NSW GOVERNMENT

Department of Planning and Environment

Koala (*Phascolarctos cinereus*)

Biodiversity Assessment Method Survey Guide

Cover photo: Koala (*Phascolarctos cinereus*), an arboreal herbivorous marsupial native to Australia. John Turbill/DPE

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Shorted forms

Abbreviation	Description
assessors	accredited person
BAM	Biodiversity Assessment Method
BAM-C	Biodiversity Assessment Method Calculator
BAR	Biodiversity Assessment Report: includes Biodiversity Development Assessment Reports (BDARs); Biodiversity Certification Assessment Reports (BCARs); and Biodiversity Stewardship Site Assessment Reports (BSSARs)
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BC Regulation	Biodiversity Conservation Regulation 2017
Biodiversity and Conservation SEPP	*State Environmental Planning Policy (Biodiversity and Conservation) 2021*
BOS	Biodiversity Offsets Scheme
BSA	biodiversity stewardship agreement
CASA	Civil Aviation Safety Authority
dbh	diameter at breast height
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwth)
GPS	global positioning system
KMR	koala modelling region
PCT	plant community type
ReOC	remotely piloted aircraft operator's certificate
SAT	Spot Assessment Technique
TBDC	Threatened Biodiversity Data Collection
TEC	collective term for threatened ecological communities (vulnerable ecological communities, endangered ecological communities, critically endangered ecological communities) listed under the BC Act and the EPBC Act

Units of measure

Symbol	Name
d	days
h	hours
ha	hectares
Hz	hertz
kHz	kilohertz
km/h	kilometres per hour
lm	lumens
m	metres
m/min	metres per minute
m/s	metres per second
min	minutes
mK	milli-kelvin
mm	millimetres
px	pixels
μm	micrometres
W	watts
°C	degrees Celsius
%	percent

1. Introduction

1.1 Purpose of this guide

The NSW Biodiversity Offsets Scheme (BOS) is underpinned by the Biodiversity Assessment Method (BAM) (DPIE 2020a). The BAM establishes a transparent, consistent and scientifically based approach for assessing impacts to, or improvements in, biodiversity.

The *Koala (Phascolarctos cinereus): Biodiversity Assessment Method Survey Guide* (this guide) aids accredited persons (assessors) when applying the BAM to:

- survey for koalas and their habitat
- map the species polygon when presence is identified, and
- document required information in the Biodiversity Assessment Report (BAR).

This guide is a companion to the BAM. The Department of Planning and Environment (the Department) will review and update this guide periodically to incorporate new information and reflect legislative or policy changes.

1.2 Biodiversity Offsets Scheme

The koala is listed as an *endangered* species in Schedule 1 of the NSW *Biodiversity Conservation Act 2016* (BC Act). The BOS requires a consistent approach to suitable habitat identification and targeted surveys for threatened species, which forms the basis of this guide.

For a proposed development, clearing or biodiversity certification site (impact assessment sites), all direct, indirect and prescribed impacts (Box 1) on koalas and their habitat must be assessed and described in the BAR (BAM 2020, Chapter 8). These impacts must be first avoided and minimised – any residual impacts require offsetting (BAM 2020, Chapter 7). For biodiversity stewardship (BSA) sites, presence of the koala and its habitat, and the management actions to improve these values, must be assessed and described in the Biodiversity Stewardship Site Assessment Report (BSSAR).

Box 1. Prescribed impacts on koalas

Clause 6.1 of the Biodiversity Conservation Regulation 2017 (BC Regulation) provides for prescribed impacts. These are direct or indirect impacts that affect biodiversity values in addition to, or instead of, those from clearing vegetation. As these biodiversity values are irreplaceable, they are often difficult to quantify and/or offset. Avoiding or minimising prescribed impacts is critical. The assessment of prescribed impacts is detailed in BAM 2020 (Chapters 6 and 8).

For koalas, consideration of habitat use and connectivity will extend beyond the assessment detailed in this guide. As koalas are a highly mobile species, prescribed impacts must be assessed and may include:

- *Habitat connectivity*. Consideration should be given to impacts on koala movement and likely survival within the subject land and broader landscape. For example, development that fragments habitat may prevent successful movement of koalas due to increased mortality risk in the hostile matrix.
- *Vehicle strikes*. Consideration should be given to the additional risk of vehicle strike to koalas present on, or likely to move through, the subject land. This will be of high importance for road developments or where increased vehicle activity is likely through various phases of a development.

Interactions with other legislation protecting koalas may also require consideration. Koalas are listed as *endangered* under both the BC Act and the Australian *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). For state significant development, impact assessments are streamlined by the Australian Government's endorsement of the BOS via the EPBC Act Condition-setting Policy (Appendix A). The Australian Government may set additional assessment requirements and conditions beyond the BOS. Also, where the BOS and the *State Environmental Planning Policy (Biodiversity and Conservation) 2021* (Biodiversity and Conservation SEPP) apply to the same land, both requirements must be met by proponents. For further information, refer to the Consolidated State Environmental Planning Policies website (Appendix A).

The methods and techniques specified in this guide may inform other threatened species assessments, such as the test of significance (section 7.3 of the BC Act) and species impact statements (Division 5 of the BC Act).

1.3 Biodiversity credits

All threatened entities are allocated to one of two biodiversity credit classes. Under the BAM, biodiversity credits are used to quantify the:

- loss in biodiversity values from the impacts of development, or
- gain in biodiversity values from management actions on a BSA site.

Ecosystem credits apply to entities where the likelihood of occurrence of the entity or elements of a species' habitat can be predicted by vegetation surrogates and/or landscape features, or for which a targeted survey has a low probability of detection. Ecosystem credits provide a measure of the threatened ecological communities (TECs), and/or threatened species habitat, reliably predicted to occur with a plant community type (PCT). They also apply to other PCTs generally.

Species credits apply to species where the likelihood of occurrence or elements of suitable habitat cannot be confidently predicted by vegetation surrogates and/or landscape features, or that are reliably detected by a targeted survey. Species credits provide a measure of the suitable habitat area for, or the number of individuals of, a threatened species.

Dual credits apply to threatened species whose habitat is divided into ecosystem credits (e.g. foraging habitat) and species credits (e.g. breeding habitat). Dual credit species are generally those with critical habitat, such as breeding habitat, that warrant particular consideration (e.g. cave breeding bats, birds dependent on hollows of particular dimensions for breeding).

Koalas are a species credit species. The BAM requires either a targeted survey or an expert report to determine the presence of species credit species (or relevant habitat component) on the subject land. Presence may also be assumed at impact assessment sites.

1.4 Scope of this guide

Under the BAM, surveys must be conducted in accordance with threatened species survey guides published by the Secretary of the Department (BAM 2020, Subsection 5.3(2.b.)). Therefore, this guide must be applied, as a minimum, when conducting surveys for koalas. Any variation from these survey methods must meet the same objectives detailed in this guide (Section 2.1), employ a systematic approach (Section 2.2), be supported by evidence and justified in the BAR; for example, peer-reviewed scientific literature or a guideline published by another jurisdiction.

The requirements for an expert report, where used as an alternative to a targeted survey, are detailed in Box 3 of BAM 2020. For koalas, an expert report should:

- address how the vegetation and/or koala habitat has been evaluated, including reference to BAM definitions of suitable habitat (Section 3.2 of this guide)
- include the species polygon if koalas are likely to be present or use the subject land, and
- include reference to past surveys, field validated habitat maps, records or other information used to form their expert opinion.

Definitions for the purpose of this guide

Barrier: a natural or artificial feature preventing movement of koalas between areas of suitable habitat; for example, fauna exclusion fencing (designed to prevent koalas crossing), and waterbodies ≥200 m wide (at the narrowest point separating areas of suitable habitat).

Continuous suitable habitat: a group of vegetation zones (meeting the definition of suitable habitat) that are separated by ≤500 m.

Discontinuous suitable habitat: vegetation zones (meeting the definition of suitable habitat) separated by ≥500 m or by a barrier. Vegetation zones may be discontinuous with some vegetation zones and continuous with others.

Koala use tree: tree species used by koalas for food and shelter. Koala use tree species vary spatially and are defined by the koala modelling region(s) in which the subject land is located.

2. Targeted species surveys

2.1 Survey objectives

Under the BAM, the objectives of a targeted koala survey are to:

1. establish koala presence on the subject land with a high level of confidence, and
2. estimate the area of habitat on the subject land, which forms the species polygon and is used to calculate species credits, where koalas are present.

