Department of Transport and Main Roads

Queensland Good jobs Better services Great lifestyle

Source: © Matt Head

Manual

Fauna Sensitive Transport Infrastructure Delivery Appendix A: Fauna survey methods

June 2024

Queensland Government

Translating and interpreting assistance

The Queensland Government is committed to providing accessible services to Queenslanders from all cultural and linguistic backgrounds. If you have difficulty understanding this publication and need a translator, please call the Translating and Interpreting Service (TIS National) on 13 14 50 and ask them to telephone the Queensland Department of Transport and Main Roads on 13 74 68.

Feedback

Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au

Contents

A1 Introduction 1

A1.1 Animal welfare considerations 2

A1.2 General guiding principles 2

A2 Non-invasive survey techniques 3

A3 Invasive survey techniques 23

A3.1 Ethical considerations for invasive survey techniques 40

A3.1.1 Trapping considerations 40

A3.1.2 Active search considerations....41

A4 Emerging survey techniques....41

A4.1 Detection dogs 42

A4.2 Thermal cameras 42

A4.3 Environmental DNA 43

A4.4 Landscape genetics 43

A5 Survey methods for pre-construction clearing of fauna 45

A6 Survey methods for post-construction monitoring 45

A7 Species-specific survey methods....46

A8 List of survey guides....52

References 53

Tables

Table A2(a) – Camera trapping 4

Table A2(b) – Acoustic recording 6

Table A2(c) – Hair tubes and hair funnels.... 8

Table A2(d) – Hollow, burrow and nest inspections 8

Table A2(e) – Searches for scats, tracks, scratches, and other signs 10

Table A2(f) – Wildlife-vehicle collision (WVC) carcass surveys 12

Table A2(g) – Soil plots, sand trays, and inkpads 14

Table A2(h) – Diurnal surveys 16

Table A2(i) – Nocturnal and dawn / dusk surveys (spotlighting, stagwatching, call playback) 17

Table A2(j) – Habitat Assessment 19

Table A2(k) – eDNA (environmental DNA).... 21

Table A2(l) – Underwater acoustic camera 22

Table A2(m) – Snorkelling Transects 22

Table A3(a) – Active searches and hand capture 24

Table A3(b) – Tile and other artificial refuge surveys.... 25

Table A3(c) – Pitfall trap and funnel trap ... 27
Table A3(d) – Box (Elliot) and cage traps ... 29
Table A3(e) – Harp traps, mist nets, and trip lining ... 31
Table A3(f) – Tagging and tracking ... 33
Table A3(g) – Electrofishing ... 34
Table A3(h) – Seine netting and dip nets ... 36
Table A3(i) – Fyke nets and gill nets ... 38
Table A3(j) – Macroinvertebrate and benthic sampling ... 40
Table A4.4 – Summary of key tasks, questions, and analysis approaches useful in transportation ecology ... 44
Table A7 – Species-specific survey methods ... 46

Figures

Figure A2(a) – Camera trap set up with bait holder ... 5
Figure A2(b) – Short-beaked Echidna (Tachyglossus aculeatus) captured on a remote camera trap ... 5
Figure A2(c) – Camera mounted on a bracket in a tree to survey for arboreal species ... 5
Figure A2(d) – Passive acoustic bat detector (Anabat) ... 7
Figure A2(e) – Suitable owl hollow ... 9
Figure A2(f) – Nest box ... 9
Figure A2(g) – Wombat burrow ... 9
Figure A2(h) – Koala scats ... 11
Figure A2(i) – Koala scratches on a tree ... 11
Figure A2(j) – Kangaroo WVC ... 13
Figure A2(k) – Sand plot adjacent to fauna fence to survey fauna movement ... 15
Figure A2(l) – Tracks in sand plots for variety of species ... 15
Figure A2(m) – Using spotlights and head torches to conduct nocturnal spotlight surveys for nocturnal species ... 18
Figure A2(n) – Ecologists undertaking a habitat assessment ... 20
Figure A3(a) – Hand capturing a lace monitor (Varanus varius) ... 25
Figure A3(b) – Common blue-tongued lizard (Tiliqua scincoides scincoides) utilising a tile for thermoregulation ... 26
Figure A3(c) – The first tile in a tile transect / grid ... 26
Figure A3(d) – Pitfall trap along a drift fence ... 28
Figure A3(e) – Cage trap ... 30

Figure A3(f) – Elliot trap 30
Figure A3(g) – Elliot traps mounted to a tree for arboreal mammal trapping 30
Figure A3(h) – Mist net set to capture birds 32
Figure A3(i) – Harp Trap set-up 32
Figure A3(j) – Electrofishing using a portable backpack 35
Figure A3(k) – Electrofishing undertaken from a boat 35
Figure A3(l) – Fish survey using a seine net 37
Figure A3(m) – Fish survey using a dip net 37
Figure A3(n) – One-armed fyke net 39
Figure A3(o) – Fyke net 39

A1 Introduction

There are many field-based methods that can be used to survey fauna, flora, and ecological communities. Surveys can be used to determine whether a species or ecological community is present, inform calculations of the likelihood of occurrence, estimate abundance or identify likely movement paths. The accuracy, cost, and timing of each survey method varies and the most effective and least-invasive methods should be employed wherever possible. This appendix lists and describes many of the field survey methods that can be used to survey fauna and their habitat, and summarises where and when they should be considered for use. Approaches and methods for desktop assessments are comprehensively described in Chapter 5 and are only briefly covered here.

Survey guidelines have been developed by both the Queensland and Commonwealth Governments and these describe the accepted best practise method and survey effort required to detect the target species or group of target species. While many survey guidelines are not mandatory, failing to survey appropriately can result in poor environmental outcomes and the department applying the precautionary principle with regard to significant impact determinations. Therefore, survey guidelines should be followed wherever possible to ensure that potential impacts are accurately assessed and thus can appropriately inform avoidance, minimisation, mitigation, rehabilitation / restoration and offset requirements. In addition, the guidelines inform good survey design which is important for collecting useful and consistent data over a period of time. However, the published survey guidelines are not always up to date and newer techniques, which are more accurate, less invasive, or more cost-effective, may have been developed since the guideline was published. New and improved survey methods can be identified by conducting a literature review, consulting subject matter experts (e.g. museum staff, university researchers, and non-government organisations implementing conservation initiatives), and exploring new technologies (e.g. thermal, acoustic, molecular etc.). These new and emerging survey techniques should be considered for use when they have been thoroughly tested and they offer better outcomes than other methods. However, it's important to note that newer survey techniques may need to be used in conjunctions with older techniques so that results can be accurately compared.

The species and communities identified during the desktop assessment, particularly threatened species, will determine the focus of field surveys, and relevant survey methods can then be identified. Fauna surveys must be undertaken by suitably qualified ecologists and conducted in accordance with relevant State and Commonwealth survey guidelines. Those undertaking surveys must hold the appropriate permits including, where relevant, a Queensland Government issued Research Permit or Protected Areas Research Permit, endorsed under an Animal Ethics Committee Approval.

This chapter introduces and outlines survey methods appropriate for general and targeted fauna surveys, estimating population sizes, and documenting movements. It is beyond the scope of this chapter to comprehensively describe all methods in sufficient detail to undertake them. Readers should refer to the relevant survey guidelines for threatened species, published survey guides, and relevant websites for specific methods.

This chapter does not cover:

- Methods for assessing habitat fragmentation and landscape connectivity (Chapter 5).
- Study designs for ecological monitoring, evaluation, and reporting (Chapter 3).

A1.1 Animal welfare considerations

Animal welfare considerations are paramount when planning, designing, and undertaking surveys. The 'three Rs' are highly relevant to undertaking surveys in order to prevent or limit the potential impacts to fauna. They encompass:

- The **replacement** of field surveys with other methods:
  - e.g. through the use of existing data rather than collecting new data.
- The **reduction** of the number of animals being impacted:
  - e.g. by considering how many individual animals actually need to be captured, handled or impacted in other ways to meet the objectives of the survey.
- The **refinement** of techniques that are used to reduce the impact on animals:
  - e.g. through the use of non-invasive or less-invasive survey techniques, such as replacing cage trapping or mist netting with camera traps, hair tubes, and acoustic surveys.

All survey techniques have the potential to impact the habitat being surveyed as well as both the target and non-target species of fauna. Wherever possible, the technique with the least impact to vegetation and habitat, and which is least invasive to fauna, should be selected. The survey techniques described in this chapter are classified as either non-invasive (Section A2) or invasive (Section A3). In practice, all fauna survey techniques fall along a continuum from least- to most-invasive. However, for the purposes of this chapter, non-invasive survey techniques are defined as those that do not require the capture and handling of fauna, and invasive survey techniques involve the capture and/or handling of fauna.

A1.2 General guiding principles

The following guiding principles should be adopted when undertaking fauna surveys.

- Ensure all animal ethics considerations and, if required, approval conditions are adhered to (Section A3.1).
- Understand why surveys are required and design the surveys and/or monitoring to meet the required objectives.
- Follow best practise study design approaches and methods, as outlined in Chapter 3.
- Employ the least invasive survey technique possible that meets the survey objectives.
- Employ the most cost-effective survey technique, such as methods that detect multiple species at the same time.
- Survey at the optimal time, including ensuring surveys are undertaken at the right time of day and year to maximise detectability. For example, frog surveys should be conducted when they are calling, and fish surveys should be undertaken when they are most active (such as during times of higher flows, migration) or when eDNA is most prevalent at sites (for example during spawning periods).

