



About This Method



This document helps you to monitor animals (birds, bats, frogs, some mammals) by recording their calls with Autonomous Recording Units (ARUs). This method has been adapted from: [Passive acoustic monitoring in ecology and conservation](#), E. Browning, R. Gibb, P. Glover-Kapfer & K. Jones (WWF-UK). You can find more information on the Monitoring Country website: monitoringcountry.org.au or scan the QR code.



This method has three parts: **1. Get Ready**, **2. Out on Country** and **3. Back in the Office**. Each part can be undertaken separately but you must complete all three parts to finish the method. At the end of the document, you will find guidance for all the gear you need - [Gather Your Gear – Complete List](#).

We recommend you read the whole document before you start.

Part 1: Get Ready



GATHER YOUR GEAR



Equipment required for this part:

- Tablets/phones with:
 - ability to take photos
 - data collection and navigation apps
- Laptop/computer with software for:
 - mapping
 - audio processing software
- GPS device (recommended)
- Autonomous Recording Units (ARUs; 1 per site). Check that each has:
 - Blank SD card with > 32 GB capacity
 - Charged batteries
 - Weather-proof casing
- Permanent marker

ENVIRONMENTAL MONITORING METHOD:

Biodiversity Monitoring with Audio Recording Units



KEEP IN MIND



Why?

Make sure there is a clear [monitoring question](#) and that the [method](#) you have selected will answer the monitoring question.

If this is the first time you are monitoring, you will need to [design the survey](#): what are you monitoring, where will you survey, and when and how often you will survey?



When?

Prepare well before heading out on Country so that you have time to gather gear or train staff, if needed.



Who?

1 ranger/staff to plan and prepare



Training and skills

Staff involved in planning are trained and competent in:

- Mapping software (like QGIS or Google Earth) and/or [monitoring point generator](#)
- Navigation systems (like Avenza app or GPS device)
- Data collection systems (like Fulcrum app or paper datasheets)
- Setting up Audio Recording Units
 - o This will depend on the type of ARU you buy and use
 - o There are many options, like [Song Meters](#), [AudioMoth](#), and [Titley Chorus](#), amongst many others, which can all be used for biodiversity monitoring



Check permissions

Consult with Traditional Owners, landholders and relevant government agencies and authorities, to determine appropriate access and approvals for environmental monitoring:

1. Where you can go – consult with the owners/managers of the land.
2. What you can do – check if you need [scientific licences or ethics permits](#)
3. What or who can you take photos of
4. What can be done with data and photos – who owns them, where will they be stored and how will data be interpreted and communicated.




Biodiversity Monitoring with Audio Recording Units



ACTIONS

Design the survey

If you have done this monitoring before, it is best to do the surveys at the same time and same sites so that you can compare the data to previous surveys and see if there have been changes.

1. Decide what you animals you want to monitor (target species/group), such as:
 - A specific group of animals, like migratory birds
 - A whole taxonomic group, like bats or frogs or birds
 - The whole acoustic community (all calling animals)
 - Specific species, like night parrots
 - This will guide where your sites are, when you will survey, and how long the ARUs will be deployed for
2. Gather species of interest [records in your area](#) and identify where potential species of interest habitat is.
 - Such as from Traditional Owners, Atlas of Living Australia (ALA) or government databases
3. Decide what you want to find out about the animals you are monitoring, such as:
 - Presence and absence (are they here or not?)
 - Occupancy (how many sites were they detected at from all surveyed sites?)
 - Distribution (a map of where they were found)
 - Species inventory (a list of all species identified)
 - Species richness (tally of numbers of species identified)
 - This will guide where your sites are, when you will survey, and how long the ARUs will be deployed for.
-  4. Decide what ARUs you will use. See [buying guides](#) for advice on which brand and model may be suitable to buy.
 - Depending on your target species/group, check if the device can record audible (most terrestrial species) or ultrasonic (bats) frequencies
 - It is best to use the same type/model of ARU across all sites
5. Decide what time of year and how often you will do the survey
 - The timing of the survey should be when the target species are calling (e.g. peak breeding season for frogs, during and after rainy seasons for migratory waterbirds)
 - Repeating the survey in different seasons throughout the year (e.g. 1 week per season) can monitor lots of different calling species.