The targeted survey design aims to reduce the risk of false negatives (i.e. the species is reported as absent from the subject land, when it is present). A high level of confidence in the results is assumed if undertaken by an appropriately skilled person (refer to Section 2.3) in accordance with this guide.

2.2 Systematic approach

This guide describes a systematic approach to targeted koala surveys. The survey approach must be considered in the planning phases of the assessment and incorporates two key elements:

1. survey design to maximise the likelihood of detecting koalas – including consideration of constraints (e.g. site, seasonal and temporal), and
2. field survey techniques that aim to search suitable habitat at an appropriate intensity.

2.3 Surveyor skills

Targeted koala surveys must be carried out by an appropriate koala surveyor (a surveyor). This is someone who can demonstrate their:

- strong knowledge of koala ecology and habitat use
- ability to accurately identify koala use trees (as detailed in Section 3.1)
- ability to accurately identify koalas using the methods detailed in this guide[1], and
- ability to distinguish koala faecal pellets (scat) from those of other species with similar characteristics (e.g. common brushtail possum (*Trichosurus vulpecula*)).

The surveyor's skills in koala field surveys must be demonstrated in the BAR by:

- relevant training and qualifications (including licence numbers)
- a recent history of experience (of at least five years) in using the relevant survey methods[1], with demonstrated success in koala identification in New South Wales
- employers' names and periods of employment (where relevant).

The surveyor is not equivalent to an 'expert' as defined in Box 3 of BAM 2020. An expert must demonstrate specialised knowledge in relation to particular biodiversity values, as the opinion of an expert replaces the need for a targeted survey. Expert status is determined and approved by the Secretary of the Department (Appendix A). The surveyor does not need to be an assessor, but the BAR must be submitted by an assessor.

The skills, experience and qualifications of any specialists (e.g. bioacoustics experts, drone pilots) supporting the targeted koala survey must also be demonstrated by a resume included with the BAR.

3. Survey design

A decision key for targeted koala surveys is provided in Appendix B. It outlines the approach for determining when a targeted survey is necessary and the appropriate methods in accordance with this guide.

3.1 Candidate species list

Based on a series of filters and site-based information, the Biodiversity Assessment Method Calculator (BAM-C) generates a list of candidate species credit species predicted to occur on the subject land (BAM 2020, Subsection 5.2.1). For impact assessment sites, where past surveys or incidental sightings have recorded one or more koalas on the subject land, it must be included in the candidate species list (BAM 2020, Subsection 5.2.1(6.)).

A species may be removed from the list where (BAM 2020, Section 5.2):

- all habitat constraints[2] listed for the species in the Threatened Biodiversity Data Collection (TBDC) are absent from the subject land
- all habitat constraints or microhabitats on which the species depends are sufficiently degraded such that the species is unlikely to use the subject land, or

[1] Demonstration of skills and experience in the survey methods relates only to those selected for the targeted koala survey (i.e. not all survey methods listed in this guide).

[2] Examples include rocky areas, waterbodies and hollow bearing trees. Habitat constraints associated with a species are identified in the TBDC and BAM-C.

- location of the subject land does not meet geographic limitations[3] listed for the species within the Interim Biogeographic Regionalisation for Australia (IBRA) subregion, or
- the species is considered vagrant to the IBRA subregion, or
- an expert report states the species is unlikely to be present on the subject land.

Where a species is removed from the candidate species list, no further assessment is required for that species on the subject land. **Justification for removing a species from the candidate species list must be documented in the BAR.** This should include evidence for any features being absent (e.g. field reconnaissance) and reference to any supporting information from published, peer-reviewed sources (e.g. scientific journals and research reports outlining the microhabitats used by the species). All remaining species require a targeted survey to determine presence on the subject land.

For BSA sites, assessment of species credit species is optional and if not undertaken, species credits will not be generated.

3.2 Suitable habitat

Suitable habitat is habitat where the target species is expected to occur or periodically use. It identifies the area where a targeted survey is required on the subject land.

Suitable habitat for koala is any PCT:

- associated with koala in the TBDC, and
- with **a minimum of one** koala use tree present, for the relevant region.

Presence of a koala use tree in any vegetation zone of a PCT associated with koalas will determine the full extent of that PCT as suitable habitat (i.e. all vegetation zones). A vegetation zone may only be excluded, based on condition, where the tree growth form is entirely absent. This must be documented and justified in the BAR.

For impact assessment sites where koalas are a candidate species, but suitable habitat is not identified, include evidence and justification in the BAR for why koalas will not use the site. For example, where past records of one or more koalas are on the subject land but significant land-use changes have occurred or there is low spatial accuracy of the koala record(s).

Onsite validation of desktop assessments of suitable habitat is required, because:

- mapping and digital data may not accurately represent all topographic details
- the history of the site and its disturbance cannot be reliably evaluated from imagery
- microhabitat features are not reliably or adequately evaluated remotely.

Any measurement using a GPS requires a positional accuracy of ≤10 m.[4]

Examples of mapping suitable habitat for koalas are detailed in Box 2 of this guide.

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[3] Examples include, but are not limited to, specific local government areas or above a defined altitude. Geographic limitations are identified in the ‘Threatened Species Profile’ and BAM-C. There are none listed for koalas.

[4] As reported by the GPS accuracy estimate.

3.2.1 Koala use trees

For the purpose of this guide, koala use tree lists are available:

- in Appendix C of this guide, and
- on the BAM-C landing page (Excel format).

The list includes tree species used by koalas for food and shelter across nine Koala Modelling Regions in New South Wales (DPIE 2019). As koalas demonstrate regional preferences for use trees, only tree species listed for the region in which the subject land is located require consideration. Identification of the relevant region can be undertaken from the Koala Modelling Regions mapping available in the SEED portal (Appendix A). Where the subject land is located on the border of two or more regions, the koala use trees for all relevant regions must be used. Refer to Appendix C for further information.

Koala use trees will be used to reference those species listed for the region(s) relevant to a subject land.

3.2.2 Assess suitable habitat

For each PCT associated with koalas, presence of koala use trees is determined from the:

- floristic assessment (BAM 2020, Subsection 4.2.1)
- vegetation integrity assessments (BAM 2020, Subsection 4.3.4).

If no koala use trees are identified, additional assessment is required. In each vegetation zone of a PCT associated with koalas, search for koala use trees along a grid of parallel traverses. Total traverse length is detailed in Table 1, with the length of traverses dependent on the area and shape of the vegetation zone. Maximum distance between parallel field traverses will range from:

- 20 m in dense vegetation (walked at approximately 1.5 km/h), to
- 40 m in open vegetation (walked at approximately 4 km/h).

Identification of a koala use tree will confirm the PCT as suitable habitat and no further assessment is required for this PCT. Parallel field traverses may be undertaken in combination with other field work such as surveys for threatened plant species.

Where no koala use trees are identified in any of the vegetation zones of a PCT associated with koalas, the PCT may be excluded from the area of suitable habitat. Where this occurs, include the GPS tracklog data for the parallel field traverses with the BAR.

Table 1 Field traverse lengths for koala use tree identification

Vegetation zone area	Total traverse length
1 – 10 ha	50 m per ha
>10 – 50 ha	500 m, or 100 m per 5 ha (whichever is greater)
>50 – 100 ha	1000 m, or 150 m per 10 ha (whichever is greater)
>100 ha	1500 m + an additional 250 m for every additional 100 ha

3.2.3 Suitable habitat continuity

Depending on the arrangement of vegetation zones, areas may be grouped into continuous and discontinuous suitable habitat (for further information, refer to Appendix D). Vegetation zones separated by:

- ≤500 m are considered continuous
- >500 m are considered discontinuous.

Suitable habitat continuity is assessed by measuring the shortest path between two vegetation zones from the boundary of each. There is no maximum extent for an area of continuous suitable habitat on the subject land.

Few features, natural or artificial, are complete barriers to koala movement. Vegetation zones are discontinuous, where they are entirely separated by:

- fauna exclusion fencing, or
- waterbodies ≥200 m in width, at the narrowest point separating the suitable habitat.

In continuous suitable habitat, vegetation zones may be separated by, for example:

- vegetation zones of PCTs not associated with koalas
- cleared areas
- non-native vegetation
- built features.

These areas are not considered part of the suitable habitat. Some, however, must be assessed for prescribed impacts relating to koalas (refer to Box 1).