- Sampling bias should be minimised as far as practicable to ensure the results of surveys are representative of the fauna community being surveyed, and not just a portion of the target community. For fish, bias could be minimised, for example, by undertaking both passive and active survey methods that in combination better survey and describe the fish community as a whole.
- Avoid surveying at times of the year when the target species is sensitive, such as trapping bandicoots and other marsupials when they are carrying pouch young or have young left in a nest or den, or disturbing threatened flying-foxes when in late stages of pregnancy (Chapter 10, Figures 2.2(a) and 2.2(b)).
- Follow or exceed the requirements of relevant survey guidelines.
- Consider the spatial extent of the survey area. For example, is there a need to survey more than just the construction footprint to understand the potential occurrence of a species and potential threats? How far might the road- and railway-effect zone (REZ) extend and does that area need to be surveyed?
- Consider the detectability and the level of confidence required for the target species. A larger number of repeat visits to a site will likely be required for more cryptic species than those that are easily detected. Similarly, a higher level of confidence in the survey result will be required for threatened species compared to least-concern species because the potential consequences of a false negative result (i.e. the species was present but not detected) are greater.
- Consider whether a monitoring program is likely required during and/or after construction. Where possible, undertake surveys during the planning and design phase so they can provide a relevant baseline for subsequent monitoring. Refer to Chapter 3 for more information.
- Consider the distribution, density, and likely movements of the target species when determining survey effort. Widespread species that occur in high densities will require less survey effort to detect compared to species which occur at low densities.
- It is not usually possible to conclude with 100% confidence that a species is absent from an area. Absence is usually expressed in terms of confidence, such as a likelihood of occurrence, and is calculated statistically or estimated based on survey effort (i.e. survey duration, number of repeat surveys), habitat suitability, species detectability, and known or likely occurrence in the broader area. Therefore, in Table A2(a) to Table A3(j), absence is given as inferred absence.

A2 Non-invasive survey techniques

Non-invasive survey techniques do not require the capture and handling of fauna. Despite this, some non-invasive techniques can still potentially impact fauna and habitats, and therefore they must be undertaken sensitively.

Non-invasive survey techniques should always be the first option because they reduce impacts on target and non-target species by minimising stress, fauna injury and mortality, and modifying behaviours. Many non-invasive techniques are also less labour-intensive and can be cost-effectively carried out for extended periods of time, as compared to some of the more invasive techniques (Section A3).

Table A2(a) – Camera trapping

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Set digital cameras in suitable habitat to capture images or videos of fauna passing in front of the camera. • Images may be infra-red (black and white) or white flash (colour). • Baits can be placed in front of the camera to encourage fauna to move into field of view to improve image quality and species identification. • Generally targeting medium- to large-sized fauna, however they can also detect small mammals, birds, and medium to large reptiles. • Can be installed at ground level or within trees and other habitats, depending on the target species. • Cameras are also utilised when surveying for fish. Baited and unbaited remote underwater video (BRUV, RUV) stations use bait to attract fish to the stationary underwater camera station, which captures footage of the species that swim past.	• Cost effective, successful, non-invasive method for detecting a wide range of taxa. • Images are stored to a memory card which can be manually downloaded or transmitted via the mobile phone network to the cloud or office computer. • Automated image sorting and classification software is being developed (e.g. Wildlife Insights) applied to speed up image processing time, including on numerous projects in Queensland[1].	• Not all species are equally detectable, such as those that are fast-moving, ectothermic or very small. • Some species can only be identified using colour images. • Species identification can be difficult for small species or species which look similar. • Population density can't be inferred because repeat sightings of the same individual are likely to be captured. • A large proportion of photos may be false triggers, which uses up battery life and memory card space, and increases time costs for image identification. • Typically powered by batteries, which may require periodic replacement (weeks to months) or being kept charged with solar panels. • Camera use within road reserves can capture images of the public and may lead to camera theft if they are not hidden from view.	• Presence / inferred absence. • Relative abundance. • Index of population size. • Species identification. • Capture independent behavioural knowledge.

[1] (McCall et al. 2020, Maitz et al. 2021, Revie and Lovegrove-Walsh 2021).

Figure A2(a) – Camera trap set up with bait holder

Source: © Briony Mitchell, WSP

Figure A2(b) – Short-beaked Echidna (Tachyglossus aculeatus) captured on a remote camera trap

Source: © Emi Arnold, WSP

Figure A2(c) – Camera mounted on a bracket in a tree to survey for arboreal species

Source: © Danelle Scicluna, WSP

Table A2(b) – Acoustic recording

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Record the calls of species that vocalise or communicate using other audible techniques, including birds, frogs, bats, mammals, and invertebrates. • Depending on the recording device, calls across a range of frequencies can be detected and recorded, including ultrasonic bat calls or bird and frog calls within human hearing range. • Species that do not call, rarely call or call at low intensity may not be detected or may be under-represented in acoustic data. • Specialist expertise may be required to identify calls for which automated keys are not yet available. • Call quality may be affected by environmental conditions, such as wind and rain.	• Acoustic recorders can be hand-held or deployed in the field for extended periods of time to capture vast amounts of data. Deployed recorders are operational in the absence of people, thus minimising potential disturbance from the surveyor. • Recording can be continuous, scheduled (e.g. short periods of time at dawn and dusk, one night per week, etc) or triggered in response to calls being detected. • Acoustic recorders can replace many other invasive techniques, such as harp trapping for bats and mist netting for birds. • Automated call recognition software and keys are being developed, enabling identification by non-experts.	• Not all microbat calls are identifiable to species and some closely related species can only be identified to a multi-species call complex (e.g. *Nyctophilus* species, and the *Scotorepens greyii / Mormopterus elery* complex). Trapping is required to confidently identify such species. • Species that do not call, rarely call or call at low intensity may not be detected or may be under-represented in acoustic data. • Specialist expertise may be required to identify calls for which automated keys are not yet available. • Call quality may be affected by environmental conditions, such as wind and rain.	• Presence / inferred absence. • Species identification. • Relative abundance or activity levels. • Identification of temporal patterns of habitat use.

Figure A2(d) – Passive acoustic bat detector (Anabat)

Source: © Carla Meers, WSP

Table A2(c) – Hair tubes and hair funnels

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Baited tubes and funnels with an adhesive insert or double-sided tape that collects fur from the target animal, which is then identified to species based on a range of characteristics. • Can be placed on the ground, within trees or other habitats / crossing structures.	• Relatively cheap and easy to transport and deploy. • Relatively non-invasive method of species identification. • May be able to obtain genetic information from hair samples.	• Hair from similar species may only be identifiable to genus[2]. • If not set up correctly, small reptiles and amphibians may be trapped by the adhesive and die. • Hair identification requires specialist expertise and equipment.	• Presence / inferred absence. • Species identification. • Relative abundance.

Table A2(d) – Hollow, burrow and nest inspections

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Hollows (e.g. natural tree hollows, nest boxes, carved hollows, artificial refuges etc.), burrows, and nests can be physically inspected (i.e. by opening the lid) or inspected with the use of a pole-mounted camera inserted into the entrance hole. • Camera traps may also be placed facing the entrance to detect fauna as they enter and exit. • Generally, targets arboreal mammals and birds with nests or terrestrial mammals in burrows or at ground-level.	• Nest boxes can be deployed for particularly cryptic species (e.g. pygmy possums) although it may take some months or years for them to be occupied.	• Inspections can disturb resident animals and care must be taken to minimise disturbance, especially during the breeding season. • Some types of hollows are easier to inspect than others. For example, the entrance to natural hollows may be too small for the camera to enter, or the hollow may be too deep to see animals at the bottom. • Preferences for hollow type, dimension and placement may be species-specific, and affect results.	• Presence / inferred absence. • Species identification. • Relative abundance.

[2] (Lobert et al. 2001)

Figure A2(e) – Suitable owl hollow

Source: © Briony Mitchell, WSP

Figure A2(f) – Nest box

Source: © Rodney van der Ree, WSP

Figure A2(g) – Wombat burrow

Source: © Briony Mitchell, WSP

Table A2(e) – Searches for scats, tracks, scratches, and other signs

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Non-invasive searching for scats, tracks, scratches, and other signs which indicate the presence of different species. • Used for general and targeted fauna surveys and often undertaken at the same time as habitat assessments or other surveys. • Scats from macropods, arboreal mammals, owls, and some reptiles can be found on bare ground, amongst grass and leaf litter, directly under trees and on logs. • Some species of reptile and quolls may deposit scats in latrines. • Microbat scats often accumulate on the walls of concrete culverts and bridges or on the floor below roosting areas. • Koala (*Phascolarctos cinereus*) scat searches may involve using specific methods such as the Spot Assessment Technique (SAT)[3] and Rapid SAT searches[4]. Trained detection dogs are also effective at searching for scats (Section A4.1). • Other signs include[5]: – Bird pellets and scats. – Flying-fox spats (chewed up fruit that is spat-out). – Skulls and other bones. – Diggings (e.g. bandicoot, rabbit). – Chew marks on hollow entrances left by cockatoos. • Feeding signs such as: – Bones under raptor nests. – Insect wings and parts near bat caves. – Incision marks for sap-feeding by yellow-bellied gliders (*Petaurus australis*). – Flowers dropped after ghost bat (*Macroderma gigas*) feeding. – Orts (chewed casuarina cones) left by cockatoos feeding.	• Many species of arboreal animals leave distinctive marks, such as scratches on tree trunks where they have climbed, or slashes that have oozed sap from glider feeding. • Genetic and hair identification can be used to identify the species that either produced the scat or are the contents of predator scats. • Scats and tracks can indicate fauna movement patterns, feeding trees, and preferred habitats.	• Not all signs can be confidently identified to species or even genus, and this is exacerbated for older signs. • Not all substrates are suitable for recording tracks. Footprints are best preserved in firm substrates such as sand or mud.	• Presence / inferred absence. • Relative abundance. • Species assemblage.