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6. Decide on the ARU recording schedule
 - The recording schedule is how often (frequency, time of day/night) and for how long the device will turn on and record sounds
 - The timing of the recordings should be when the target species are calling (e.g. sunrise and sunset for birds, after rain for frogs, night for bats)
 - The length of the recordings also depends on the target species (e.g. for lots of different species you take 1-minute recordings every 5 minutes for 24 hours, or for birds you can take 30-minute continuous recordings in the 30 minutes before and after sunset)
 - Aim to get 120 hours of recordings per site
7. Use the [monitoring point generator](#) or mapping software to select your sites
 - 3-5 ARUs per km², spaced 250-500 m apart
 - If you are interested in the whole acoustic community or taxonomic group, have equal numbers of sites in each of the major habitat types
 - If you are interested in specific species or a specific group, put your sites in areas where you are likely to detect them based on records or habitat type (e.g. monitoring sites for migratory birds should be near waterbodies)
8. Give each site a unique name, and export and save the location data in your data management system
9. Plan how you will process and analyse the audio recordings (manually and/or auto-recognition software)
 - There are many free and accessible audio processing software options like [Kaleidoscope](#), [Raven](#), [WarbleR](#), and [Arbimon](#)
 - Training is required for each software but there are usually guides and videos
10. Consider whether you will need expert help in identifying species from calls
 - Identifying calls can be difficult if you are not familiar with the species
 - There are online libraries of wildlife call sounds like [Xeno-canto](#), [eBird](#), the [FrogID app](#)
 - You can contact experts for particular groups (e.g. frogs, bats, or birds) who may be able to help identify species in your area

ENVIRONMENTAL MONITORING METHOD:

Biodiversity Monitoring with Audio Recording Units



✓ Make a plan and prepare for the survey

1. Plan which dates you will put the ARUs out and collect them
 - Batteries, SD card size, temperature, and recording settings will change how long the ARUs function for
 - If you are leaving ARUs out for a long time, plan to service ARUs (change SD cards and batteries) at some point during the survey
 - ARUs can be deployed in rounds at different sets of sites if you don't have enough ARUs for every site
 - e.g. you have 10 ARUs but you want to monitor 30 sites for 2 weeks each site. Deploy ARUs at the first 10 sites for 2 weeks, then collect and redeploy them at the next 10 sites, and then again at the final 10 sites. The survey will have three deployments of ARUs over 6 weeks.
2. Prepare maps of sites and load sites onto navigation devices
3. Plan how you will record information on Country (electronic data forms or paper datasheets)
4. Plan your [data management system](#) (how you will store sound recordings and ARU deployment data)
 - Audio recordings can take up a large amount of memory/space, so it is best to keep them in a cloud-based server (online) and have a local back-up copy (hard drive)
-  5. Check **GATHER YOUR GEAR** lists for [Get Ready](#), [Out on Country](#) and [Back in the Office](#) ([complete list on last page](#)) and get any equipment you don't have.
 - See [buying guide\(s\)](#) for advice on which ARUs may be suitable to buy
6. Charge electronic devices (tablets/phones, power banks, GPS) and batteries

✓ Train



1. Check the **Training and skills** requirements for [Get Ready](#), [Out on Country](#) and [Back in the Office](#) steps and arrange any training or expertise that you need
2. Run everyone involved in the survey through the plan
 - Be clear on how many people will be involved, what everyone will be doing, and what they will need to do the survey
3. Run a training session for all rangers involved in the survey to learn or refresh:
 - a. How to use the devices (like tablets/phones and GPS)
 - b. How to use data collections apps and record data
 - c. How to program ARUs

ENVIRONMENTAL MONITORING METHOD:

Biodiversity Monitoring with Audio Recording Units



✓ Set up the ARUs

1. Read through the ARU user guide (depending on which units you are using)
 - a. e.g. [Song Meter](#), [Song Meter Micro 2](#), [AudioMoth](#)
2. Give each ARU a unique name (e.g. ARU01) and write it on the outer cover of the ARU and on its matching SD card in permanent marker
 - If you plan to service the ARUs during the surveys or deploy them at different sites, make sure the ARU has another SD card. Write the same unique name on the card and something to show that it is the second card (e.g. ARU01.2)
3. Check that the SD card is empty
4. Insert the SD card into the ARU
5. Put charged batteries into the ARU
6. Turn the ARU on to set it up for recording
 - Use the manufacturers step-by-step user guide for more detail
 - Some ARUs have an app or software that can be downloaded to your tablet/phone/computer to help with set up
7. Assign the ARU with its unique name
 - Only do this the first time you use the ARU
8. Set the recording format to .wav, .FLAC or .W4V
9. Set the recording resolution to 16 bits
10. Set the sampling rate to double the maximum frequency of sounds of the target species
 - a. For audible calls (most terrestrial animals): 44.1kHz or 48kHz
 - b. For ultrasonic calls (bats): 200kHz
11. Set the recording schedule
12. Check that the SD card has space
13. Check that the date and time are correct
14. Turn off the device

The ARU is now ready to be used, and when you turn it on in the field, all of the settings will be retained.