Box 2. Mapping suitable habitat for a targeted koala survey

Using the best available ortho-rectified aerial imagery:

1. Map all PCTs associated with koalas on the subject land.
2. Identify those PCTs with koala use trees present – these are suitable habitat.
3. Measure the shortest distance separating vegetation zones determined suitable habitat. Clearly identify all vegetation zones separated by ≤500 m as areas of continuous suitable habitat.
4. Identify any fauna exclusion fences or waterbodies ≥200 m wide separating vegetation zones. Where these occur, map the vegetation zones as separate areas of suitable habitat.

Example 1 – Impact assessment site

On the subject land identified in Figure 1, all mapped PCTs are associated with koalas in the TBDC. Koala use trees were identified in VZ1 and VZ4. No koala use trees were identified in VZ2.

The following PCTs and vegetation zones are considered suitable habitat for koalas (Figure 2):

- PCT A (VZ1)
- PCT C (VZ3 and VZ4).

As these vegetation zones are separated by <500 m, they are considered continuous suitable habitat.

Example 2 – Biodiversity stewardship site

On the subject land identified in Figure 3, all mapped PCTs are associated with koalas in the TBDC. Koala use trees were identified in VZ1 and VZ2. No koala use trees were identified in VZ3 and VZ4.

Box 2, continued

The following PCTs and vegetation zones are considered suitable habitat for koalas (Figure 4):

- PCT A (VZ1)
- PCT B (VZ2).

As the eastern and western polygons for VZ1 and VZ2 are separated by >500 m, they are considered discontinuous. The eastern and western polygons for VZ1 and VZ2 form two separate areas of continuous suitable habitat. A targeted survey must confirm presence in each area of continuous area of suitable habitat for it to be mapped in the species polygon (Section 5).

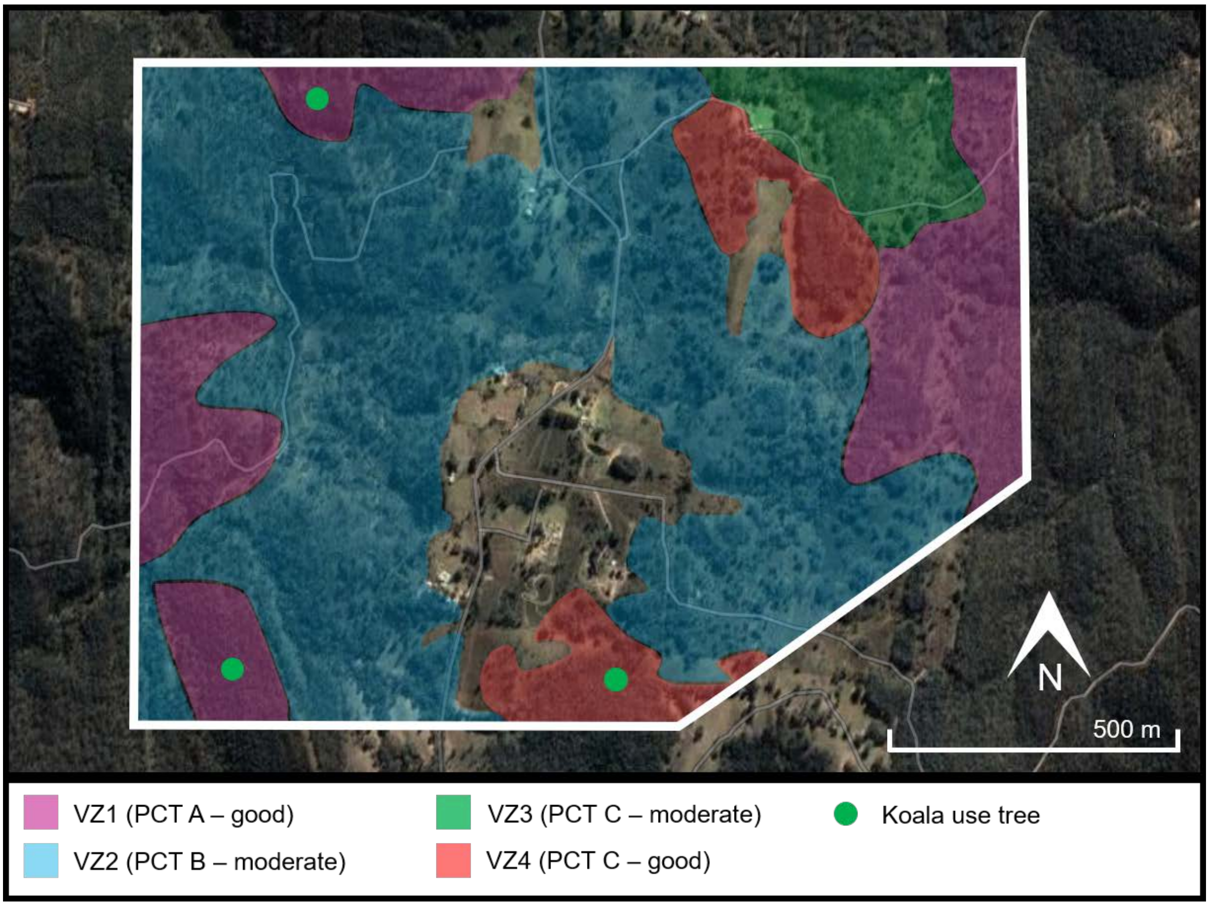

Figure 1 **Example 1: Identifying PCTs associated with koalas and koala use tree presence**

