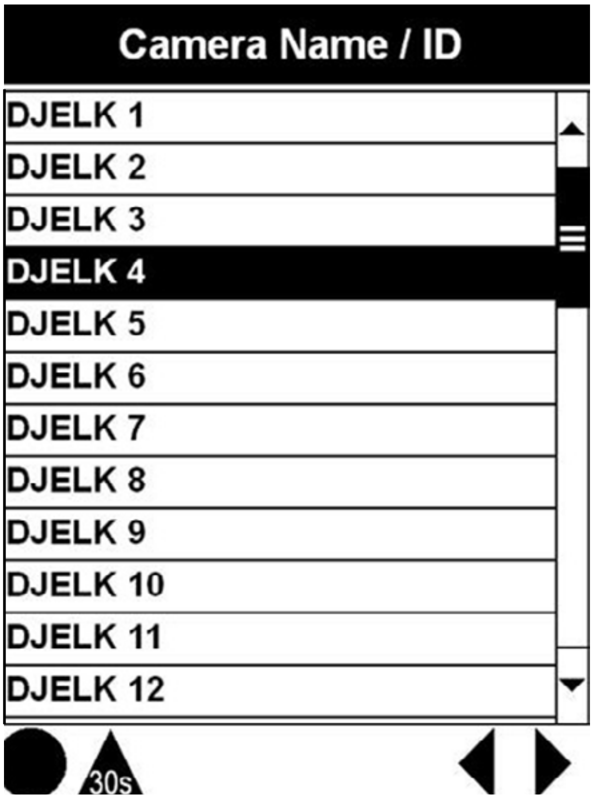
When you know your survey name beforehand, you can program it in so it is on the quick list on the PDA.



Site numbers can be converted to names or whatever is appropriate. Extra information about that site can be attributed to the element, and can be called to view within the database. For example when working within a particular community group, sites may have a common verbal language name that everyone knows, so this can be programmed here. The site name can be stored behind the community name, to be viewed in the database. The sequence loops back to this screen to allow for multiple remote cameras to be attributed to a site.

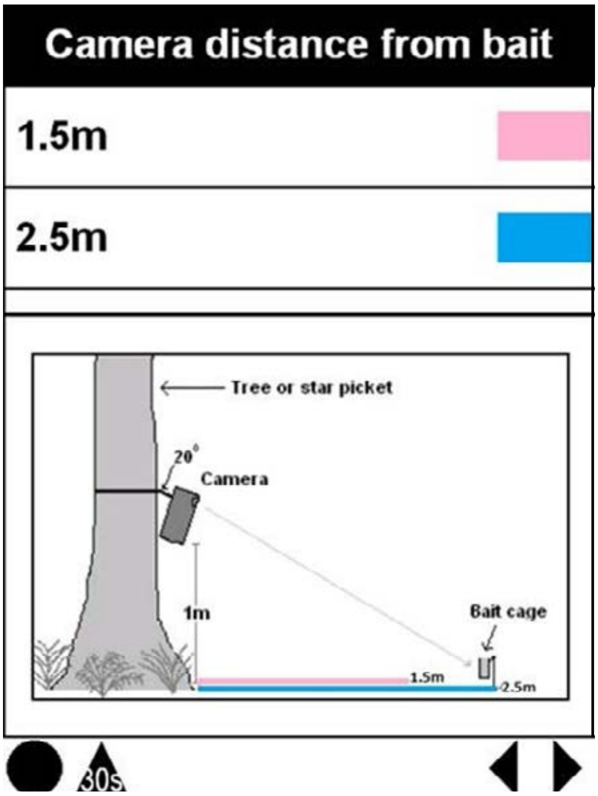


Note that behind the camera name, information can be stored, such as the brand and model of camera. This information can be seen again when you view the database.

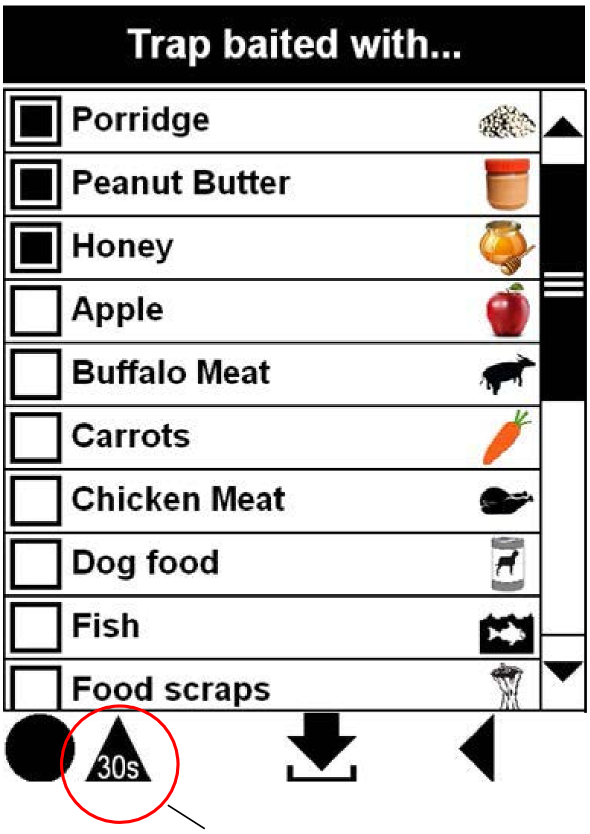


The sequence now splits into deploying or collecting a camera. First we will follow the deploying sequence by choosing 'Set Camera'.