[3] (Phillips and Callaghan 2011)
[4] (Bioilink 2022)
[5] (Triggs 2004)

Figure A2(h) – Koala scats

Source: © Carla Meers, WSP

Figure A2(i) – Koala scratches on a tree

Source: © Emi Arnold, WSP

Table A2(f) – Wildlife-vehicle collision (WVC) carcass surveys

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Surveys of dead or injured fauna on and adjacent to roads and railways. • Survey takes place on foot or in a slow-moving vehicle (e.g. 20-40 km / h). Accurate species identification may be difficult when surveys are performed from a vehicle. • It's best to undertake surveys early in the morning before carcasses are scavenged or damaged. • Both sides of the road or railway should be searched, particularly if carrying out the survey from a car or surveying a road with multiple lanes. • Mark dead animals to avoid double counting during subsequent surveys and check pouches for live young that may require medical attention. • Data can be recorded and analysed using a database with GPS software or maps and should include: – Start and finish time of the survey, including route, to determine survey effort. – Location. – Species / species group. – Date and time found. – Sex, age (juvenile / adult). – Adjacent land use, vegetation type. – Road design (i.e. bend, cut and fill, fencing etc.).	• Wildlife-vehicle collision (WVC) data can be analysed in conjunction with local population data to obtain a more complete view of how WVC are affecting local population size and movement patterns. • Results can be used to determine the target species, location and design of wildlife crossing structures, fencing or other mitigation measures. • WVC surveys can be undertaken for a specific project or can be obtained from incidentally collected WVC data from wildlife carer databases, police crash statistics, insurance companies, agency data, and citizen scientists. • Data from surveys can be used to inform road upgrade projects (e.g. widening) but are more limited to informing greenfield developments. However, WVC surveys at nearby or similar roads and railways can be informative. • Carcasses can be used for complimentary studies, such as disease surveillance, parasite loads, etc.	• WVC surveys only record unsuccessful crossings and do not record fauna that do not attempt crossings or achieve successful crossings. • Surveying on and alongside roads and railways can be dangerous. Human safety must be considered when planning searches due to the proximity to moving vehicles. • Carcasses may be scavenged before being surveyed, or damaged and unable to be identified. It is a less effective survey method for soft bodied animals like amphibians and reptiles as they degrade quickly. • Low rates of WVC does not necessarily imply that WVC is not a significant threat to fauna. Past WVC may have reduced the local population size, resulting in fewer animals to be killed. Therefore, low rates of WVC may represent a high rate of population loss.	• Presence / inferred absence. • Species identification. • Relative abundance. • Unsuccessful crossings. • Fauna movements.

Figure A2(j) – Kangaroo WVC

Source: © Danelle Scicluna, WSP

Table A2(g) – Soil plots, sand trays, and inkpads

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Use of various substrates (i.e. soil, sand, ink) deployed to specifically capture footprints and other fauna markings, which are then identified to species or genus. • Rarely used nowadays and often replaced with camera trapping.	• Easy to deploy and set up. • Does not prohibit the movement of species. • Can be used under bridges where it is too wide for camera traps.	• Not all footprints are able to be identified to species due to poor capture of the print, or rain and other conditions that degrade the substrate or print. In addition, the prints of some species are indistinguishable from each other. • Only useful for species that walk along the ground or arboreal species where substrates can be placed in trees or other locations. • Quite labour intensive as the plots should be monitored regularly (two to three time a week) to avoid the loss of data as a result of overlapping tracks. • Suitable grade of sand can be difficult to obtain and install in remote locations.	• Presence / inferred absence. • Species identification. • Relative abundance.

Figure A2(k) – Sand plot adjacent to fauna fence to survey fauna movement

Source: © Aurecon

Figure A2(l) – Tracks in sand plots for variety of species

Source: © Aurecon

Table A2(h) – Diurnal surveys

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Non-invasive surveys conducted during the day for species that are active or detectable during the day, most commonly diurnal birds. • Bird surveys are generally conducted during low-wind and no-rain conditions in the morning, and again in the late afternoon, corresponding with periods of high bird activity. Birds are identified by direct observation (using binoculars or spotting scopes) and call recognition.	• Targeted diurnal surveys may be undertaken for several species, including basking amphibians and reptiles. • Diurnal bird surveys can be for the entire bird assemblage, or certain species, and can be conducted in different habitats (e.g. wetland, waterways, woodland, forest, or grassland) depending on the target species. • Surveys are usually conducted with standardised survey effort (e.g. one hectare, 20 minutes), allowing comparisons among surveys.	• Requires a skilled observer to ensure all species are correctly identified. • Only conducted during suitable weather (avoiding windy and rainy conditions). • Repeat surveys are required to ensure most species are detected.	• Presence / inferred absence. • Species identification. • Relative abundance.

Table A2(i) – Nocturnal and dawn / dusk surveys (spotlighting, stagwatching, call playback)

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Surveys are conducted from dusk to dawn to detect species that are active at night. Most nocturnal species have peaks of activity at dawn and dusk. • Spotlighting is conducted using a hand-held torch, spotlight or headlamp to detect animals via their reflective eyeshine, including possums, gliders, macropods, geckoes, frogs, and owls. Fauna are also detected by their calls and noises as they move around. • Stagwatching involves the detection of wildlife as they leave their hollow or roost, usually conducted at around dusk. Can include direct observations by people or the use of cameras or acoustic recorders. Can also be undertaken at burrows, dens, cave entrances or waterbodies. • Call playback is often used in association with spotlighting. A call of a target species (i.e. owl, frog) is recorded and played back in the field, after which the observer listens for a response of the target species to determine its presence. Call playback can be undertaken as a transect survey or a point survey. • Nocturnal surveys can also be undertaken using hand-held or drone-mounted thermal cameras that detect the heat of the animal which contrasts against the heat of the surrounding background. Follow up with a standard spotlight survey may be required to identify the animal to species.	• Non-invasive and relatively cheap survey method when conducted using torches or spotlights. • An effective method for surveying nocturnal fauna. • Surveys are relatively quick to undertake, and multiple sites can be surveyed on the same night.	• Call playback and spotlighting can disturb animals if undertaken for too long or too frequently, or if the spotlights are too bright or the call playback recordings are too loud. • Only conducted during suitable weather (avoiding windy and rainy conditions). • Call playback relies on the surveyor having adequate knowledge to identify calls and can only be used to survey certain species (i.e. specific calls to initiate responses may not be available). • Relatively expensive when thermal cameras and/or drones are used. Other constraints include: • Limited use of drones in areas with dense canopy cover. • Limited use of thermal cameras in warmer climatic environments.	• Presence / inferred absence. • Species identification. • Relative abundance.

Figure A2(m) – Using spotlights and head torches to conduct nocturnal spotlight surveys for nocturnal species.

Source: © Mike Youdale, WSP

Table A2(j) – Habitat Assessment

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Used to identify and describe the habitat and inform the likelihood of fauna occurrence (e.g. *Melaleuca* swamplands, mixed eucalypt open woodland, regrowth semi-evergreen vine thicket, very open woodland with native grassy understorey etc). • Can include quantification of specific habitat features (e.g. hollow-bearing trees, peeling bark, leaf litter etc.) that certain species require. • Habitat assessments should record the following data: – Dominant vegetation composition and structure. – Potential food sources (e.g. flowering and fruiting species of plants). – Potential to support prey for threatened fauna (e.g. amphibians for ornamental snake (*Denisonia maculate*), possums and gliders for powerful owl (*Ninox strenua*). – Microhabitat features for breeding and shelter (i.e. hollows, dense leaf litter, rocky outcrops). – Nearby waterways or distance to water. – Level of disturbance (previous clearing, fire, agricultural use etc.) and potential threatening processes (weeds and vertebrate pests, proximity to roads and railways etc.). – Any fauna or evidence of fauna presence (e.g. scats, tracks, scratching on trees) that are observed opportunistically should be recorded.	• A useful way to determine the best places to focus additional survey effort.	• Can only infer potential habitat for species (i.e. further surveys may be required to confirm species presence. • Habitat assessments undertaken at the wrong time of the year can fail to identify potential habitat (i.e. natural grassland environments and ephemeral wetlands can be more difficult to identify at certain times of the year.	• Habitat attributes.

Figure A2(n) – Ecologists undertaking a habitat assessment

Source: © Troy Jennings, WSP

Table A2(k) – eDNA (environmental DNA)

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Involves the extraction of genetic material from the environment. eDNA samples are usually collected from aquatic habitats to survey for aquatic and semi-aquatic wildlife. • Samples are sent to a laboratory for analysis where the unique sequence of each DNA molecule is analysed for matches against a database of species. A match confirms which species are found in the area where the sample was collected.	• Useful survey technique for highly mobile or cryptic species like platypus (*Ornithorhynchus anatinus*). • Samples are easy and quick to collect meaning multiple sites can be surveyed. • Can be used to survey areas where there may be logistical limitations for traditional survey methods. • Sample collection is not limited by weather conditions. • Potential to identify the presence of multiple species from the same sample. • Can be more cost effective than undertaking ecological presence / absence surveys which are usually labour intensive and limited by seasonal and weather conditions.	• The success of eDNA relies on the availability of genetic sequencing for the target species. • eDNA can be transported throughout ecosystems, making it difficult to confidently determine a species presence in a specific area. • Results are not instantaneous, and analysis of the samples must be conducted by professionals. • Multiple, repeat samples may be required to ensure false negatives are avoided, particularly where the presence of rare or cryptic species are suggested. • The method on its own cannot indicate abundance, only presence / absence of a species. • Collecting a sufficient volume of water from highly turbid sites is problematic and time consuming, often necessitating considerably more replicates to be collected.	• Presence of rare and endangered or pest species not sampled physically.

Table A2(l) – Underwater acoustic camera

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Adaptive Resolution Imaging Sonar and Dual-frequency Identification Sonar acoustic cameras can be used to determine presence, abundance, length, behaviour, and possibly species (of fish >100 millimetres long). • Works by transmitting and receiving sound pulses that bounce off underwater animals or objects and are converted into high-resolution digital images, allowing for real-time counts and observations of fish in their natural habitat without the need for visible light.	• Can be deployed to survey fish and other large aquatic fauna such as turtles. • Can survey habitats in a variety of settings, including deep or turbid environments, or at night.	• Processing the large outputs of data can be time consuming. • Software is available to automatically analyse acoustic video data, but manual ground truthing is also required. • While capital cost of equipment is high, the operational costs are lower than traditional survey methods and become more cost-effective as more surveys are completed. • The technology cannot be used effectively in turbid water. • Data collected may not be representative of the full fish community at a site due to habitat preferences and cryptic nature of many species.	• Presence / inferred absence. • Relative abundance. • Species identification.