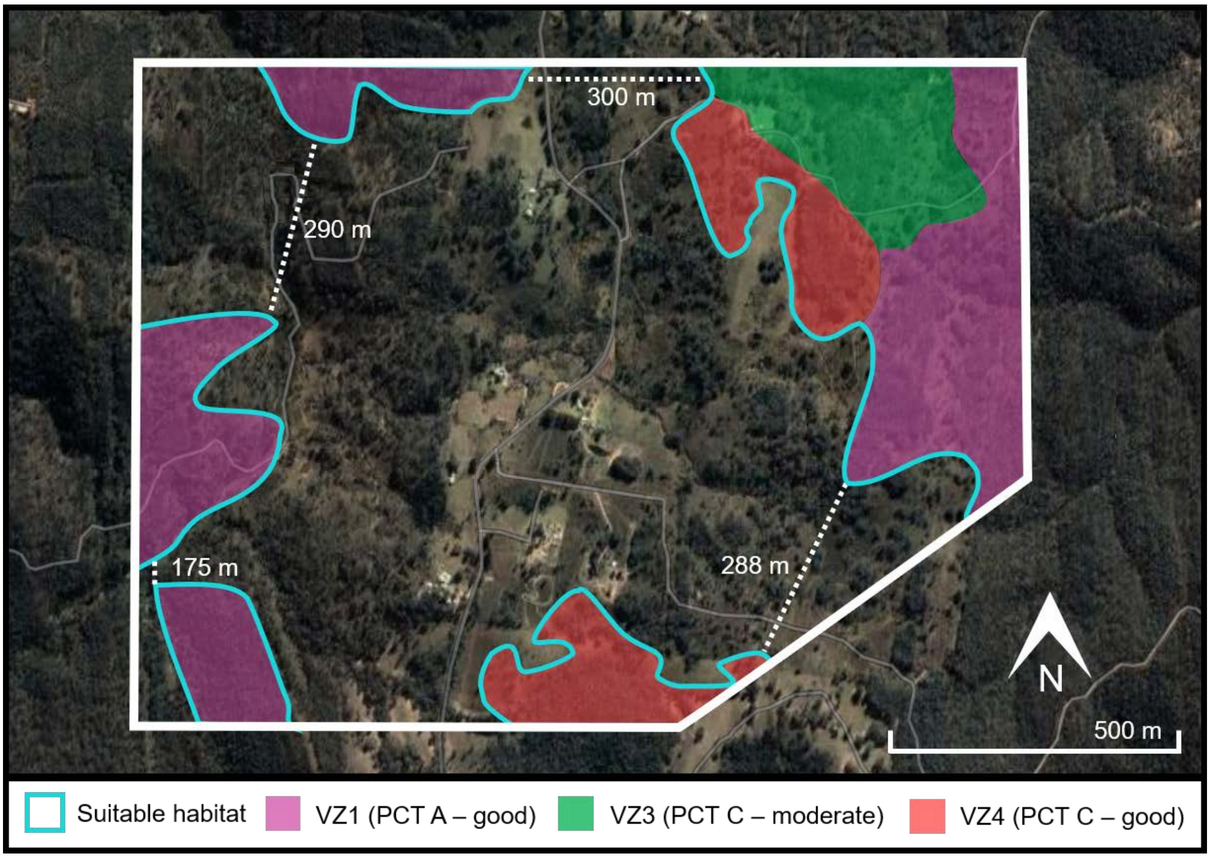

Figure 2 Example 1: Assessing suitable habitat continuity

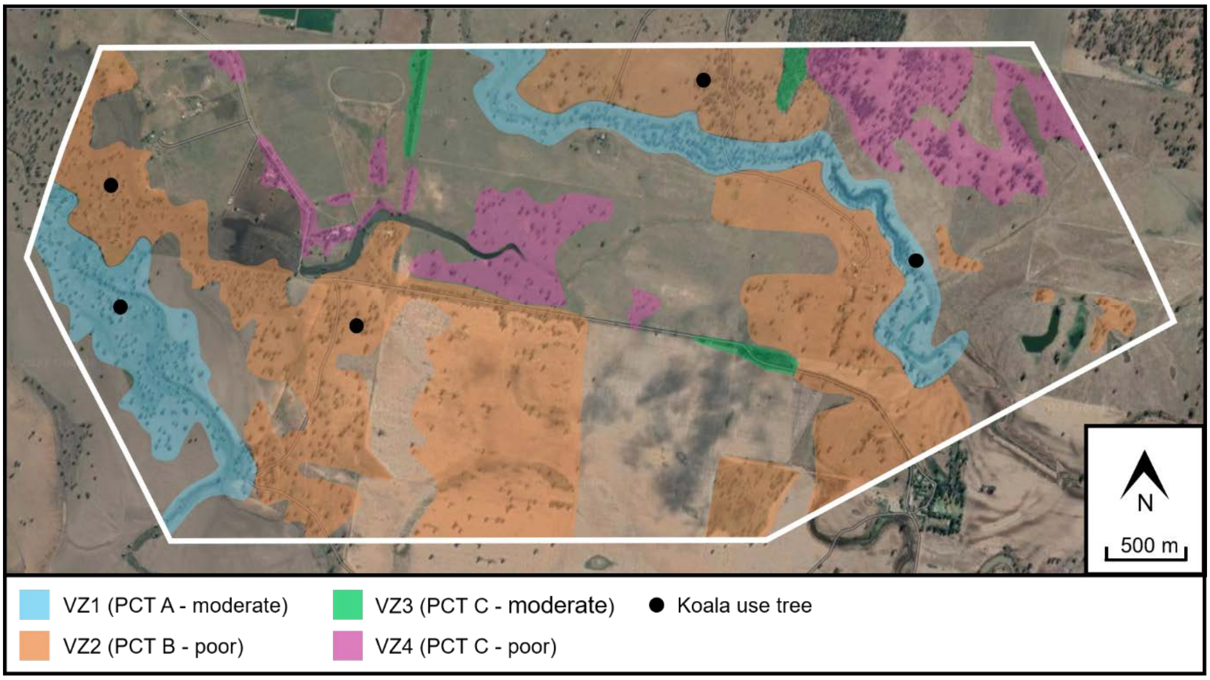

Figure 3 Example 2: Identifying PCTs associated with koalas and koala use tree presence

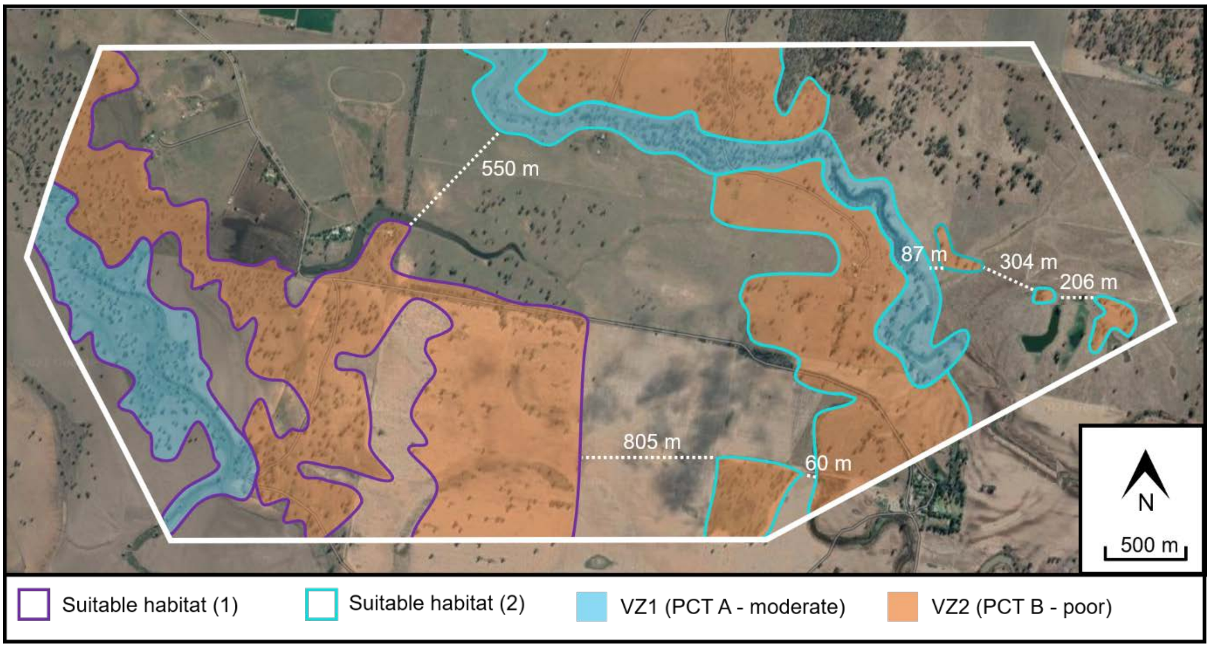

Figure 4 Example 2: Assessing suitable habitat continuity

3.3 Survey timing

Conduct surveys at the optimal time for koala detection. General guidance on the appropriate time to survey is documented in the TBDC and displayed in the BAM-C survey matrix in the Habitat Survey tab. Survey periods specific to each method are detailed in Chapter 4 of this guide.

Surveys may be conducted outside the identified times, but only when there is a justifiable reason; for example, due to spatial or temporal variation in temperature or breeding season. Adjusted survey times must be documented and justified in the BAR.

In some situations, surveying at the optimum time to detect koalas may not be possible or feasible (e.g. where project timeframes are constrained). The proponent may choose to use an expert report (BAM 2020, Section 5.3) to assess the species presence on the subject land. Alternatively, for impact assessment sites, the species may be assumed present.

3.4 Meteorological conditions

The survey effort described in this guide assumes suitable conditions for koalas and the relevant method as detailed in Chapter 4 of this guide.

The meteorological conditions on the subject land, prior to and at the time of the survey, must be recorded using a portable meteorological station or the closest Bureau of Meteorology station. Document in the BAR:

- rainfall (mm) for the 72 h prior to the survey
- rainfall (mm) for each day or night of the survey
- minimum and maximum temperature (°C) for each day or night of the survey
- relative humidity (%) for each day or night of the survey
- mean wind speed (km/h), for each day or night of the survey.

3.5 Survey effort

The minimum survey effort to detect koala presence on the subject land requires the total effort for **two** standard survey methods to be met. A scat detection method, which may indicate past occupancy, must be paired with a non-scat detection method as follows:

1. Spot Assessment Technique (SAT) (Section 4.1) or detection dogs (Section 4.2), **and**
2. spotlighting (Section 4.3) or passive acoustic (Section 4.4) or drones (Section 4.5).

Survey effort is detailed for each method in Chapter 4. Where areas of suitable habitat are discontinuous, survey effort must be applied to each, independently.

The two survey methods may be undertaken in any order, or concurrently where the timing requirements of each method can be met.

3.5.1 Confirming presence

Koala presence is confirmed within an area of continuous suitable habitat if detected by either survey method. If koala presence is confirmed by a survey using the first method, a survey using the second method is not required.

Where suitable habitat is discontinuous, presence must be confirmed within each separate area of suitable habitat.

Koalas may be incidentally detected (e.g. observed) on the subject land during other assessments and/or site visits. Where suitable habitat is available on the subject land, incidental sightings confirm presence.

3.5.2 Large area assessments

Options to reduce survey effort for very large or inaccessible areas include:

- dividing the proposed subject land into stages
- refining the areas of suitable habitat through site survey and expert report
- reducing the survey area by realigning the boundaries or footprint of the proposed development or biocertification (i.e. reducing the area of impact).