Next Section – Part 2: Out on Country



Part 2: Out on Country



GATHER YOUR GEAR



One set of this equipment for each team:

- Tablets/phones
- Power bank (optional)
- GPS device and spare batteries (recommended)
- Hammer, mallet, or picket driver
- Multi-tool or side cutter for snipping cable ties
- Spare batteries (if servicing ARUs)
- Flagging tape (optional)

One set of this equipment for each site:

- Autonomous Recording Unit (ARU) with
 - Charged batteries, blank SD card, and preprogrammed settings
- Star picket
- 300 mm x 4.8 mm sized cable/zip ties

KEEP IN MIND



Where

If livestock or other wildlife might damage ARUs, you may need to change the timing of the survey, move the site, or have guy lines to keep animals away.



Who?



2 rangers per team



Training and skills

Make sure everyone knows the plan.

Field staff are trained and competent in:


- Navigation systems (like Avenza app or GPS device)
- Data collection systems (like Fulcrum app or paper datasheets)
- Identifying habitat types for species of interest
- Deploying ARUs in the field



Biodiversity Monitoring with Audio Recording Units



ACTIONS

 Check that your electronic devices (tablets/phones, power banks, GPS, batteries) are charged before you head out.

Ground truth sites

7. If this is your first time doing the survey, go to each site to check that it is:
 - Accessible – can you access it? e.g. are there creeks, or thick vegetation, or steep and rocky terrain that prevent you reaching the site?
 - Suitable habitat – is it the type of habitat your target species would likely be in?
8. If needed, move sites so that they are more accessible and/or in the correct habitat type.
9. If a site is moved, record new location coordinates.

Deploy ARUs

1. Choose a spot to deploy the ARU that is:
 - a. At least 1.5 m away from trees, tall shrubs, large boulders and water
 - b. Away from things that will be noisy, like branches in the wind and flagging tape
 - c. Away from hard, flat surface that will echo, like rock and water
 - d. Above where long grasses may grow while the ARU is deployed
2. Mark the ARU location on your navigation device
 - Brightly coloured flagging tape can help to locate the site when you come back
3. Hammer in the star picket
4. Attach the ARU with a cable tie/ziptie to the stop of the star picket so that it is:
 - a. At least 1 m above the ground
 - b. Secure/doesn't move around
 - c. Microphone pointed towards preferred habitat of target species
 - d. Microphone horizontal or pointed slightly down
 - This allows rain or dew to drain away.
 - DO NOT POINT THE MICROPHONE UP
 - e. If using pole-mounted bat ARUs [Faunatech's step-by-step guide](#) is helpful
5. Snip off the ends of the cable tie/zip tie
6. Turn on the ARU
7. Check that the ARU has an empty SD card, charged batteries and has preprogrammed recording settings.

 8. Record **deployment data**



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✓ Service ARUs (optional)

9. Turn off the ARU
10. Eject the SD card and replace it with a new, blank SD card
11. Remove the dead batteries and replace them with charged batteries
12. Check that the ARU is firmly attached, and the star picket is solidly in the ground
13. Clear away any plant growth under the ARU that could cause noise.
14. Turn on the ARU

 15. Record **service data**

✓ Collect ARUs

16. Turn off the ARU
17. Cut the cable tie to remove the ARU from the star picket
18. If you don't plan to monitor at the site again, remove the start picket and flagging tape