Table A2(m) – Snorkelling Transects

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• The activity by which turtles pop to the surface to breathe when swimming. Snorkel transects can be used to quantify density through timed searches when turtles can be identified visually, counted, and sexed.	• Turtles can be surveyed without disrupting their behaviour.	• Estimating abundance can be difficult as individual identification is typically not possible.	• Presence / inferred absence. • Relative abundance. • Species identification.

A3 Invasive survey techniques

Invasive survey techniques involve, or potentially involve, the capture and handling of fauna. The most invasive are those that capture and potentially restrain animals for relatively long periods of time, typically overnight, such as cage or Elliot trapping and pitfall trapping. Less invasive techniques are those where the period of restraint is typically shorter in duration (e.g. harp trapping or mist netting). Active searches of habitat (e.g. overturning rocks and logs and searching under crevices in tree bark or under leaf litter) are also less invasive as the animal is only restrained for as long as it takes to identify the species.

Invasive trapping methods are usually aimed at detecting a target species, however many are also useful in surveying least-concern fauna. Trapping should only be conducted by suitably qualified and experienced ecologists, in accordance with the conditions stipulated in their Animal Ethics Approval and Research Permit. Examples of trapping methods commonly utilised for ecological surveys are outlined in in the following tables.

Table A3(a) – Active searches and hand capture

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Surveys involve searching the sites that animals shelter in, and their removal from under logs, rocks, bark, and leaf litter or in holes and burrows. • Animals are only captured / handled if required for identification or recording purposes. Immediately after processing, habitat features are carefully replaced and captured animals are released under vegetation, leaf litter, bark or a log as close as practicable to the point of capture. • A common technique for surveying amphibians, reptiles, and some mammals.	• Cost effective and easy to undertake as no equipment is required. • Can be undertaken in a variety of habitats and ecosystems.	• Requires experienced personnel to capture and/or correctly identify observed species. • High degree of diligence and care is required to ensure surveys are undertaken in a safe manner due to the risks associated with venomous fauna (i.e. snakes, spiders). • Searches can impact the microhabitat if care is not taken. • Surveys can be limited by weather conditions, depending on the target species. • Can cause some stress to the captured fauna, but this is usually only for a temporary period of time.	• Presence / inferred absence. • Abundance. • Species assemblage. • Individual details (age, sex, reproductive status, etc).
• KOALA CAPTURING			
• Capturing Koalas using extendable poles with flags attached to one end. The poles are manipulated from the ground or by an arborist and are waved above the Koala's head to be perceived as a threat and to encourage the Koala to descend to the ground[6].	• Poses fewer risks than other Koala capture techniques, such as the safety line (or noose) and flag technique.	• Can be time consuming. • Can be near impossible to undertake successfully if the Koala is higher up in the tree than the length of the pole. • Koalas can get acclimatised to the flag and be less responsive, resulting in failed captures. • Can cause some degree of stress to Koalas.	

[6] (DPIE 2020)

Figure A3(a) – Hand capturing a lace monitor (Varanus varius)

Source: © Troy Jennings, WSP

Table A3(b) – Tile and other artificial refuge surveys

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Tiles or other artificial refuges are placed in situ and over time fauna move under them. Periodic surveys are conducted by lifting the tile, and fauna underneath are captured and identified. Commonly used for reptiles, including legless lizards. • The removal of tiles after the survey should be done gradually and sensitively, to avoid further habitat disturbance.	• Animals are free to occupy and leave the shelters at any time. • Surveys are simple to undertake and relatively cheap to implement.	• Deployment and demobilisation of tiles / artificial refuge can be labour intensive. • Requires experienced personnel to capture and/or correctly identify any observed species. • Surveys can be limited by weather conditions (i.e. typically conducted in the morning when reptiles are most likely to be utilising the shelters for thermoregulation.	• Presence / inferred absence. • Species identification. • Relative abundance. • Species assemblage. • Individual details (age, sex, reproductive status, etc).

Figure A3(b) – Common blue-tongued lizard (Tiliqua scincoides scincoides) utilising a tile for thermoregulation

Source: © Danelle Scicluna, WSP

Figure A3(c) – The first tile in a tile transect / grid

Source: © Briony Mitchell, WSP

Table A3(c) – Pitfall trap and funnel trap

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Pitfall trapping typically targets small–medium sized reptiles, amphibians, and small terrestrial mammals. • Buckets, PVC tubes or other similar receptacles are dug into the ground so that the rim is level with the surface. Typically deployed in a line or in an array. • Drift fencing is placed along the line which funnels animals to the pitfall traps. Animals fall in and are unable to climb out. • Individual pitfall traps can be covered to protect captured animals and provide shelter from rain, extreme heat, and falling debris. • Pitfalls must be checked at dawn to prevent animals overheating and to minimise the risk of fighting or predation among animals trapped at the same time.	• Can trap a variety of fauna species. • Reasonably cheap method of trapping.	• Can take a long time to set up and is labour intensive if holes are dug by hand. Use machinery where possible. • May trap non-target species. • If buckets are used, larger predatory species (i.e. monitor lizards) can fall into the traps or be enticed into the traps and prey on other trapped species.	• Presence / inferred absence. • Species identification. • Relative abundance. • Species assemblage. • Individual details (age, sex, reproductive status, etc.
• Funnel trapping is used primarily for catching medium-large sized snakes, skinks, and dragon lizards. • The trap consists of a wire frame wrapped with shade cloth, approximately 75 centimetres long with a funnel opening at both ends. Like a pitfall trap, it is usually placed alongside a drift fence to funnel animals towards the trap.	• No risk of drowning in the event of unexpected rain. • Funnel traps are constructed of green shade cloth providing a visual barrier from potential predators and protection from the sun. • Minimises disturbance to habitat and soil. • Identification and release of snakes and dragons does not require handling.	• Can be a little difficult to see and retrieve animals from funnel traps, and therefore they require a thorough check before re-setting them for another trapping session.	

Figure A3(d) – Pitfall trap along a drift fence

Source: © Carla Meers, WSP

Table A3(d) – Box (Elliot) and cage traps

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Box traps are made of sheet metal or similar material and cage traps are made of wire mesh. Elliot® traps are the common type of box trap used in Australia and come in three different sizes. • Other traps include mesh fencing for macropods. • Traps are baited and animals enter the trap to eat the bait. The door is closed when they enter the trap or pull on the bait holder. • Box and cage traps can be positioned on the ground or in trees, depending on the target species. • Baited box traps for aquatic surveys can also be placed in shallow water to capture small fish and crustaceans. • Traps should be set with appropriate nesting material inside to provide any captured animals with some shelter from extreme temperatures. Protection from rain / sun can also be provided by placing vegetation on top of Elliot traps, or covering the closed end of cage traps with a hessian or plastic bag. • Trapping success depends on the type of trap, bait used, and placement in suitable habitat and movement runways or pathways. Trap success can be enhanced through the use of drift fencing. • Traps should be closed when target species is not active to avoid bycatch.	• Some traps can include automated alerts sent via cellular data to advise when triggered. • Traps can be used in any type of habitat. • Traps are safe to use for most fauna and provide shelter. • Species identification can be 100% confirmed by taking various morphometric measurements, such as weight, body size, tooth wear, age, colour, etc.	• Initial set up and daily inspections, sometimes over multiple days, can be labour intensive. • Multiple checks during each 24-hour period may be needed during the breeding season for certain sensitive species. • May catch non-target species and can be stressful to captured animals. • Traps will only capture the first animal to enter and trigger the trap. • Suitability for aquatic surveys is limited to shallow water habitats.	• Presence / inferred absence. • Species identification. • Relative abundance. • Species assemblage. • Individual details (age, sex, reproductive status, etc).

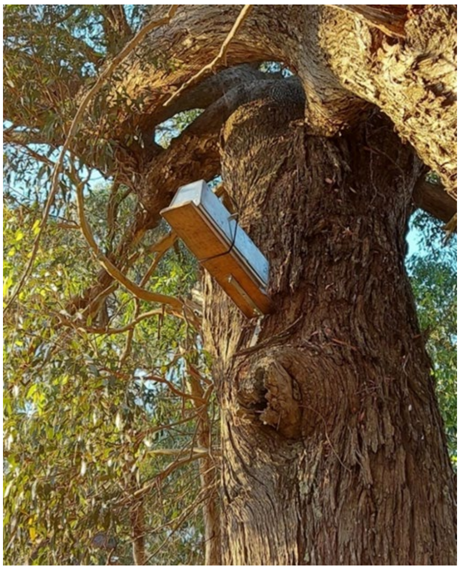
Figure A3(e) – Cage trap

Source: © Rodney van der Ree, WSP

Figure A3(f) – Elliot trap

Source: © Angus Houston, WSP

Figure A3(g) – Elliot traps mounted to a tree for arboreal mammal trapping



Source: © Danelle Scicluna, WSP

Table A3(e) – Harp traps, mist nets, and trip lining

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Harp traps and mist nets are used to capture microbats, flying-foxes, and birds. Trip lines are used to catch microbats above waterbodies. • Harp traps resemble harps with two to three banks of vertical fishing line which are set at night in flight paths of microbats. Bats do not detect the fishing line and once they collide with it, they slide down to a holding bag at the base where they stay until removed and processed. Bats are either released immediately or stored in calico bags during the day until they can be released later that night. • Mist nets are lines of polyester netting or nylon string strung between two poles. The net has multiple ‘pockets’ to capture bats and birds. Mist nets are much larger than harp traps and can be set to cover larger areas. • Mist nets for bird surveys should be opened just after sunrise to coincide with the morning chorus, when birds are usually active. Nets should not be opened in the dark, except in limited circumstances, due to the risk of capturing microbats and flying-foxes. • Trip lining can be used to catch bats at small waterbodies such as dams and waterholes. A high tensioned nylon line sits above the surface of the water. As the bat skims along the water to drink, they strike the line, fall into the water and swim to the bank where they can be collected.	• Able to collect various morphometric measurements (e.g. body weight, size, colour, tooth wear etc.) to confirm species identification. • If required, captured animals can be banded and recaptured to estimate population size, longevity and etc.	• Any bat surveys need to be undertaken by qualified handlers that are vaccinated to protect against Australian Bat Lyssavirus (ABL). • Harp trapping and mist netting for birds and bats should only be undertaken when conditions are dry, warm, and calm. • Harp traps should be checked multiple times throughout the night, especially if a large number of bats are expected or there is a risk of capturing predatory bat species. • Mist nets should be constantly monitored to allow for the timely extraction and processing of captured birds and bats. • Trip lining is not very suitable in areas with dense vegetation around the water’s edge. • Trip lining can cause more stress to the animal than the other survey techniques and so should be considered only after less invasive methods have been attempted and demonstrated to be ineffective[7].	• Presence / inferred absence. • Species identification. • Relative abundance. • Species assemblage. • Individual details (age, sex, reproductive status, etc).

