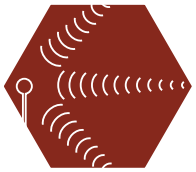
NKMP Methodologies



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NATIONAL KOALA MONITORING PROGRAM

The National Koala Monitoring Program (NKMP) aims to fill knowledge gaps for future Koala recovery and management efforts. CSIRO is leading the co-design of the four-year program and facilitating the roll out of NKMP with the broader Australian community. The key objectives of this monitoring program are:

- Inclusive – to enable all members of the Australian community to contribute to this national koala monitoring effort.
- Long-term – to build individual and collaborative capacity to collect robust data that can be used for evidence-based decision-making.
- Integrative - to build best-practice methods and data management systems to integrate available and new data to provide local and national insights into koala population status and trends.

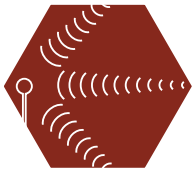
The NKMP uses a wide range of approaches to monitoring koalas. This enables us to use a wealth of existing knowledge and suit our data collection methods to the specific needs of each site.

Keen to learn more? Visit National Koala Monitoring Program. Any questions or keen to find out how you can share your koala observations or data? Contact us at KoalaMonitoring@csiro.au

WHAT YOU WILL NEED TO USE AUDIO RECORDERS TO SURVEY FOR KOALAS

Koalas are a widespread, easily recognised, and iconic species. Despite this, finding koalas can be difficult because they often occur at low densities and they can be remarkably difficult to see when pressed against a tree trunk or in a clump of leaves high above the ground. Luckily, in the breeding season, koalas are quite vocal. Males will often bellow loudly to attract mates and establish territorial boundaries. Audio recorders can be used to capture these sounds over a large area and record the presence of koalas that may not be easily seen. The recordings can be fed into automated recogniser software to detect the bellows of koalas. Audio recording has the advantage that it can cover a larger area for a longer time with less per-unit survey effort and costs than some other methods.

We will consider two types of audio surveys. Presence-only surveys, for when you simply want to know if koalas are present in a given area and density surveys for when you want to estimate how many koalas are present in an area. Estimating density from audio surveys is not a simple task and requires some advanced statistical analysis.



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Standard equipment:

1. A colleague.
2. A GPS and enough battery power for the duration of the field work.
3. A map of the site, with salient features marked.
4. Measuring tape/GPS for laying out sampling grid.
5. A notebook/datasheets.
6. A compass.
7. Two-way radios.
8. Appropriate field gear (PPE) such as robust shoes / boots, hat, suitable long trousers and long-sleeved shirt for some scrub-bashing.
9. Enough water and some snacks to spend a few hours away from a car, on your own.
10. A basic first aid kit.

Audio recorder-specific requirements:

11. Audio recorders - enough to cover your study area.
12. Spare batteries for recorders.
13. Spare SD cards for recorders.

Note: *The more remote the area you are working in, the more safety systems you should employ (e.g. satellite phones, personal locator beacons, safety check-in systems, extra provisions).*

THINGS TO CONSIDER WHEN PLANNING AN AUDIO SURVEY

Think about what you want to get out of the survey at the other end. Are you only interested in finding out if koalas are present? Or do you also want to know how many there are? The question you are asking will shape how you deploy your recorders and how much work is required to answer it.

Koala breeding season is roughly August to December in Queensland and NSW, but it is likely to be a little later in colder, southern parts of their range. Deploy your recorders in this window to maximise your chances of hearing koalas bellowing. Koalas tend to peak in calling either side of midnight but recording from sunset to sunrise is recommended to maximise detections.

You will need to deploy your recorders for a certain length of time to get the data you want. This could be from days to months depending on the questions being asked and the likelihood of hearing a koala. The lifetime of the project from deployment to maintenance, collection of data and analysis may be longer than you expect, and that time needs to be accounted for. Are your recorders properly protected from the elements? Units should be waterproof as a minimum.

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Adverse weather conditions such as high winds, high temperatures, or heavy rain can limit the detector's ability to distinguish koala calls or cause koalas to call less frequently than usual. Try to plan your survey to avoid windy and rainy conditions if possible. If not possible, consider that you may need to add on extra survey nights if some data is unusable.

Try to place your recorders away from sources of background noise such as roads, fast flowing streams or dams with a lot of frogs calling.

Choose the hardware that suits your project and balances the sensitivity of the recorder with the logistics of deploying them in your chosen landscape. You may opt for a smaller, lighter option but might sacrifice some data quality or battery life. Smaller units also have the advantage of being easily distributed to landholders via the mail. More information on hardware below.