 19. Record **collection data**

RECORD DATA

Data to record when deploying ARUs

What to record	Required?	Notes
<i>Information to record about each ARU deployed</i>		
Project name	Yes	Make it clear which project this data belongs to and its purpose
Date	Yes	Record the date the ARU was put out on Country
Personnel	Yes	Record the name of the people who put out the ARU - this is helpful if any questions come up about the data
Site name/number	Yes	Record the site name/number where the ARU was put out
Location coordinates	Yes	Record an accurate location of where the ARU was put at the site (using a handheld GPS if possible) (latitude and longitude or eastings and northings)
ARU ID	Yes	Record the name written on the ARU
SD card ID	Yes	Record the name written on the SD card
<i>Information to record about each site</i>		
Fire age	Optional	Record the fire history of the site.
Habitat notes and or photo	Optional	Describe or take a photo of the habitat type at the site. Make note of which device it was taken on, and the filename of the photo (usually end in .JPG)
Signs of disturbance	Optional	Types and causes of disturbance you can see at the site (e.g. signs of introduced predators, vegetation clearing, wrong-way fire)
Stories and notes	Optional	Record information or stories from Elders, and anything else worth noting about the area or animals.

ARU Biodiversity Monitoring

Get Ready

On Country

In Office

Gear List

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Data to record when servicing ARUs

What to record	Required?	Notes
<i>Information to check is correct when servicing an ARU</i>		
ARU ID	Yes	Check that the name written on the ARU is correct
SD card ID	Yes	Check that the name written on the SD card you take out of the ARU matches the ARU ID
Location	Optional	Check that the location is correct (using a handheld GPS if possible) (latitude and longitude or eastings and northings)
<i>Information to record about each ARU serviced</i>		
Project name	Yes	Make it clear which project this data belongs to and its purpose
Date	Yes	Record the date the ARU was serviced
Personnel	Yes	Record the name of the people who serviced the ARU - this is helpful if any questions come up about the data
Site name/number	Yes	Record the site name/number
SD card ID	Yes	Record the name written on the new SD card you put into the ARU
ARU issues	Optional	Record if anything has gone wrong with the ARU (e.g. dead batteries, full SD card, ARU damaged by stock or rain, vegetation has grown lots)



Data to record when collecting ARUs

What to record	Required?	Notes
<i>Information to check is correct when collecting an ARU</i>		
ARU ID	Yes	Check that the name written on the ARU is correct
SD card ID	Yes	Check that the name written on the SD card you take out of the ARU matches the ARU ID
Location	Optional	Check that the location is correct (using a handheld GPS if possible) (latitude and longitude or eastings and northings)
<i>Information to record about each ARU collected</i>		
Project name	Yes	Make it clear which project this data belongs to and its purpose
Date	Yes	Record the date the ARU was collected
Personnel	Yes	Record the name of the people who collected the ARU - this is helpful if any questions come up about the data
Site name/number	Yes	Record the site name/number
ARU issues	Optional	Record if anything has gone wrong with the ARU (e.g. dead batteries, full SD card, ARU damaged by stock or rain, vegetation has grown lots)

Next section – **Part 3: Back in the Office**





Part 3: Back in the Office



GATHER YOUR GEAR



Equipment required for this part:

- Tablets/phones (or paper datasheets) that you used to record data
- Data management system
- Laptop or computer with software for:
 - Spreadsheets
 - Mapping
 - Acoustic recordings analysis software
 - [Kaleidoscope](#) – free or paid; view, listen to, and label audio recordings
 - [Raven](#) – free or paid; view, listen to, and label audio recordings
 - [WarbleR](#) – requires use of R statistical software
 - [Arbimon](#) – global online platform
- SD card from the ARUs

KEEP IN MIND



When?

Always try to complete this work as soon as you can after returning from your time on Country so that recordings on the SD cards aren't overwritten or lost.



Who?



1 person to manage the data



Training and skills

Staff managing data are trained and competent in:

- Mapping software (like QGIS or Google Earth)
- Spreadsheet software (like Microsoft Excel)
- Data collection systems (like Fulcrum app or paper datasheets)
- Data management systems (like databases, cloud storage and external hard drives)
- Using acoustic recordings analysis software