3.6 Field survey plan

Prepare a field survey plan based on the habitat characteristics of the subject land (Section 3.2) and in accordance with the BAM (BAM 2020, Sections 5.2–5.3). The following steps outline a general method for deriving a survey plan:

1. Identify areas of the subject land considered suitable habitat (Section 3.2) – only these areas require surveying.
2. Identify areas of discontinuous suitable habitat – survey effort must be applied to each area independently (Section 3.2).
3. Determine the most appropriate survey methods for the site, considering the limitations outlined for each method (Chapter 4).
4. Determine the required survey effort based upon area of suitable habitat, as outlined for each method (Chapter 4).
5. Determine survey dates appropriate for the technique, as outlined for each method (Chapter 4).
6. Select survey sites based on steps 1–3 above.
7. Select survey dates based on steps 4 and 5. Allow flexibility for unfavourable conditions, which may include low light, heavy rainfall, severe weather (e.g. lightning, hail, strong winds) and difficult terrain (Section 3.3).

Initial site assessments should detect any factors that may hinder or facilitate the survey process (e.g. terrain, vehicle access tracks, walking tracks, season, etc.). These factors, combined with the limitations of each method, must be considered in the context of the subject land. Justification for selected methods must be detailed in the BAR.

3.7 Evaluate survey efficacy

Preliminary surveys should be evaluated against an expected outcome to assess the efficacy of survey effort and identify any problems that will affect results (e.g. equipment failure). An expected outcome can be obtained by examining the results of published surveys using equivalent methods from the same or similar regions. Issues with survey effectiveness, and steps taken to address these, must be documented in the BAR.

4. Survey methods

Koalas inhabit a variety of eucalypt forests and woodlands of New South Wales (Appendices C and D). As a cryptic species that frequently occurs in low densities, detecting koalas is challenging. Methods in this guide refer to the following standard techniques. This guide provides a range of direct (i.e. in which the animal is observed) and indirect (i.e. in which signs of its presence are observed) survey methods. Each method details the minimum requirements for determining koala presence on the subject land.

Refer to Appendix E of this guide for a summary of all survey methods.

As scratch mark detection varies with tree species and distinguishing koala scratches from those of other arboreal animals (e.g. brushtail possums, gliders or goannas) is unreliable (Phillips & Callaghan 2011), they are not used in this guide.

Where koalas are sighted, distinguishing features including age, sex, and health/condition should be noted, where possible.

4.1 Spot Assessment Technique

The SAT is an indirect survey method, assessing the presence of koala scat within a prescribed search area (Phillips & Callaghan 2011; Phillips & Hopkins 2008; Phillips & Hopkins 2009).

4.1.1 Limitations

Given scat deposition varies spatially and temporally (Ellis et al. 1998; Phillips & Callaghan 2011) the use of conservation detection dogs is preferred in low quality koala habitat. The use of SAT must be justified in the BAR with reference to the vegetation condition and quality of habitat for koalas.

This method is less effective for sites with dense ground cover, as this will strongly influence the probability of scat detection (Cristescu et al. 2012; Jiang et al. 2020).

As heightened insect activity during wet conditions increases scat decomposition rates, SAT surveys should not be undertaken within three days of rainfall (Cristescu et al. 2012; Melzer et al. 1994; Rhodes et al. 2011).

4.1.2 Timing

SAT may be undertaken all year round, during daylight hours.

4.1.3 Method

Select survey locations using a grid with:

- 150 m spacing, for suitable habitat ≤50 ha
- 250 m spacing for suitable habitat >50 ha.

To increase koala detection probability, sampling frequency (i.e. grid spacing) is greater than that proposed in previous grid-based SAT surveys (DECCW 2010; Phillips & Hopkins 2008; Phillips & Hopkins 2009).

Centre the grid over each area of suitable habitat. Where suitable habitat is discontinuous, consider the required survey effort for each area independently. Grid intersections represent the sites at which the SAT protocol is to be undertaken (SAT sites, Figure 5). Coordinates for each grid-cell intersection must be uploaded into a hand-held GPS for location in the field.

The total number of SAT sites required for an area of suitable habitat is determined by dividing the approximate number of hectares by 2.25 (for 150 m grid spacing) or 6.25 (for 250 m grid spacing). Areas of suitable habitat ≤5 ha require a minimum of three SAT sites, located in different PCTs, where relevant.

The SAT protocol, as detailed in Phillips & Callaghan (2011), must be undertaken at each SAT site as follows:

1. Locate and mark the tree[5] of any species closest to the grid intersect coordinates – this is identified as the centre tree. To accommodate floristic variations, selection of the centre tree may vary by 10% of the sampling interval (i.e. 25 m for a 250 m grid).
2. Move outwards from the centre tree, identifying the 29 nearest trees of any species to the centre tree within the area of suitable habitat. Where the minimum sampling effort of 30 trees cannot be met, sample the highest number possible before overlapping with the adjacent SAT site.
3. Undertake a radial search for koala scat beneath each of the 30 marked trees, within a prescribed search area extending 1 m from the base of each tree. Scat search effort is a minimum of two person-minutes for each tree. For trees with a large dbh, it is expected that additional search time will be required.
4. Searches should begin with a brief inspection of the undisturbed litter or grass and grass like growth form cover within the 1 m search area. If no koala scats are detected, a more thorough inspection of the search area, involving disturbance by hand of the litter or grass and grass like growth form cover, is required.
5. The search at each tree is concluded when:
   a. a koala scat is detected, or
   b. the search time ends with no koala scat detected.
6. Where the search time ends before a koala scat is detected, the SAT survey must continue at the next nearest tree.

All 30 trees at each SAT site must be sampled until a koala scat is detected, or all have been sampled. Koala presence within an area of suitable habitat is confirmed by detection of a koala scat.

Details of SAT surveys, for inclusion in the BAR, are outlined in Appendix F.

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[5] For the purpose of a SAT assessment, a tree is defined as ‘a live woody stem of any plant species (excepting palms, cycads, tree ferns and grass trees) which has a diameter at breast height (dbh) of 100 mm or greater’ (Phillips & Callaghan 2011).

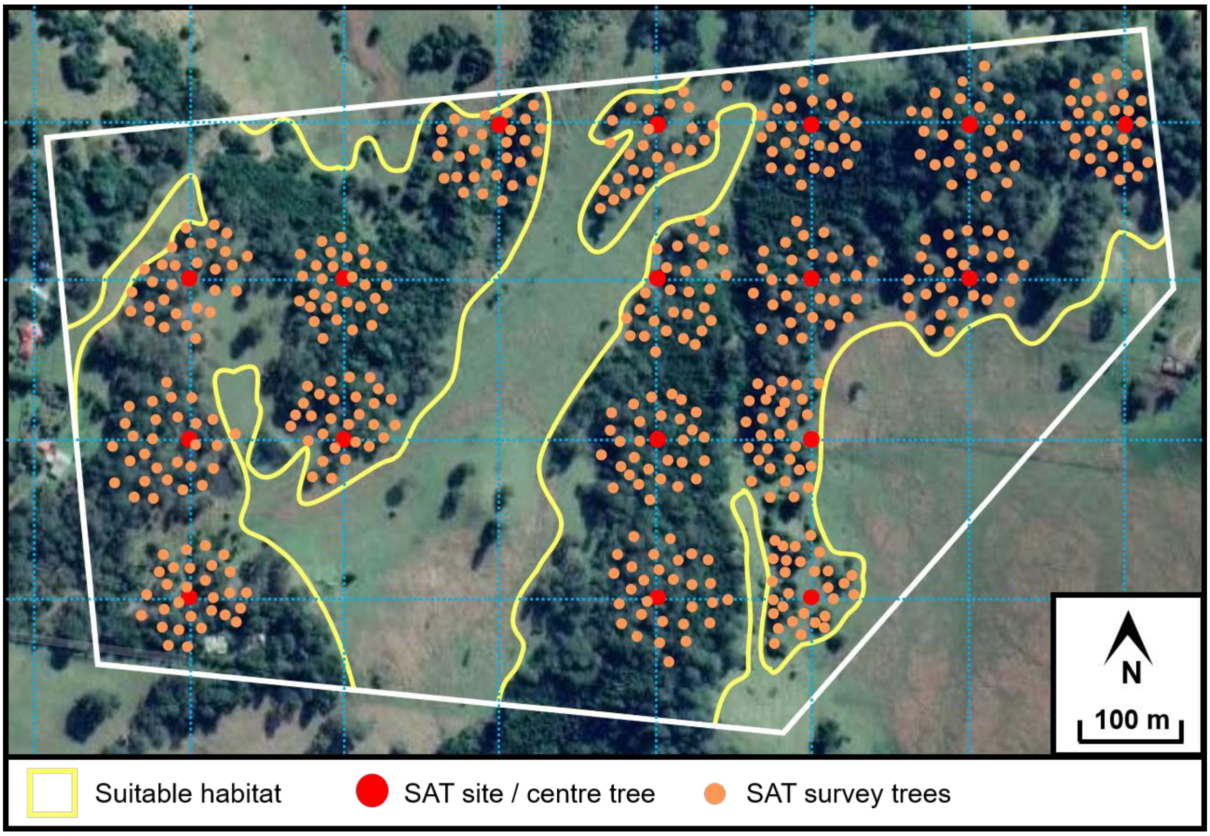

Figure 5 **SAT surveys – example of SAT site selection on a subject land with 28 ha of continuous suitable habitat**

4.2 Detection dogs

A detection dog, trained to identify koala scat, is an indirect method for detecting koala presence. The superior speed and accuracy of detection dogs make them suitable for large sites (>50 ha), sites characterised by complex litter, and/or low-density koala populations (Arnett 2006; Cristescu et al. 2012; Cristescu et al. 2015).