Most audio surveys use some kind of auto-recognition software to analyse the data afterwards and pick out the koala calls from background noise. Although this does cut down on labour, the detections will still need to be manually checked to identify any false positives, which sometimes can be many.

Your recorders will pick up mostly males (although females do vocalise but not typically as a bellow and not to advertise themselves). If you are interested in population density, it may be necessary to supplement the audio survey with other methods to determine if the local population has a 1:1 sex ratio (i.e. does hearing 10 males mean there are also 10 females in the area?).

AUDIO HARDWARE

There are a number of options available for audio recorders and depending on your specific needs you will need to carefully balance factors such as cost, sensitivity and portability. Here are a few popular brands.

Wildlife Acoustic Song Meters

SM Micro – A very small and lightweight device. Measuring 101 mm x 74 mm x 28 mm and weighing ~200 g (with batteries). With 3 AA batteries it can record for up to 180 hours and data is stored on a single micro-SD card. It is weatherproof but requires a desiccant sachet to be added to soak up condensation. A smaller device like this will not perform as well as larger devices with external microphones but will be easier to carry. Approximate cost: A$370/unit.

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SM mini – This is a mid-range unit available from this manufacturer. Measuring 123mm x 168mm x 36mm and weighing ~300g. It has a single built-in microphone. Powered by standard AA batteries it can record up to 200 hours. If powered by lithium batteries this increases to about 1000 hours. Settings can be changed via a mobile app with Bluetooth. Approximate cost: A$730/unit.

SM 4 – One of the larger units available on the market. Measuring 218mm x 186mm x 78 mm and weighing ~1.3kg (with batteries). This unit has two built-in microphones, large data storage and the ability to cone to external power (e.g. a car battery). With four D batteries the estimated recording time is 510 hours. With two SD card slots it has the potential to store up to 1TB of data. Approximate cost: A$1300/unit

Song Meter SM4 and Mini units have a detection range of ~300m for koalas and as such are not recommended for smaller patches of habitat (<25ha) unless you manually reduced their sensitivity (gain) because you may capture bellows from koalas outside of your study area.

AudioMoths

AudioMoths are a lightweight, low-cost, open-source acoustic monitoring device. Measuring 58mm x 48mm x 18mm and weighing ~80g (with batteries). With three AA lithium batteries they can record for ~250 hours and data is stored on a microSD card. AudioMoths can be used as simple recorders but are also capable of being programmed to do certain tasks on-board such as potentially analysing calls in real time. Approximate cost: A$150/unit.

Due to their detection range for koalas (~ 100m), to minimise false positives (for example form detecting bellows from outside your study area), AudioMoths are not recommended for sites <4ha.

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Frontier Labs – Bioacoustic Recorders (BARs)

BAR-LT units from Frontier Labs, Brisbane are similar to SM4 units in size and characteristics. Measuring 150mm x 115mm x 70mm and weighing 900g (with batteries). These units can be powered by six rechargeable batteries giving up to 600 hours of recording time or can be powered externally. Data is stored on four SD cards. One or two microphones can be used. There is a choice between two microphone types; low frequency and high (normal) frequency. Advice from Frontier Labs suggests that male koala bellowing, and female koala shrieking are both suited to the low frequency microphone (see below). If species' calls are a desired target, this may necessitate the use of two different microphones on the one unit. This works but will add to the per unit cost. Approximate cost: A$1000/unit.

The recording unit model must be suited to the acoustic characteristics of koalas. The known frequency range for a male koala's bellow is approximately 80–750 Hz (inhalation) and 90–400 Hz (exhalation). The sampling rate should be at least double the highest frequency of a koala call.

Titley Electronics - Chorus

Chorus acoustic recorders record in the normal hearing (acoustic) range and also detect ultrasonic (microbat) calls. They have two microphone coupling points, so there is a choice to have one normal range audio microphone, audio + ultrasonic microphones, or two normal microphones. Measuring 194mm x 123mm x 50mm and weighing 400g (without batteries). These units are be powered by four AA batteries giving up to 300 hours of recording time. Data is stored on one SD card. Approximate cost: A$750/unit in its basic configuration. Extra microphones ($250) and other accessories are available.