[7] (Department of the Environment Water Heritage and the Arts 2010a)

Figure A3(h) – Mist net set to capture birds

Source: © Jon Colemon, WSP

Figure A3(i) – Harp Trap set-up

Source: © Troy Jennings, WSP

Table A3(f) – Tagging and tracking

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Used to quantify the movements of fauna and how they interact with each other, infrastructure, and the natural environment. • Animals are captured and the tracking device is fitted using a species-specific method, such as a collar, harness, glued directly to the skin or feathers, or attached to their feet or tail. The animal is then released at the site of capture. • Tracking devices use different technology, including: – Satellite. – High frequency radio waves. – GPS units utilising mobile telephone networks. – Dart tags (for fish). • Location accuracy, cost, and study duration can vary significantly depending on transmitter type, fauna species, and data needs.	• Can target most terrestrial and aquatic species (depending on size and type of the tracking device). • Fauna doesn't need physical monitoring via foot or vehicle and data can be checked from a computer or phone. • Reduces the need for ongoing or repeated interactions with fauna. • Depending on the method, location accuracy can be very precise, and the location recorded very frequently. • The quality of the data and information obtained can be very insightful.	• Animal needs to be captured and restrained to fit transmitter which may cause some temporary stress. • There are potential longer-term impacts to the fauna carrying the transmitter due to transmitter weight, poor attachment, etc. • Technology can fail (i.e. battery depletion and/or solar stops working, or transmitters can fall off the animal and get lost). • Transmitters can be expensive to purchase and attach to the animal. Ongoing costs for monitoring may also be expensive. • Sample size needs to be considered as several individuals need to be captured and tracked for the data to be useable.	• Species identification. • Fauna movement. • Fauna interactions. • Habitat use.

Table A3(g) – Electrofishing

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Fishing technique that uses direct current electricity flowing between a submerged cathode and anode which attracts and/or stuns fish, allowing them to be captured with a net. • Can be undertaken using a portable backpack or from a boat. • Backpack electrofishing is suitable for fish species present in shallow water & small pools. Boat based electrofishing is suitable for fish species in deeper water and edge habitats in river reaches and large pools. • Multiple "shots" over representative habitats records fish catch per power on time which can be used to determine species abundance. • It is important when processing and handling fish that stress is minimised. Where captured fish are to be retained prior to being processed, the receptacle in which they are held should be placed within the shade in a quite place, be covered and be suitably aerated. • Fish should be held at an appropriate density, and crowding should never occur. • Predator and prey fish species should not be kept within the same receptacle. • Where fish are being handled, it should be ensured that any equipment, hands, etc that physically come into contact with them should be the same temperature as the fish, and be wetted down with water from the site of capture prior to the fish being handled. • The body of the fish should be fully supported when out of the water, and they should always be held horizontally, and never held by the gills.	• Catches most species in an area. • Useful for covering a large area quickly.	• Effectiveness varies according to fish size and species composition in an area. • Not effective in saltwater. • Can injure fish, especially those with longer bodies, as well as other aquatic animals like platypus, turtles, and non-target species. • Requires specialist equipment and personnel.	• Species assemblages. • Community composition and abundance. • Identify barrier impacts by determining presence or absence of migratory species of fish.

Figure A3(j) – Electrofishing using a portable backpack

Source: © Aaron Jenkin, Aquatica Environmental

Figure A3(k) – Electrofishing undertaken from a boat

Source: © Aaron Jenkin, Aquatica Environmental

Table A3(h) – Seine netting and dip nets

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Active nets pushed through water to sample fish & crustaceans in wadeable waters. • Seine fishing uses weighted nets with a mesh size ranging from 1.0-15.2 centimetres. They can be used singly or in combination as a block of nets at the downstream end of a riffle zone or narrow section of a channel. A number of personnel are positioned side-by-side upstream and proceed slowly towards the net, feeling substrate, under logs, and along edges of undercut banks. • Dip nets are an open-faced net attached to a handle, often used in a sweeping motion to capture fish and crustaceans. • It is important when processing and handling fish that stress is minimised. Where captured fish are to be retained prior to being processed, the receptacle in which they are held should be placed within the shade in a quite place, be covered and be suitably aerated. • Fish should be held at an appropriate density, and crowding should never occur. • Predator and prey fish species should not be kept within the same receptacle. • Where fish are being handled, it should be ensured that any equipment, hands, etc that physically come into contact with them should be the same temperature as the fish, and be wetted down with water from the site of capture prior to the fish being handled. • The body of the fish should be fully supported when out of the water, and they should always be held horizontally, and never held by the gills.	• Simple and rapid method of determining fish species and sizes in suitable habitat.	• Multiple people are required to undertake seine fishing surveys. • Sein fishing is not suitable for deep water or areas with large amounts of rocky or timber habitat. • Both net types have the potential to capture non-target animals such as turtles and platypus. • Where seines with larger mesh sizes are solely employed, small bodied species may not be captured and as a result survey data would be skewed towards medium to larger bodied fish, resulting in an incomplete record of the community composition at a site.	• Species assemblages. • Secondary or additional method to support other survey methods in most cases.

Figure A3(l) – Fish survey using a seine net

Source: © Aaron Jenkin, Aquatica Environmental

Figure A3(m) – Fish survey using a dip net

Source: © Aaron Jenkin, Aquatica Environmental

Table A3(i) – Fyke nets and gill nets

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Passive nets that are set within suitable habitat. • Multiple mesh sizes required for capturing a wide variety of fish species. • It is important when processing and handling fish that stress is minimised. Where captured fish are to be retained prior to being processed, the receptacle in which they are held should be placed within the shade in a quite place, be covered and be suitably aerated. • Fish should be held at an appropriate density, and crowding should never occur. • Predator and prey fish species should not be kept within the same receptacle. • Where fish are being handled, it should be ensured that any equipment, hands, etc that physically come into contact with them should be the same temperature as the fish, and be wetted down with water from the site of capture prior to the fish being handled. • The body of the fish should be fully supported when out of the water, and they should always be held horizontally, and never held by the gills.	• Samples a wide range of fish species. • Able to cover large areas and a broad range of habitats. • Gill nets can sample deep water. • Fyke nets have lower impact on captured fish. • Fyke nets can be oriented to determine the direction of travel (upstream / downstream).	• Labour intensive to set nets and clear fish. • Gill nets have the potential to injure fish. • Both net types have the potential to capture non-target animals such as turtles and platypus. • Must be regularly monitored to minimise impacts to target and non-target species (particularly gill nets). • Passive technique that relies on the fish actively moving into the net. This method when used on its own is prone to producing survey results that are not representative or indicative of the entire fish community. Ideally therefore, this technique should be undertaken in combination with an active technique (e.g. electrofishing) to ensure the entire fish community is represented in survey results.	• Species assemblages. • Community composition and abundance.

Figure A3(n) – One-armed fyke net

Source: © Carla Meers, WSP

Figure A3(o) – Fyke net

Source: © Aaron Jenkin, Aquatica Environmental

Table A3(j) – Macroinvertebrate and benthic sampling

DESCRIPTION AND METHOD	ADVANTAGES	DISADVANTAGES	DATA PRODUCED
• Use of active dip or larval nets to collect pelagic fish larvae and macroinvertebrates, and bottom grabs to sample benthos.	• Larval nets can be selected to capture specific sized larvae or macroinvertebrates. • Easily deployed and retrieved. • Replicated sampling can determine differences in faunal communities between locations.	• Requires a high level of operator training and strict processes to prevent contamination of samples between sites.	• Species assemblages. • Community composition and abundance.

A3.1 Ethical considerations for invasive survey techniques

Invasive survey techniques involve the capture and/or handling of fauna, and many of the non-invasive techniques potentially involve some disturbance or interference with habitat. All survey techniques must aim to eliminate or reduce the likelihood and severity of impacts to fauna.

A3.1.1 Trapping considerations

All trapping techniques which involve the capture and/or handling of fauna should consider the following:

- Pitfall, cage, and Elliott traps that are set overnight must be checked before sunrise or within two hours of sunrise, before temperatures become harmful. Traps open during the day must be checked before dusk. Mist nets must be constantly supervised, and any captured animals immediately removed. Harp traps must be checked periodically during the night and cleared before dawn. Traps for aquatic fauna must be checked regularly.
- Trapping should be avoided during the breeding season to minimise risk to dependent young that may be deposited in a nest or den.
- Shelter should be provided within and on top of traps (e.g. hessian bags covering cage traps and leaf litter to cover Elliot traps).
- Shelter should be provided at the bottom of pitfall traps and a float (e.g. cork / foam) added to reduce the risk of drowning if there is a rain event. Pitfall traps must be closed if they begin to fill with water, and they should not be opened until the risk of drowning has passed.
- Trapping should not be undertaken during extreme weather, including extreme heat or cold, high rainfall or strong wind.
- During wet periods, a plastic bag or other waterproof cover should be wrapped around the end of the cage or box trap to provide protection for fauna.
- Close traps if predating ants or other predators become a problem, and ensure that when traps are set up that they are positioned away from large ant nests.
- Consider pathogen and weed spread when using trapping equipment in multiple locations and ensure they are thoroughly washed and disinfected before using on new projects or sites.