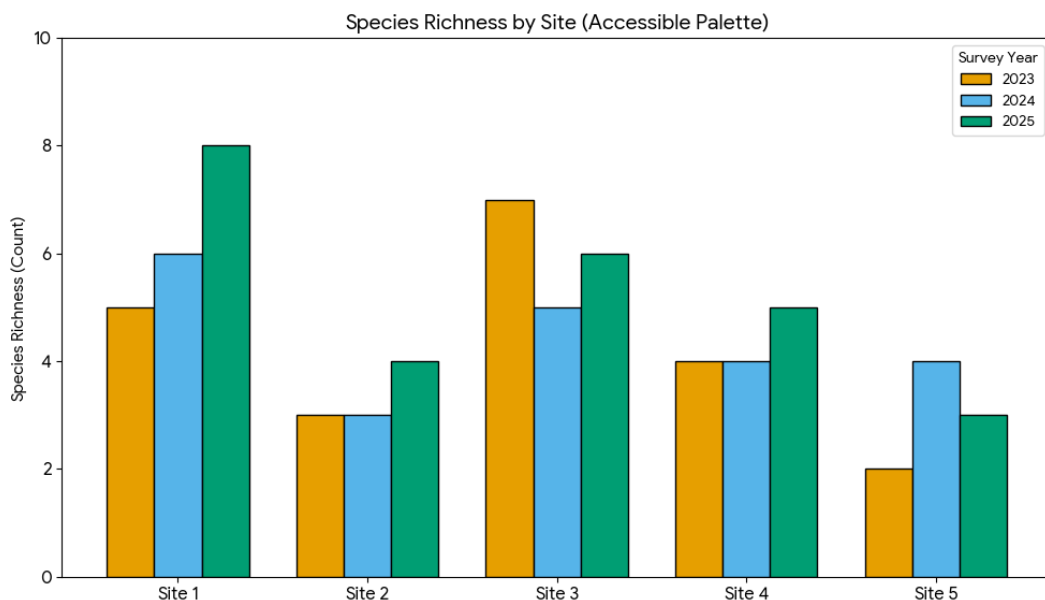




ACTIONS

Data entry, analysis and reporting

1. Record a summary of what you did and why, any observations (like weather conditions, fire history and site condition), anything that went wrong or didn't work and things that worked well.
2. Upload the **ARU deployment, servicing and collection data** to your data management system
 - Recommended: get someone else to proof the data to check for mistakes
3. Upload any photos or videos taken during the survey to your data management system
4. Remove SD cards from ARUs and upload to your data management system
5. Use acoustic recordings analysis software to check recordings and identify species calls
 - a. Contact experts to help confirm calls and check for any that may have been missed -some species have calls that vary a lot and can be easy to misidentify
6. Import the data into a spreadsheet and
 - a. Calculate species richness – the number of species you detected during surveys
7. Create a simple line or bar graph to compare
 - a. Species richness across different sites and over time



An example of how site level species richness data can be presented in a graph to track changes over time or show differences between sites (Image created with assistance from Gemini, a large language model by Google AI).