AUDIO SOFTWARE

Until relatively recently, in order to extract koala calls from your recordings you would have to go through and listen to every recording. Luckily there have been a lot of advances in automated recognition and there is software available that will do this for you. There are a number of different programs available, and most do an acceptable job of finding koalas calls in your recordings. Once the software has pulled out what it thinks are all the koala calls you will still have to check if there are any false positives where it has identified something as a koala incorrectly and do some random checking for false negatives where koala calls have been missed. If you don't have the time or the capacity to run these programs yourself, you may want to hand the data analysis over to a trusted partner.

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AviaNZ

This is free and open-source software that can be used for analysing audio recordings. It is primarily designed for bird calls but can be used to identify koala calls. **AviaNZ** allows you train filters to recognise individual species. The NSW Department of Primary Industries has developed a koala recogniser that can be used in AviaNZ. Other researchers have created different filters for koala calls which may be publicly available.

Kaleidoscope Pro, Wildlife Acoustics

This software uses 'cluster analysis' to recognise similar patterns of sounds and group them together. Once grouped, the identified sounds can be annotated as 'koala' and then used to train a recogniser to automatically identify koalas from other recordings. This approach would mean the user would need to either have access to an existing classifier or make their own from a subset of their recordings that they go through and manually annotate each cluster that sounds like a koala. This software has other features like generating reports and carrying out more detailed analysis on the sound levels. It requires a paid subscription of A$400/year. A free trial is available for a short period.

PROTOCOL

We will consider two main types of audio survey for koalas

Presence-only surveys – A relatively simple survey aimed at finding out if koalas are in your study area. If you detect koalas, you may want to follow up with other types of survey.

Density surveys – A more rigorous survey with more detailed analysis aimed at estimating how many koalas might be in your study area.

Presence-only survey

The sensitivity of your chosen recorder will determine the range over which it can detect a koala call and this in turn will determine the spacing of your recorders needed to cover as much of your study area as possible. Below is a generalized protocol based on deploying Audiomoth recorders over an area of 85ha.

- Identify your target habitat and calculate how much area you need to cover (here ~85ha)
- Recording units should be attached to a small diameter tree at around shoulder-height (~1.5-1.8m above ground) and enclosed in waterproof casing.
- Audiomoth recorders have an estimated detection range of ~100m for detecting koalas depending on the habitat and other variables. Aim for a

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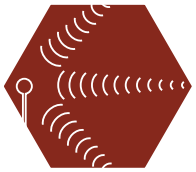
***Fig.1*: Placement of Audiomoth recorders (green dots) across a habitat patch of 85ha with the aim of detecting koala presence. In this habitat the estimated detection range of the recorders is about 100m (yellow circles).**



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density of one unit per 5–10ha for complete coverage. Given male koalas will often have larger home ranges than this, and recorders can be left in-situ for 1-2 weeks, complete coverage may not necessary. The exact placement for this kind of survey is not as important as for density surveys where a defined grid is required. Here you are aiming for as near total coverage of your area of habitat as possible without overlap in your recording areas.

- Set the units to record from sunset to sunrise every night. Be aware that if this is a long-term deployment (multiple months) you should give yourself a buffer on either side or those settings will need to be adjusted over time as the sunrise/set times change.
- The length of your deployment will vary for a lot of reasons. However, research has suggested that in low density areas, at least 4–7 nights is required to maximise your chances of recording a koala. Aim for seven nights if possible, with minimal rain. Ten nights is close to the limit of the battery life and memory storage space of an Audiomoth recorder. If you plan to record data for longer, you should plan to check on your units well before they run out of battery.
- When the survey is finished, collect the recording units and download the data from their SD cards for processing.
- Specialist software (discussed above) is used to scan the recordings and look for recognisable koala calls. You may have the ability to process this data yourself or may want to pass it to an expert for analysis.

Recording the Data

Apart from the actual recordings from the units, for each survey you should record as much detail as possible. Of particular importance is recording the **area covered, number of units** and the **number of survey nights**. This will help determine survey effort and make it possible to compare between surveys. Try to record the following:

Survey –

- A unique identifier for this survey
- Who deployed the units
- Record the serial number of each recorder used so that you can back track if there are issues with the recorder
    - A map of your recorder locations with your target habitat outlined
    - IDs and GPS locations of your recorders
    - Number of nights surveyed
    - Size of habitat patch covered
    - Make and model of your recorders

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- The sensitivity of the recorder (from the manufacturer's specifications and any justification for why you assumed it would be lower or higher in your habitat)
- The settings you used on your recorder
- Any notes on why you chose to put recorders in certain places (e.g. avoided a road, targeted a specific area etc.)
- Details of any problems, malfunctions or adjustments (e.g. skipping a night due to strong wind, battery failures)

Data Analysis –

- Unique identifier for this data that links to the details of the survey
- Who analysed the data?
- What software did they use?
- The version of the software and recogniser used because these are regularly updated
- Dates, times and locations of detections
- IDs of recorders that detected a koala
- Number of detections per night, which would be suitable for occupancy analysis.