- If death of fauna occurs, trapping should be stopped at the site if further mortality is considered likely. Trap deaths must be reported to the relevant animal ethics committee.
- Processing of fauna should be done as quickly as possible to limit stress. Fauna should be released in the same spot as they were captured, in a sheltered location. Nocturnal fauna should be released prior to or shortly after dawn, or at dusk if possible. If held over the day, they should be housed in cool, quiet, and sheltered locations.
- Strict hygiene protocols (e.g. hand washing, single-use gloves) are required when trapping and handling amphibians to minimise the spread of disease such as chytrid (Chapter 18).

A3.1.2 Active search considerations

Active searching that necessitates the disturbance of habitat, including the peeling of bark, lifting and rolling of logs and rocks, and searching through leaf litter, should consider the following:

- Every attempt should be made to keep damage to a minimum from active searches. Additionally, ensure any disturbed habitat is replaced as much as possible, such as re-rolling rocks and logs back into place and not removing whole sheets of exfoliating bark if the animal can be identified without removing the whole section. Ensure sufficient time between repeat surveys for damage to recover and fauna to recover from the disturbance.
- Avoid handling or disturbing fauna unless absolutely necessary. This especially applies to fauna that are nesting or have young (e.g. birds on nests, possums with joeys, migratory bird roosts).
- Any captured animals should be released at the site of capture as soon as possible following identification.
- Limit call playback sessions to one site per night to minimise disturbance, especially where territorial species may be attracted to the calls at different sites.
- Exposure to white light temporarily reduces night vision of birds and mammals, so avoid prolonged exposure to animals when using a spotlight beam and only use to briefly locate and identify the species. Infra-red beams, red filters or reducing brightness can be used to reduce the light intensity.

A4 Emerging survey techniques

Fauna survey methods are constantly evolving with new techniques, and improvements to existing techniques, being developed. New and improved techniques should always be considered when designing field surveys if they improve survey efficacy or cost-effectiveness. However, it is also important to consider whether changes in survey methods may compromise the consistency of long-term survey data that has already been collected (e.g. changes to survey technique may increase rate of detection) or complicate comparisons to results from other areas that were collected using an older method. In this section, we describe some new and emerging survey techniques that have recently been developed and tested.

A4.1 Detection dogs

Trained detection dogs can be used to detect numerous species of plants and animals and are increasingly being used in searches for threatened species[8]. Detection dogs in Australia have been primarily used to detect koalas, including their scats. However, dogs can be used to survey a wide range of species once they have been trained on them[9]. This survey technique has emerged over recent years as a new, cost-effective way of conducting targeted species surveys over large project areas. Koala detection dogs have been recently used on road and rail projects in Queensland including sections of the Bruce Highway upgrade and the Moreton Bay Rail Project.

The use of koala detection dogs provides a highly reliable field survey alternative to traditional visual and scat search methods. Koalas and their scats can be cryptic and difficult for people to detect, particularly where the midstorey and leaf-litter is dense. As scat odour persists in the field for weeks to months, detection dogs can record hidden scat at a higher rate, more accurately, and more efficiently than traditional ecological surveys alone[10].

The scats that are detected can also be collected and used for other aspects, such as estimating the immediate and long-term genetic consequences of linear transport infrastructure, quantifying changes in population size and estimating the extent of dispersal post-construction required to maintain connectivity.

Use of koala detection dogs can be an efficient way of gathering data over large project areas. Accurate presence / absence data, population estimates, and dispersal behaviour data can greatly influence the outcomes of a koala impact assessment and thus more accurately inform potential impacts and offset requirements. It can also better inform management protocols during construction, and the design requirements for species-specific mitigation measures.

A4.2 Thermal cameras

Thermal imaging technologies including handheld cameras, as well as cameras fitted to drones, are emerging as an efficient method for direct targeted mammal surveys. Thermal cameras rely on detecting a heat signature, and therefore a difference in temperature between an animal and the ambient environment. Therefore, thermal cameras can be used to target warm blooded animals including mammals and birds. The reliance on detection of temperature difference means that survey timing and target species are an important factor in the use of thermal camera surveys. For example, thermal cameras are more effective during cooler ambient temperatures (dawn and night time, typically after midnight), and on fauna with a warmer body temperature than the ambient environment (i.e. not generally suitable for reptiles and amphibians).

Targeted Koala surveys using thermal cameras are being utilised within the industry during ecological surveys, as well as pre-clearing surveys during construction as a tool for on-ground koala management. Thermal cameras fitted to drones can provide an assessment of an entire site when deployed using systematic parallel linear line-transects, or similar, and can record more koala individuals within a given site than traditional methods such as spotlighting or SAT[11]. However, the use of aerial drones can be restricted by legislative and environmental factors (i.e. suitable flight

---

[8] (Cristescu et al. 2015, Thomas et al. 2020, Bennett et al. 2022)
[9] (Bennett et al. 2022)
[10] (Cristescu et al. 2015)
[11] (Ryan R. Witt 2020)

weather), and the accuracy of the data can be compromised with increased flight speed and tree canopy density. Disturbance to fauna from drones should also be considered and any guidelines followed.

Similarly, handheld thermal cameras can be used on the ground and provide an added survey technique during dawn, dusk, or nocturnal spotlighting surveys. They can be used to detect more cryptic animals such as Koalas and small mammals, as well as ground nesting or arboreal stick nesting bird species. However, the operator needs to continuously scan the site in order to see the target species as animals can be obscured by trees and branches when viewed from certain angles.

The cost of purchasing, maintaining, and using thermal cameras and drones has reduced significantly since their development and, as such, is becoming increasingly accessible and utilised within the ecology field. This technology can provide a cost-effective method that reduces survey effort whilst providing more data.

A4.3 Environmental DNA

Environmental DNA (eDNA) is the use of genetic material that is extracted from soil, sediment, water, or snow. This survey technique is most commonly used to monitor aquatic and semi-aquatic wildlife. In these instances, eDNA is extracted from a water sample, with the DNA having originated from saliva, urine, faeces, and skin cells of animals that have recently visited or entered a waterbody. This technology is particularly useful in detecting the presence of animals that are highly mobile or cryptic, as the animal does not need to be present at the time of sampling and is thus non-invasive.

The success of eDNA relies on genetic sequencing for the target species being available in order to match to the sample collected. Fortunately, eDNA is becoming more cost effective and reliable, with continual advancements in the quality and diversity of open-access genetic database information and sequencing technologies available[12].

Furthermore, studies have shown that eDNA sampling can be more sensitive than some of the more traditional aquatic survey methods used, such as backpack electrofishing[13]. Therefore, consideration should be given to the collection of eDNA samples as a secondary survey method to supplement and support standard aquatic survey techniques.

A4.4 Landscape genetics

The collection and analysis of genetic material from target species across a study area and/or over time can efficiently measure important parameters such as dispersal, migration, gene flow, and other biological variables[14]. The use of genetic approaches in transportation ecology is becoming widespread and are increasingly the most efficient and cost-effective way to measure many of the following parameters:

- The barrier effect of existing roads and railways[15].
- The success of crossing structures at mitigating the barrier effect[16].

---

[12] (Beng and Corlett 2020)
[13] (McColl-Gausden et al. 2021)
[14] (Sunnucks and Balkenhol 2015)
[15] (Frère et al. 2023)
[16] (Soanes et al. 2018)

- The size and 'health' of the population by measuring effective population size.
- Which species and which individuals (e.g. adults, dispersing juveniles) are crossing linear infrastructure using crossing structures or other techniques.
- The effects of the road or railway on breeding success, population size, etc.
- The identification of unidentifiable WVC carcasses, scats, and other samples.

Genetic samples can be collected from scats, skin samples when animals are captured (e.g. ear notches, tail clips), remotely collected fur samples[17], and feathers. Specialist expertise and equipment are required to both extract DNA from the samples and analyse and interpret the data. The kinds of questions that can be answered using molecular population genetic approaches are given in Table A4.4.

Table A4.4 – Summary of key tasks, questions, and analysis approaches useful in transportation ecology

TOPIC AND RELEVANT QUESTIONS	GENETIC APPROACH
DEFINITION AND MAPPING OF POPULATIONS	
• How many populations are there and where are they located?	• Genotypic clustering and spatially-explicit landscape genetics.
• How long have they been there?	• Comparisons of outcomes of genotypic, frequency-based, and DNA sequence-based analyses.
BETWEEN-POPULATION PROCESSES	
• How are populations structured and how different are they?	• Spatial autocorrelation, Mantel tests. Frequency differentiation tests of genotypes, gene frequencies, and DNA sequences.
• What are the rates, patterns of dispersal, and gene flow? • What kinds of individuals disperse with what probability?	• Assignment / parentage tests for contemporary estimates, medium-term estimates from gene frequencies, long-term estimates from DNA sequences and coalescent analyses.
• What proportions of individuals are from different sources and how mixed is the ancestry of individuals?	• Assignment tests and mixed-stock analyses.
WITHIN-POPULATION PROCESSES	
• What is the effective population size?	• Patterns of genetic variation, particularly in microsatellites and DNA sequences
• Has the effective population size changed recently?	• Tests based on loss of genetic variation and coalescence.
• Have fundamental population processes (e.g. mating systems, kin interactions) changed?	• Assignment, parentage, and kinship tests → local dispersal, social / mating systems, and kin structure.

[17] (Clevenger and Sawaya 2010)

TOPIC AND RELEVANT QUESTIONS	GENETIC APPROACH
MONITORING AND MITIGATION	
• Species identification of animal vehicle collision. • Causes of mortality.	• DNA sequence comparisons with databases. • Forensics applications, e.g. DNA sampled from classes of motor vehicle or roads.
• Censusing, births, deaths, reproductive success, migration, sex ratio, space use including road-crossing, and use of mitigation structures.	• Non-invasive sample collection, genotype-matching, genetic capture-mark-recapture analysis.
PROPERTIES OF LARGE-SCALE SYSTEMS	
• Relationship between road networks and functional connectivity, barrier / filter effects of natural and built landscape features. • Relationship between road impacts and population persistence.	• Connectivity modelling, isolation-by-resistance, partial mantel tests, and emerging improvements. • Demogenetic modelling.

Source: Sunnucks and Balkenhol 2015.