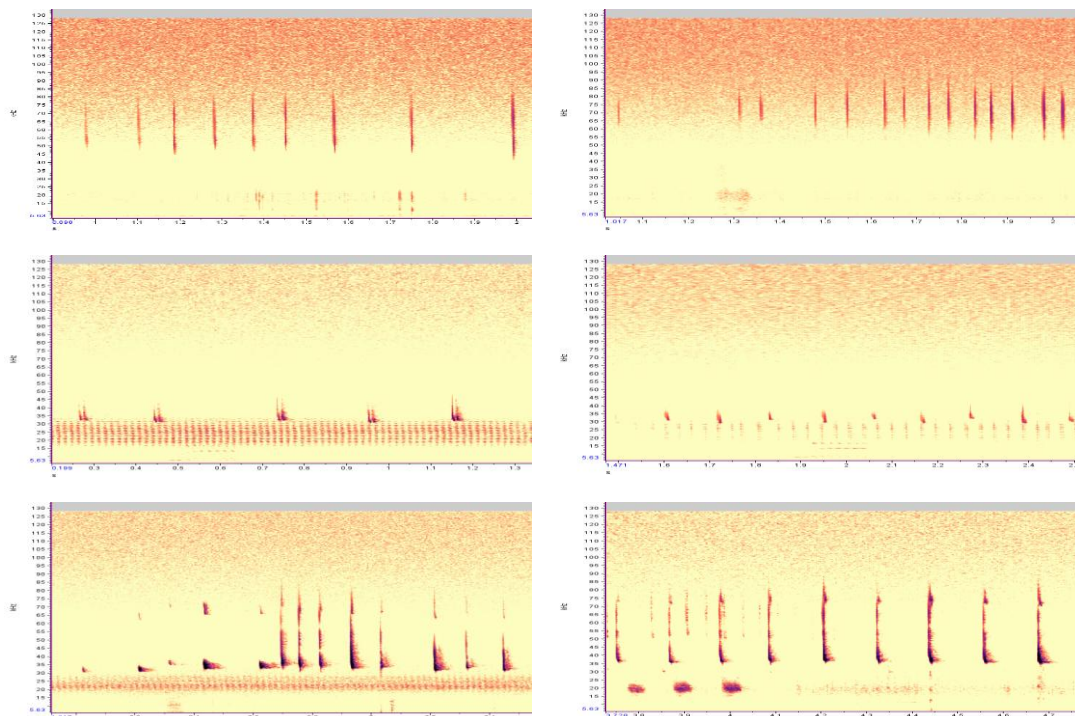
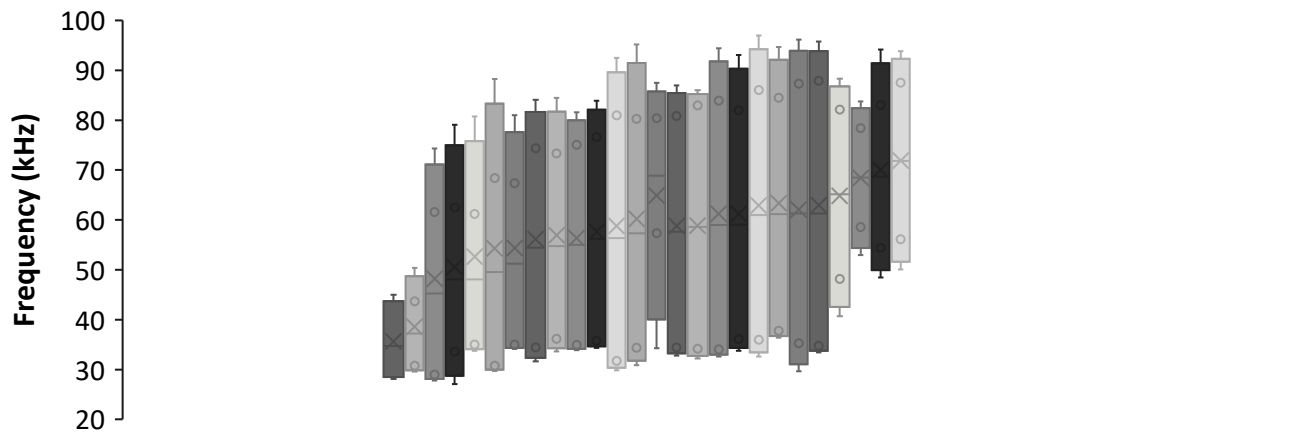
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b. For bats:

- i. plotting low, mean, and high frequency ranges from similar call samples can help visualise what may be different species or species behaviours, as species often call at different frequency ranges



Example observed frequency ranges (mean low and high frequency, minimum frequency, maximum frequency, median) of three distinct vocalisation clusters from bat audio surveys, with reference to how the calls look in the processing software (audio visualisations).

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8. Use the mapping software to create a map of
 - a. All sites surveyed
 - b. Presence and absence maps (where species were detected and not detected)
 - c. Presence and absence maps over time (is where species are being detected over time changing?)
9. Discuss with the ranger team or community the results of the monitoring, any reasons for the presence or absence of species of interest, and if there have been any changes to previous years
 - Consider whether trends might be related to your management (like cat control or fire management) to check how well management is working, or if you need to make adjustments
10. Share the data according to any data sharing or funding agreements you have made

Next section – Full Equipment List



Gather Your Gear – Complete List



The complete **GATHER YOUR GEAR** list for **Get Ready**, **Out on Country** and **Back in the Office**.

Gear List	Required?	Get Ready	On Country	In Office
Tablets/phones: <ul style="list-style-type: none"> Ability to take photos Apps for data collection (like Fulcrum) and navigation (like Avenza) 	✓	✓	✓	✓
Laptop or computer with software for: <ul style="list-style-type: none"> Mapping (like QGIS or Google Earth) Spreadsheets (like Microsoft Excel) Acoustic recording analysis software 	✓	✓		✓
GPS device & spare batteries	Recommended	✓	✓	
Power bank	Recommended		✓	
Audio Recording Units (1 per site) with: <ul style="list-style-type: none"> SD card >32GB Batteries 	✓		✓	
Permanent marker				
Star picket (one per site)				
300 mm x 4.8 mm cable ties/zipties				
Hammer, mallet or picket driver				
Multi-tool or side cutter				
Flagging tape				
Data management system (like databases, cloud storage and external hard drives)	✓			✓