Density survey

Conducting an audio survey with the aim of estimating koala density uses a very similar protocol to that for simple presence-only surveys outlined above. The main differences are that the spacing of the recorders needs to be more carefully arranged on a regular grid (though there is some flexibility to adjust the precise location of each recorder) and the analysis of the data is more complex. In the example in Figure 2 below, recorders are set out in a 5 x 5 grid with units spaced at 400m. This allows for the same koala to be picked up on adjacent recorders which is a feature of the statistical approach (spatial count modelling) used to model density from this data. In this example Songmeter S4 units were used with an estimated detection range of 300m.

The protocol for setting out the recorders and the information that should be recorded for this survey are otherwise identical to that outlined above for presence-only surveys. Typically, a two-week deployment is the aim, which will allow for exclusion of some rainy nights and still use 7-10 nights for the data analysis. The analysis used for estimating density from passive acoustic monitoring is complex and will need an experienced ecological modeller/statistician to produce results and interpret them. See this suggested paper for further reading.

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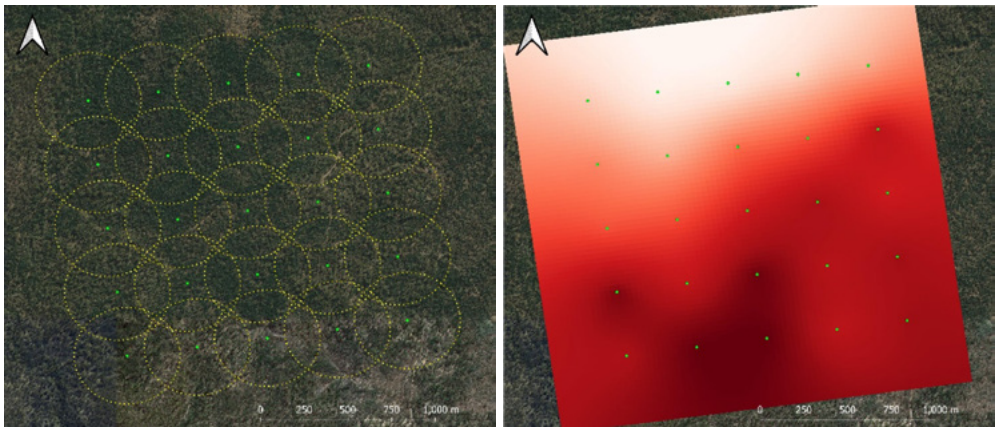

***Fig 2:* Left) Placement of Songmeter S4 audio recorders for a survey aimed at estimating density of koalas. S4 units have an estimated 300m range. Units are placed 400m apart in a regular grid. This set up allows for correlated detections from adjacent recorders for use in a spatial count model. Right) A mock up example of the kind of density map produced by spatial count modeling where darker red colours have higher predicted density of koalas.**

It should be noted that this method will provide the estimated density of male koalas in your study site. Assuming a 1:1 sex ratio in the population this number would be doubled to get the full population density. However, the sex ratio may not always be perfectly 1:1 and you may need to confirm this via other methods, acknowledge that your results depend on this assumption, or make clear that you are calculating male density only. There are also a lot of statistical assumptions that are made with this modelling approach that your data may not necessarily meet.

SOME EXTRA TIPS

- Don't forget to get required permission before setting up a audio recorder in the field.
- Researchers in the field have found 1-hour long audio files make for efficient processing.
- Audio surveys can potentially produce a large amount of data and you may need a computer that has a fast processor and enough memory to handle the audio data. Otherwise, data processing times could be very long.
- If the aim is to cover a broad landscape, a large grid could be used for deployment or more realistically a sample could be taken based on a stratification.
- Given sound recorders pick up koalas over a few hundred metres deployment on the side of roads can be quick and efficient (make sure they are well hidden) but aim to sample a diversity of topographic positions.

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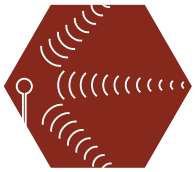

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ACKNOWLEDGEMENTS

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