4.2.1 Limitations

To ensure their welfare, detection dogs should not be used in extreme weather conditions (e.g. high temperatures) or in areas of feral predator baiting.

Detection dogs may have difficulty accessing areas with rugged terrain and/or suitable habitat with dense vegetation, such as post-fire regeneration.

As heightened insect activity during wet conditions increases koala scat decomposition rates, detection dog surveys should not be undertaken within three days of rainfall (Cristescu et al. 2012; Melzer et al. 1994; Rhodes et al. 2011).

4.2.2 Timing

Detection dog surveys may be undertaken all year round, during daylight hours.

4.2.3 Method

Three 200 m transects are required for every 5 ha of suitable habitat, spaced ≥100 m apart (Box 3). Locate transects evenly throughout suitable habitat, ensuring representative coverage of PCTs and avoiding edges, where possible. Where the area of suitable habitat is

≤2 ha, a single transect may be used. For suitable habitat >5 ha, the size and shape of the area will influence the arrangement of transects, with larger areas having longer transects (Figure 6). Where suitable habitat is discontinuous, consider the required survey effort for each area independently.

Detection dogs survey for scat along the transect. The detection dog handler walks the central transect twice, first in one direction and then the opposite. The detection dog is permitted to roam freely within the 25 m to the side of the transect (Figure 6). Whilst search times will vary with terrain, vegetation and individual dogs, the detection dog handler should walk the transect at approximately 10 m/min.

Coordinates for the start point of each transect must be uploaded into a hand-held GPS for location in the field. Determine the direction of travel for each transect in advance, to ensure the surveyor moves a known distance, at a set speed, in accordance with their planned level of survey effort (DSEWPaC 2011).

Koala presence within an area of suitable habitat is confirmed by detection of a koala scat.

The detection dog must be trained ethically to detect koala scat. In partnership with their handler, they must have prior field experience surveying for koalas, and the relevant approvals and permits. The detection dog and their handler must be assessed[6], as a team, within the previous 12 months to demonstrate competency in:

- reliable commanding and handling of the detection dog
- reliable koala odour recognition and response in accordance with nominated and appropriate indication type (e.g. passive, freeze, dig/scratch, etc.)
- reliable non-target disinterest
- reliable behaviour that does not harm native fauna.

Welfare of the detection dog is a priority and must be monitored throughout the survey. Adequate rest periods, sun protection and drinking water must be provided.

Details of detection dog surveys, for inclusion in the BAR, are outlined in Appendix F.

Box 3. Calculating survey effort for detection dogs

To calculate the number of 200 m transects required, divide the hectares of suitable habitat by 5, then multiple by 3. Round to the nearest full number according to standard convention.

Figure 6 demonstrates suitable habitat of 28 ha:

- 28 / 5 = 5.6
- 5.6 x 3 = 16.8 (round to 17).

Therefore, 17 x 200 m transects must be undertaken in the suitable habitat. Arrangement of the transects will depend on the site configuration – transects may be combined in length while adhering to the ≥100 m spacing.

[6] Peer or industry assessments are acceptable. This will be reviewed as accreditation standards are further developed.

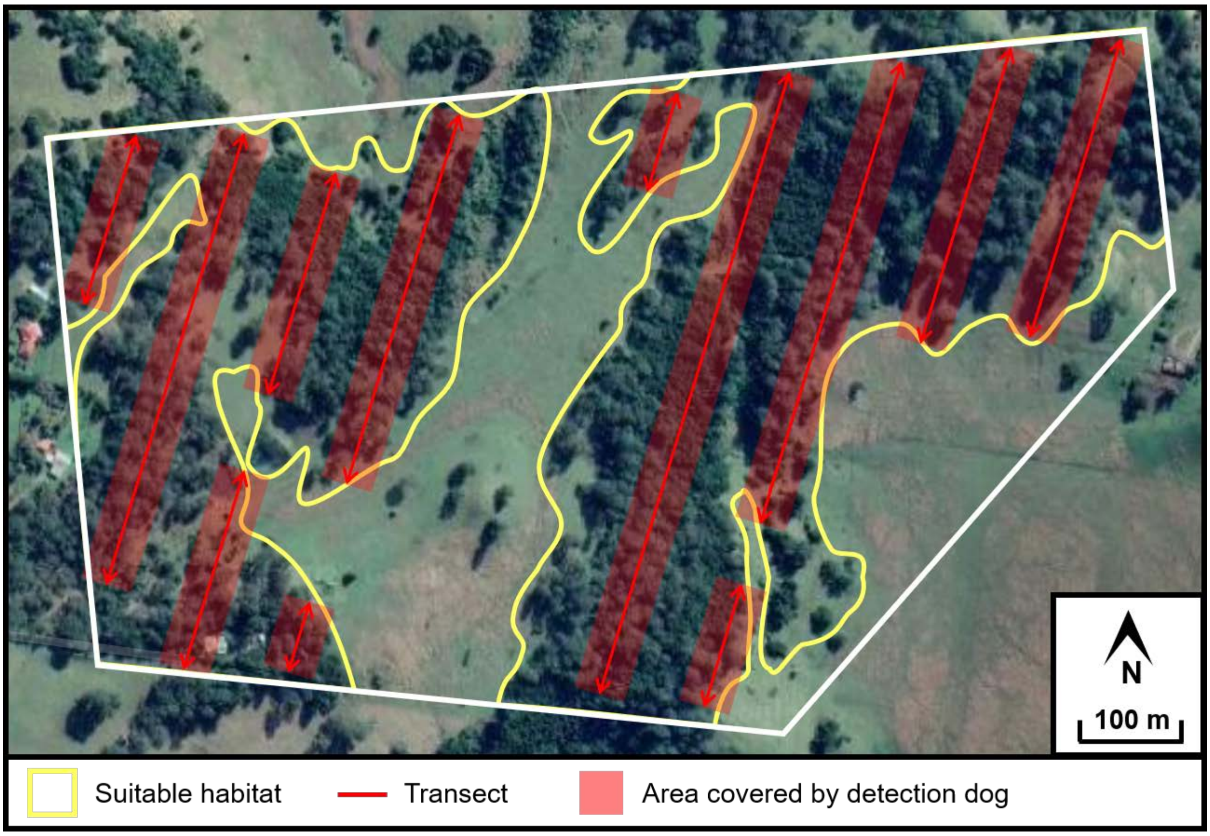

Figure 6 **Detection dog – example of transect arrangement on a subject land with 28 ha of continuous suitable habitat**

4.3 Spotlighting

Spotlighting is a direct survey method suitable for detecting koalas. As a nocturnal, arboreal species with bright eye-reflectance, large body size and slow movement patterns, koalas can be detected by spotlighting (DSEWPaC 2011; Kavanagh & Stanton 2012; Wilmott et al. 2019; Witt et al. 2020).

4.3.1 Limitations

Animal movement and 'eye shine' (reflection of light from the animal's eye) are key factors influencing the detectability of koalas in spotlighting surveys (NSW DEC 2004). Therefore, spotlighting is not appropriate in dense vegetation, tall forests (e.g. trees up to 30 m in height), on steeply sloping land or in deep gullies, as the light cannot penetrate an adequate distance from the surveyor (DSEWPaC 2011).

Spotlighting surveys should not be undertaken in extreme temperatures, rainfall or high wind, as these conditions may reduce fauna activity and detectability (DSEWPaC 2011).

4.3.2 Timing

Spotlight surveys may be undertaken all year round.