A5 Survey methods for pre-construction clearing of fauna

The detection and removal of fauna prior to clearing is critical to reduce the risk of animal injury and mortality. The survey methods described in this Appendix can be used to detect and/or capture and relocate fauna from the construction footprint. The methods which most effectively detect and capture fauna should be adopted.

The specific methods, timing, and processes for pre-construction clearing of fauna, including salvage and relocation, are described in Chapter 7.

A6 Survey methods for post-construction monitoring

The survey methods adopted during post-construction monitoring and evaluation are dependent on the target species and the objectives of the evaluation.

Most of the survey methods described in this appendix can be used to evaluate the impacts of the road or railway on fauna and to quantify the use and effectiveness of mitigation measures (e.g. crossing structures, fencing, hollow replacement programs, WVC rates etc).

While the survey method used in these contexts is similar to those used to detect fauna during planning and construction, the design of the monitoring and evaluation program is very different. The design of the program refers to the treatment being applied (e.g. installation of fences or crossing structures), the number of sites being surveyed (i.e. replication), the collection of data before and after an intervention, and the use of treatment sites and control sites. It is important that the data collected has sufficient inferential strength to answer the questions posed. Chapter 3 describes the design and implementation of monitoring and evaluation programs.

A7 Species-specific survey methods

Survey methods for specific species groups of fauna are described in Table A7.

Table A7 – Species-specific survey methods

TARGET FAUNA	SURVEY TYPE	DESCRIPTION	CROSS REFERENCE
		AMPHIBIANS	
	Call playback (transect surveys)	• Walk through searches in suitable habitat listening for calling male frogs. Transect width can be determined by strength of call from target species. It is recommended to locate at least six calling males in order to determine the width of the transect, and therefore the approximate area to search. • Call playback, using recordings of species calls, can be used to encourage individuals to respond so individuals can be located within suitable habitat.	Table A2(i)
	Call playback (point surveys	• All calling frogs heard while standing at a single location are recorded. Depending on area of suitable habitat, it may be of benefit to conduct these fixed-point surveys at regular spacings.	Table A2(i)
	Pitfall traps	• Pitfall traps placed within suitable habitat for the target species are likely to trap frogs.	Table A3(c)
	Acoustic recording	• Can be used to detect target species when placed in areas of suitable habitat while reducing the physical survey effort.	Table A2(b)
	Spotlighting	• Nocturnal searches for frogs using torches or headlamps to locate individuals within suitable habitat.	Table A2(i)
		BIRDS	
All birds	Diurnal and nocturnal surveys	• Walking searches through habitat areas to target bird species using both visual and auditory observations. This includes spotlighting at night for some nocturnal species.	Table A2(h) Table A2(i)
	Call playback	• Uses a recorded sound of the target species to elicit a response. Used for species that call infrequently or are cryptic, and often used for nocturnal species such as owls.	Table A2(i)
	Mist netting	• Can be used in a variety of habitats to target specific bird species that may be difficult to find during diurnal surveys. Can be used to measure species diversity, populations numbers, longevity, etc.	Table A3(e)
	Acoustic recording	• Can be used to detect target species when placed in suitable habitat areas while reducing the physical survey effort.	Table A2(b)

TARGET FAUNA	SURVEY TYPE	DESCRIPTION	CROSS REFERENCE
	Spotlighting	• Spotlighting within suitable habitat to find target nocturnal species.	Table A2(i)
Waterbirds	Aerial surveys	• Involves surveying in an aircraft. Usually used when ground counts are impractical. Unlikely to be used for road and rail projects because wetland areas are typically avoided due to construction difficulties.	N / A
	Diurnal surveys	• Walking searches along shorelines and wetland habitats, and scanning from vantage points using binoculars or spotting scopes. Spotting scopes allow for counting and enable small species and leg bands to be identified.	Table A2(h)
	High resolution photography	• Can aid in reviewing species composition, distinguishing similar species, identification of sexes, and confirmation of estimated numbers. Can be used as a stand-alone technique or during other types of bird surveys.	N / A
	Call playback	• Can be used to elicit a response from cryptic species such as the Lewin's rail (*Lewinia pectoralis*).	Table A2(i)
		REPTILES	
Freshwater turtles	Snorkelling transects	• Observing and identifying turtles as they pop to the surface to breathe when swimming.	Table A2(m)
	Spotlighting	• Spotlight through sections of stream by walking or in a boat at night. Capturing turtles by hand or with a large net to identify and measure species.	Table A2(i)
	Trapping (All techniques use baits	• Submerged crab nets with wide funnel openings with a surface marker. • Hoop traps with an attached holding pen accessed via a one-way entrance, traps can be set with holding pen above water to allow for surfacing to breath. • Cathedral traps are modified submerged collapsible traps with an additional chamber above, accessed via a vertical one-way entrance from a lower chamber. • Baits that can be used include beef heart, lettuce, banana, apple, sardines.	N/A
	Seine netting	• Active nets pushed through water to sample fish and crustaceans in wadable waters.	Table A3(h)
Other species (snakes, skinks, geckoes etc.)	Diurnal, dusk, and/or nocturnal searches	• Microhabitat searches through suitable habitat (i.e. searching leaf litter, tree bark, hollow logs, man-made material including roof tiles, pipes & metal etc.).	Table A2(h) Table A2(i) Table A3(a)
	Tile surveys	• Tiles or other artificial refuges are placed in areas of potential habitat and are later surveyed to determine species presence.	Table A3(b)

TARGET FAUNA	SURVEY TYPE	DESCRIPTION	CROSS REFERENCE
	Pitfall trapping	• Pitfall traps placed within suitable habitat for small reptiles.	Table A3(c)
	Funnel traps	• Funnel traps are versatile for trapping reptiles and can be used in a variety of habitats. They can be used to target active burrows and other microhabitat areas, and can be used with or without a drift fence.	Table A3(c)
MAMMALS			
Arboreal species	Spotlighting and stagwatching	• Spotlighting within suitable habitat to find target nocturnal species, with stagwatching involving the specific detection of wildlife as they leave their hollow or roost, usually conducted at around.	Table A2(i)
	Camera trapping	• Digital cameras placed in suitable habitat, usually mounted to a tree, to capture images or videos of arboreal species passing by.	Table A2(a)
	Elliot trapping Cage trapping	• Traps are baited and animals enter the trap to eat the bait, triggering the trap to close. Can be positioned on the ground or in trees, depending on the target species.	Table A3(d)
	Thermal cameras	• Targets warm blooded animals by detecting a heat signature, and therefore a difference in temperature between an animal and the ambient environment.	Section A4.2
	Call playback	• Call playback can be used for some of the arboreal mammals including the koala and yellow-bellied glider.	Table A2(i)
	Hair tubes and hair funnels	• Hair tube traps can be attached to tree trunks, branches, and artificial structures that arboreal species may use. Can be used on glider poles and canopy bridges to detect use. The collected hair is then identified to species or genus.	Table A2(c)
Small-medium sized species	Elliot trapping Cage trapping	• Traps are baited and animals enter the trap to eat the bait, triggering the trap to close. Can be positioned on the ground or in trees, depending on the target species.	Table A3(d)
	Pitfall Trapping	• Pitfall traps placed within suitable habitat for small-medium sized mammals such as antechinus and native mice.	Table A3(c)
	Camera trapping	• Digital cameras placed in suitable habitat to capture images or videos of species passing by. Set up will depend on the species being surveyed but cameras are usually mounted to a stake or tree approximately one metre above the ground.	Table A2(a)
	Spotlighting	• Spotlighting within suitable habitat to find target nocturnal species.	Table A2(i)

TARGET FAUNA	SURVEY TYPE	DESCRIPTION	CROSS REFERENCE
	Diurnal and nocturnal surveys	• Microhabitat searches through suitable habitat (i.e. searching leaf litter, tree bark, hollow logs, man-made material including roof tiles, pipes & metal etc.).	Table A2(h) Table A2(i)
Microbats	Acoustic recording (echolocation call detection)	• Used to target particular species in specific habitats including creeks, rocky outcrops, caves, and potential flyways. Particularly used for species in the *Rhinolophidae* and *Hipposiderida*e families. Activate monitoring via walking can be used to cover small areas of interest. Must be a minimum of one hour in duration beginning at dusk for a minimum of two nights per transect.	Table A2(b)
	Roost searches	• Microbat species are limited by the availability of roost habitat within an area and some species can only be surveyed by capture at the roost (e.g. Coastal Sheath-tail Bat *Taphozous australis*). Therefore, it may be necessary to search for roosts in order to determine if bats are present in a project area and are potentially impacted. • Searches for microbat roosts should include caves, mines, boulder piles, rock crevices, tree hollows, dead trees, buildings, bridges, culverts, drains, and abandoned fairy martin (*Petrochelidon ariel*) nests.	N / A
	Harp trapping	• Traps are placed in suitable flyway areas (i.e. vegetation corridors, over water tanks, and at cave or mine entrances) to capture and collect bats.	Table A3(e)
	Mist netting	• Ideal method for trapping bats over isolated water bodies (i.e. dams, tanks, waterways) in the arid and semi-arid zone, or other open habitats.	Table A3(e)
	Trip lining	• Trip lining can be used to catch bats at small waterbodies such as dams and waterholes, but should be used only after less invasive methods have been attempted and demonstrated to be ineffective.	Table A3(e)

TARGET FAUNA	SURVEY TYPE	DESCRIPTION	CROSS REFERENCE
Flying-foxes	Roost searches	• Flying-foxes are highly mobile and will move great distances in response to flowering and fruiting events, which vary with season. Individuals can change roosts regularly and roosts can be colonised or vacated within relatively short periods. In addition to roost searches, searching for presence of food species should be used to assess potential importance of a survey area to the species. • Ground counts: Flying-foxes can be counted during the day while they are in the roost, which enables species identification. For larger colonies, sample counts such as transects sampling or point sampling can be used to estimate roost size. • Fly-out counts: Flying-foxes can be counted in the air as they leave camp at dusk.	N/A
	Foraging habitat	• Spotlighting or call recording to detect foraging flying - foxes.	Table A2(i)
		• Habitat assessments to record feed species, which are almost certainly going to be used by flying - foxes when fruiting or flowering.	Table A2(j)
Macropods	Diurnal nocturnal surveys	• Searches through suitable habitat and at specific times when target species is active. For example, larger macropod species including eastern grey kangaroo (*Macropus giganteus*) can be found in many habitat types, during most parts of the day. Other species such as rock-wallabies (*Petrogale sp.)* are most active at dawn and dusk, and favour rocky outcrop habitats.	Table A2(h) Table A2(i)
	Scat, track, scratch, and other sign searches	• Searches through suitable habitat for scats and tracks can be a useful way of determining species presence.	Table A2(e)
	Camera trapping	• Digital cameras placed in suitable habitat to capture images or videos of species passing by or when attracted by bait or lure. Set up will depend on the species being surveyed but cameras are usually mounted to a stake and set approximately one metre above the ground, or attached to a tree.	Table A2(a)