You can program whatever distances are required by your sample design.

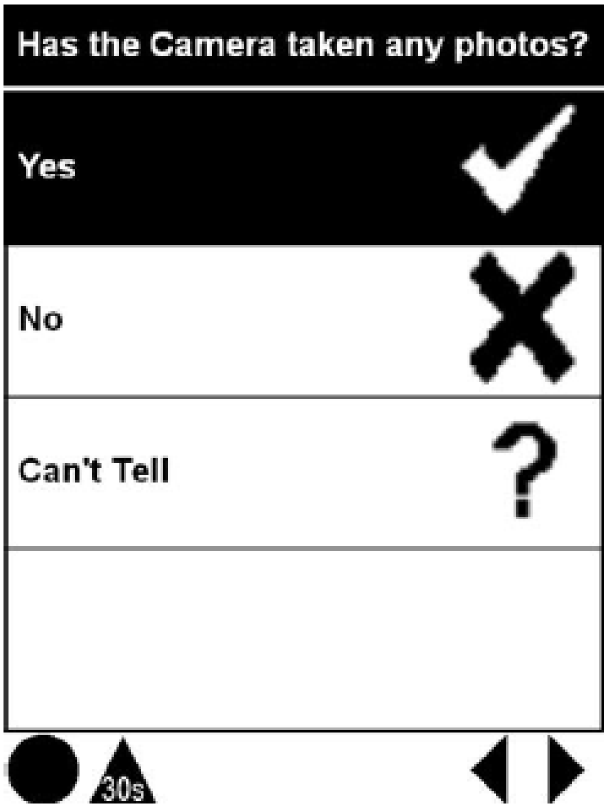


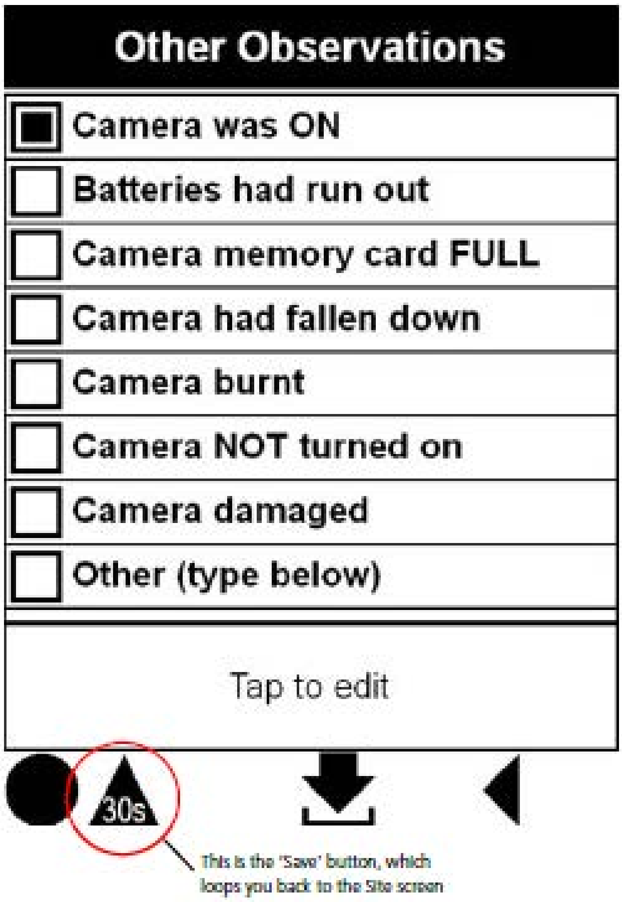
You can program this quicklist to reflect the bait you are using.



This is the 'Save' button, which loops you back to the Site screen.

Now we follow the camera retrieval sequence by choosing 'Pick up'.


Has the Camera taken any photos?
Yes
No
Can't Tell
30s


Other Observations
Camera was ON
Batteries had run out
Camera memory card FULL
Camera had fallen down
Camera burnt
Camera NOT turned on
Camera damaged
Other (type below)
Tap to edit
30s
This is the 'Save' button, which loops you back to the Site screen

Djelk Rangers demonstrating camera set up to participants at a workshop in Darwin in November 2014

A one day workshop in November 2014 on using remote cameras for wildlife surveys attracted over 50 participants from across Northern Australia.

National Environmental Research Program
NORTHERN AUSTRALIA HUB
Improving biodiversity conservation in northern Australia

Northern Territory Government

This research was supported by funding from the Australian Government's National Environmental Research Program

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