4.3.3 Method

For suitable habitat ≥5 ha, two 200 m transects are required for every 5 ha of suitable habitat (Box 4) (DSEWPaC 2011). Where the area of suitable habitat is <5 ha, a single transect may be used. Locate transects evenly throughout suitable habitat, ensuring representative coverage of PCTs and avoiding edges, where possible. Space transects ≥100 m apart, as a maximum spotlight penetration of 50 m is assumed for each side of the transect (DSEWPaC 2011; Lindenmayer et al. 2001). The size and shape of the suitable habitat will influence the arrangement of transects, with larger areas having longer transects (Figure 7). Where suitable habitat is discontinuous, consider the required survey effort for each area independently.

Undertake spotlighting along the transects at night. Repeat the spotlighting survey on a second night (DSEWPaC 2011; NSW DEC 2004).

Coordinates for the start point of each transect must be uploaded into a hand-held GPS for location in the field. Determine the direction of travel for each transect in advance, to ensure the surveyor moves a known distance, at a set speed, in accordance with their planned level of survey effort (DSEWPaC 2011).

Spotlighting surveys are undertaken on foot, moving at approximately 10 m/min (van der Ree & Loyn 2002). Consequently, a 1000 m transect will take approximately 100 min, depending on the surveyor and the vegetation density (Box 4). Where the suitable habitat is characterised by a low tree density, spotlighting surveys may be undertaken from a slow-moving vehicle (speed ≤5 km/h) (NSW DEC 2004). This must be documented and justified in the BAR.

The spotlight must be held near the surveyor's line of vision to maximise detection of eye shine and moved at a slow, consistent speed over the canopy on both sides of the transect (DSEWPaC 2011). Potential detections must be confirmed with the use of binoculars.

Spotlighting requires the use of a lightweight, hand-held spotlight powered by a suitable battery. Higher spotlight intensity will ensure better light penetration through vegetation (NSW DEC 2004). Spotlight intensity, however, must be less than 1500 lm (100 W), as excessive brightness may cause wildlife to look away (DSEWPaC 2011). The minimum spotlight intensity requirements are 750–1100 lm (50−75 W) in all forest types. Wellbeing of wildlife must be prioritised when spotlighting by reducing the light intensity for prolonged observations (e.g. use of a red light or dimmer switch).

Koala presence within an area of suitable habitat is confirmed by direct observation.

Details of spotlighting surveys, for inclusion in the BAR, are outlined in Appendix F.

Box 4. Calculating survey effort for spotlighting

Calculating number transects required

To calculate the number of 200 m transects required, divide the hectares of suitable habitat by 2.5. Round to the nearest full number according to standard convention.

Figure 7 demonstrates suitable habitat of 28 ha:

- 28 / 2.5 = 11.2 (round to 11).

Therefore, 11 x 200 m transects must be undertaken in the suitable habitat. Arrangement of the transects will depend on the site configuration – transects may be combined in length while adhering to the 100 m spacing.

Calculating survey effort (time)

To estimate the time needed to complete the spotlighting transects (in minutes), divide the total transect length by 10:

- 11 x 200 m = 2,200 m
- 2,200 m / 10 = 220 min

As all transects must be surveyed twice, double the time for the full survey effort.

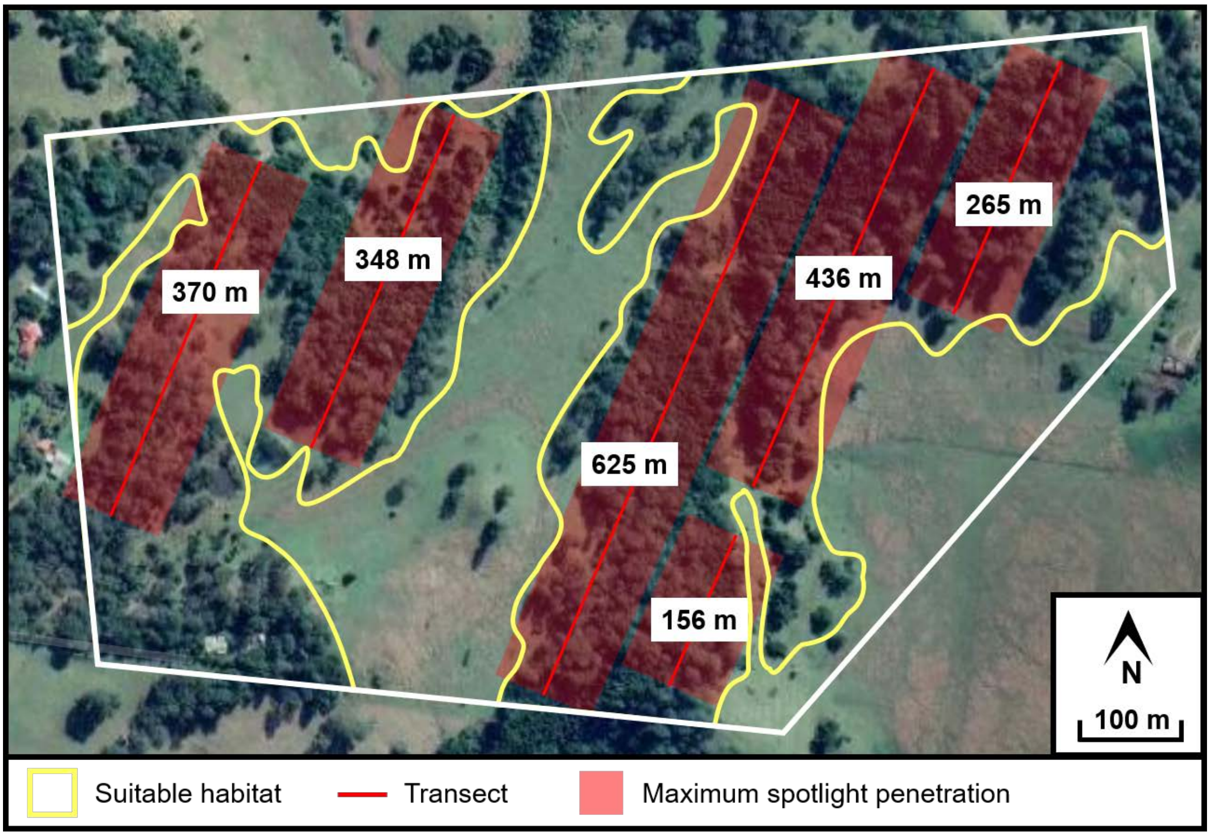

Figure 7 Spotlighting survey – example of transect arrangement on a subject land with 28 ha of continuous suitable habitat

4.4 Passive acoustic

Passive acoustic surveys record vocalisations to confirm koala presence on the subject land (Hagens et al. 2018; Law et al. 2018; Law et al. 2020). Male koalas produce loud, distinctive bellows during the breeding season that may be used to determine presence with acoustic recording units (Ellis et al. 2011; Hagens et al. 2018; Smith 1980).

This method is most suitable for subject land with low quality habitat (e.g. poor soil fertility), where the terrain is rugged, or ground vegetation is dense. The method may also provide a cost-effective approach for surveying large areas of suitable habitat.

4.4.1 Limitations

Detection range of recording units is related to microphone sensitivity and varies between models. To avoid false positives (e.g. detecting bellows beyond the subject land), evaluate the suitability of a recording unit by comparing its detection range with the subject land area. For example:

- Song Meter (SM4) (Wildlife Acoustics, Inc.): with a detection range of approximately 300 m, is unsuitable for a subject land of <25 ha, unless sensitivity is manually reduced.
- Audio Moth (Open Acoustic Devices): with a detection range of approximately 100 m, is unsuitable for a subject land <4 ha.

Passive acoustic surveys must not be undertaken during conditions with high wind speeds, high temperatures (>35°C) or rainfall (>3 mm per night), which can reduce koala bellowing frequency and/or detectability (Ellis et al. 2011; Hagens et al. 2018; Law et al. 2018; Law et al. 2020). Where any of these conditions occur during the recording period, the survey must be extended by an equivalent number of nights. Where possible, select sampling locations to minimise background noise; for example, near roads or waterbodies where traffic noise or frog calling may reduce bellow detectability.

As male koala vocalisations are louder and more frequent than females (Smith 1980), passive acoustic surveys are generally biased towards detection of male koalas. Law et al. (2020) highlight, however, that male bellowing is associated with breeding activity.

4.4.2 Timing

Given koala bellowing is greatest during breeding, passive acoustic surveys can be undertaken from September to December (Ellis et al. 2011; Hagens et al. 2018; Law et al. 2018).