TARGET FAUNA	SURVEY TYPE	DESCRIPTION	CROSS REFERENCE
Koalas	Call playback	• Can be used to locate individuals within an area of suitable habitat.	Table A2(i)
	Spot Assessment Technique (SAT)	• Survey method used to assess the presence of koala scat within a prescribed search area. Survey locations use a grid with either 150 metre spacing (suitable for habitat <50 hectares) or 250 metre spacing (suitable for habitat >50 hectares). Grid is centred within area of suitable habitat. The SAT protocol must be followed when undertaking a SAT survey. Koala presence within suitable habitat is confirmed when scat is detected.	Table A2(e)
	Spotlighting	• Spotlighting within suitable habitat to find koalas.	Table A2(i)
	Targeted scat, track, scratch, and other sign searches	• Searches through suitable habitat for koala scats.	Table A2(e)
	Detection Dogs	• Detection dogs are trained to identify koala scat and are suitable for large areas due to their speed of survey.	Section A4.1
	Acoustic recording	• Recording of vocalisations to confirm the presence of koala. Male koalas make a distinctive loud bellowing call during the breeding season and this is generally the best time to survey using this technique. Method is not suitable for use in low quality habitat where terrain is rugged, vegetation is dense, and/or there are low densities of Koalas.	Table A2(b)
	Drones	• Drones paired with thermal sensors can detect koalas and can greatly reduce on foot survey effort.	Table A2(i) Section A4.2
AQUATIC SPECIES			
	Dawn and nocturnal surveys	• Nocturnal surveys within suitable riparian habitats can be used to target aquatic fauna, such as rakali (*Hydromys chrysogaster*) and platypus. The spotlighting technique is generally incorporated to spot individuals within the water during early morning and nocturnal surveys for the platypus.	Table A2(i)
	Fyke net	• Where platypus are likely to be present, the opening of the fyke should have a two inch mesh panel secured to ensure platypus cannot enter the net and become entrapped and potentially killed. Nets should be set in the afternoon, and checked and removed the following dawn. Two nets can be set, with one facing upstream and the other downstream.	Table A3(i)
	Camera Trapping	• Can be used to target aquatic species in suitable habitats.	Table A2(a)

TARGET FAUNA	SURVEY TYPE	DESCRIPTION	CROSS REFERENCE
	Environmental DNA (eDNA)	• DNA can be collected from water habitats to identify species presence. Platypus, in particular, urinates, defaecates, and grooms while swimming and this can be sampled from within the water column. The collection of eDNA can be impacted by varying environmental factors such as water temperature, pH, exposure to UV light etc. This technique is not as effective at detecting Rakali as this species mostly grooms and defaecates on land.	Table A2(k) Section A4.3
	Burrow Counts	• Burrow counts can be used to identify the presence of platypus within an aquatic habitat.	Table A2(d)

A8 List of survey guides

- *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland* (Eyre et al. 2022).
- *Survey Guidelines for Australia's threatened Frogs* (Department of the Environment Water Heritage and the Arts 2010c).
- *Survey Guidelines for Australia's threatened mammals* (Department of Sustainability Environment Water Populations and Communities 2011b).
- *Survey Guidelines for Australia's threatened birds* (Department of the Environment Water Heritage and the Arts 2010b).
- *Survey Guidelines for Australia's threatened bats* (Department of the Environment Water Heritage and the Arts 2010a).
- *Survey Guidelines for Australia's threatened reptiles* (Department of Sustainability Environment Water Populations and Communities 2011c).
- *Survey guidelines for Australia's threatened fish* (Department of Sustainability Environment Water Populations and Communities 2011a).
- *Australian code of electrofishing practice*. NSW Fisheries. Standing Committee on Fisheries and Aquaculture. ISBN: 9780731094127 Pyrmont, N.S.W. 1997.

References

Beng, K. C., and R. T. Corlett. 2020. *Applications of environmental DNA (eDNA) in ecology and conservation: opportunities, challenges and prospects*. Biodiversity and Conservation 29:2089-2121.

Bennett, E., L. T. Jamieson, S. N. Florent, N. Gill, C. Hauser, and R. Cristescu. 2022. *Detection dogs provide a powerful method for conservation surveys*. Austral Ecology 47:894-901.

Bioilink. 2022. SAT Training and Accreditation.

Clevenger, A. P., and M. A. Sawaya. 2010. *Piloting a non-invasive genetic sampling method for evaluating population-level benefits of wildlife crossing structures*. Ecology and Society 15:7[online].

Cristescu, R. H., E. Foley, A. Markula, G. Jackson, D. Jones, and C. Frère. 2015. *Accuracy and efficiency of detection dogs: a powerful new tool for koala conservation and management.* Scientific Reports 5:8349.

Department of Sustainability Environment Water Populations and Communities. 2011a. *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*.in E. Department of Sustainability, Water, Populations and Communities, editor. Australian Government.

Department of Sustainability Environment Water Populations and Communities. 2011b. *Survey Guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.*in E. Department of Sustainability, Water, Populations and Communities, editor. Australian Government.

Department of Sustainability Environment Water Populations and Communities. 2011c. *Survey Guidelines for Australia's threatened reptiles: Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*.in E. Department of Sustainability, Water, Populations and Communities editor. Australian Government.

Department of the Environment Water Heritage and the Arts. 2010a. *Survey Guidelines for Australia's threatened bats: Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.*in W. Department of the Environment, Heritage and the Arts, editor. Australian Government.

Department of the Environment Water Heritage and the Arts. 2010b. *Survey Guidelines for Australia's threatened birds: Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.*in W. Department of the Environment, Heritage and the Arts, editor. Australian Government.

Department of the Environment Water Heritage and the Arts. 2010c. *Survey Guidelines for Australia's threatened frogs: Guidelines for detecting frogs listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.*in W. Department of the Environment, Heritage and the Arts, editor. Australian Government.

DPIE. 2020. *Best Practice Guidelines for the use of Koalas in Scientific Research*.in I. a. E. Department of Planning, editor. New South Wales Government.

Eyre, T. J., D. J. Ferguson, G. C. Smith, M. T. Mathieson, M. F. Venz, L. D. Hogan, C. L. Hourigan, A. L. Kelly, and J. Rowland. 2022*. Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland, Version 4.0* .in D. o. E. a. Science, editor. Queensland Government, Brisbane.

Frère, C. H., G. D. O'Reilly, K. Strickland, A. Schultz, K. Hohwieler, J. Hanger, D. De Villiers, R. Cristescu, D. Powell, and W. Sherwin. 2023. *Evaluating the genetic consequences of population subdivision as it unfolds and how to best mitigate them: A rare story about koalas*. Molecular Ecology 32:2174-2185.

Lobert, B., L. Lumsden, H. Brunner, and B. Triggs. 2001. *An assessment of the accuracy and reliability of hair identification of south-east Australian mammals.* Wildlife Research 28:637-641.

Maitz, N., E. Spencer, and W. Support. 2021. *Fire monitoring in SEQ.* Accessed via wildlifeinsights.org

McCall, A., H. Hines, and I. Gynther. 2020. *QPWS&P Bushfire Recovery Project – Phase 1*. Accessed via wildlifeinsights.org.

McColl-Gausden, E. F., A. R. Weeks, R. A. Coleman, K. L. Robinson, S. Song, T. A. Raadik, and R. Tingley. 2021. *Multispecies models reveal that eDNA metabarcoding is more sensitive than backpack electrofishing for conducting fish surveys in freshwater streams.* Molecular Ecology 30:3111-3126.

Phillips, S., and J. Callaghan. 2011. *The Spot Assessment Technique: A tool for determining localised levels of habitat use by Koalas Phascolarctos cinereus*. Australian Zoologist 35.

Rees, H. C., B. C. Maddison, D. J. Middleditch, J. R. M. Patmore, and K. C. Gough. 2014. *REVIEW: The detection of aquatic animal species using environmental DNA – a review of eDNA as a survey tool in ecology.* Journal of Applied Ecology 51:1450-1459.

Revie, P., and J. Lovegrove-Walsh. 2021. *Detecting the quolls in Bunya Mountains National.* Accessed via wildlifeinsights.org.

Ryan R. Witt, C. T. B., Lachlan G. Howell, Shelby A. Ryan, John Clulow, Neil R. Jordan, Bob Denholm, Adam Roff. 2020. *Real-time drone derived thermal imagery outperforms traditional survey methods for an arboreal forest mammal*. PLOS ONE 15.

Soanes, K., A. C. Taylor, P. Sunnucks, P. A. Vesk, S. Cesarini, and R. van der Ree. 2018. *Evaluating the success of wildlife crossing structures using genetic approaches and an experimental design: lessons from a gliding mammal.* Journal of Applied Ecology 55:129-138.

Sunnucks, P., and N. Balkenhol. 2015. *Incorporating landscape genetics into road ecology.* Pages 110-118 in R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. John Wiley and Sons, Ltd.

Thomas, M. L., L. Baker, J. R. Beattie, and A. M. Baker. 2020. *Determining the efficacy of camera traps, live capture traps, and detection dogs for locating cryptic small mammal species.* Ecology and Evolution 10:1054-1068.

Triggs, B. 2004. *Tracks, Scats and Other Traces. A Field Guide to Australian Mammals.* Oxford University Press Australia.