4.4.3 Method

Survey effort will depend on the area of suitable habitat and detection range of the recording unit. The density of recording units and recording period (number of consecutive nights) is detailed in Table 2 (Gonsalves & Law 2021). Where suitable habitat is discontinuous, consider the required survey effort for each area independently.

Pre-program the units for continuous recording from sunset to sunrise (Hagens et al. 2018; Law et al. 2018; Law et al. 2020).

Deploy recording units evenly throughout the suitable habitat (Figure 8). Spacing of recording units must be at least double the detection range of the model. Detection range should be considered when locating recording units near the subject land boundary. For large, continuous areas of suitable habitat, a grid system may be used to select survey sites based on the densities outlined in Table 2.

Table 2 Passive acoustic surveys – minimum effort requirements

Suitable habitat	Maximum detection range of the recording unit	
	Approximately 100 m	Approximately 300 m
≤50 ha	1 recording unit / 5 ha Recording period: 7 nights	1 recording unit / 25 ha Recording period: 7 nights
>50 – 100 ha	1 recording unit / 10 ha Recording period: 10 nights	1 recording unit / 50 ha Recording period: 10 nights
>100 ha	10 recording units + 3 recording units / additional 200 ha Recording period: 12 nights	2 recording units + 1 recording unit / additional 200 ha Recording period: 12 nights

Mount the recording unit approximately 1.5–1.8 m above the ground, ideally in an open position where no branches or foliage will interfere with the acoustic recording (Hagens et al. 2018). Where a tree is used, select a trunk narrower than the recording unit. The use of plastic bags for protection against rain may also reduce the sensitivity of recordings (DPIE 2020b). This must be addressed in the survey design and documented in the BAR.

The recording unit model must be suited to the acoustic characteristics of koalas. At the height of bellowing activity, the frequency range of a koala's call is approximately 80–750 Hz (inhalation) and 90–400 Hz (exhalation) (Ellis et al. 2011). Sampling rate settings will vary with each model. The sampling rate must be at least double the highest frequency produced during a koala call. Higher sampling rates will improve the quality of recorded calls. For example, commonly used sampling rates include:

- Song Meter (SM4) (Wildlife Acoustics, Inc.): 22 kHz
- Audio Moth (Open Acoustic Devices): 32 kHz.

Recordings must be analysed for koala bellows by a bioacoustics specialist, with relevant training and experience (refer to Section 2.3). The bioacoustics specialist may use an algorithm to identify koala calls when results of its performance are available. This must be documented in the BAR, and manual validation also undertaken.

Where koala bellows are detected, presence is confirmed in all suitable habitat overlapping with the detection range of the recording unit. Where presence is confirmed in an area of continuous suitable habitat, it extends to the entirety of that area.

Details of passive acoustic surveys, for inclusion in the BAR, are outlined in Appendix F.

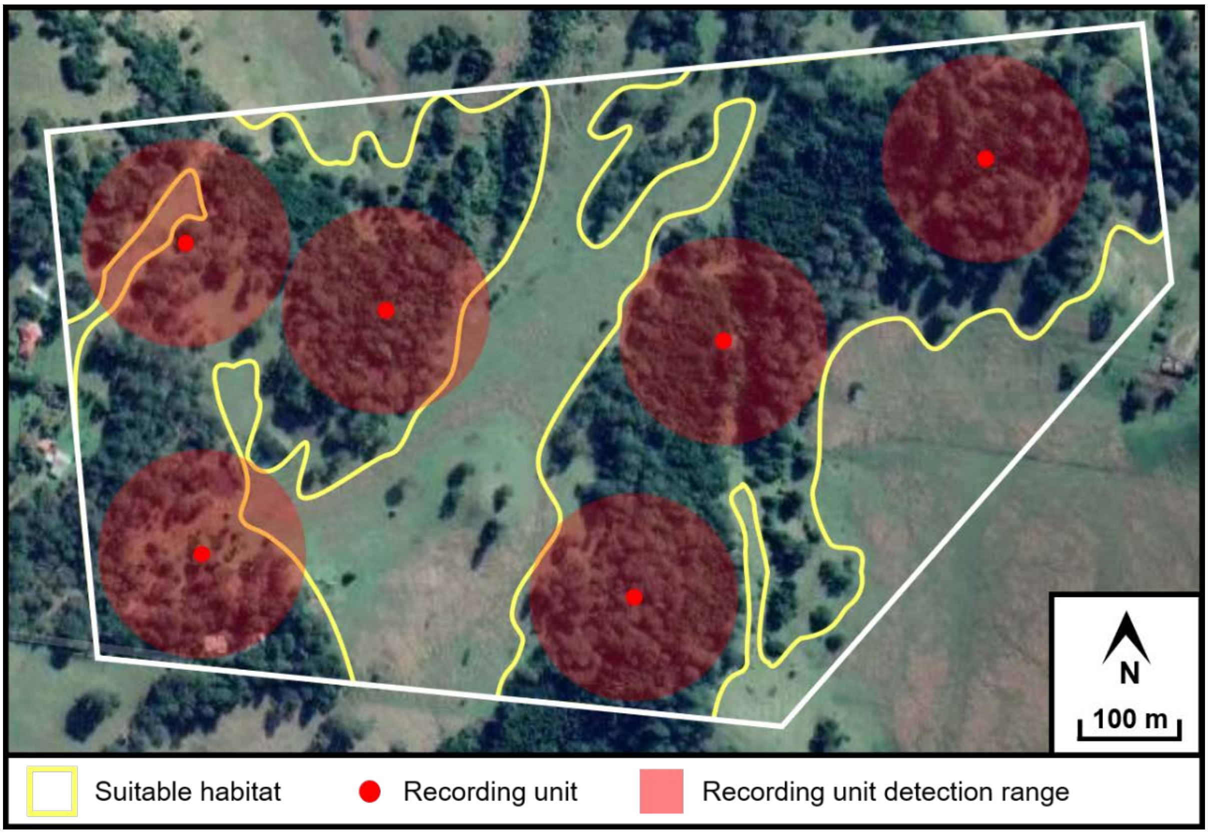

Figure 8 **Passive acoustic survey – example of survey site selection for a subject land with 28 ha of continuous suitable habitat, using a recording unit with a 100 m detection range**

4.5 Drones

Drones, also referred to as remotely piloted aircraft systems (RPAS), are a rapidly emerging tool to support detection of cryptic species such as koalas (Beranek et al. 2020; Corcoran et al. 2019; Hamilton et al. 2020). When paired with thermal sensors, drones detect the difference in brightness between a koala's thermal signature and their surrounding environment (Hamilton et al. 2020).

Drone surveys are particularly effective for large subject lands, as up to 200 ha can be surveyed per night. This method is also suitable for subject lands with difficult to access areas.

4.5.1 Limitations

Civil Aviation Safety Authority (CASA) regulations must always be followed, including maintaining visual line of sight (Appendix A). Additional permissions and approvals are required for flying at night or beyond visual range, including a remotely piloted aircraft operator's certificate (ReOC). Pilots must have specific permission for conducting a drone survey from the landowner, land manager or custodian.

Drone surveys must be undertaken at night and/or early morning before sunrise to maximise the temperature differential between the surrounding canopy, the bodies of koalas and other fauna (Beranek et al. 2020).

Drone surveys cannot be undertaken in conditions of high wind or humidity (rain or fog). Wind resistance ≥10.5 m/s may cause the drone to drift from its flightpath, potentially resulting in blurry images or loss of aircraft (Beranek et al. 2020; Corcoran et al. 2019). High humidity can affect koala detectability as the water vapour present in the air can reduce thermal signatures (Cilulko et al. 2013). Dense vegetation, including the understory, may also impede detection of koalas (Witt et al. 2020).

Machine learning algorithms to automate koala heat signature detection are under development and will likely offer further improvements to the method (Corcoran et al. 2019; Hamilton et al. 2020). At present, training and testing of these algorithms across a range of habitats and koala populations is required and they are not suitable for the purpose of this guide (Beranek et al. 2020).

Disturbance to nesting birds must be considered (Lyons et al. 2018). Where threatened bird species are present on the subject land, drone surveys should be avoided during their breeding season.

4.5.2 Timing

Drone surveys are dependent on ambient temperature. Suverys must only be conducted when the daily minimum temperature (i.e. for 24 hours) is expected to be ≤18°C (Adam Roff 2020, pers. comm.). This generally limits surveys to between March and December for much of New South Wales.

Surveys must be undertaken at night, between 21:00 and dawn, to maximise the heat differential between koalas and their surrounding vegetation.

4.5.3 Method

This method is based on Beranek et al. (2020), which can be used for further guidance.

A gimbal system with a longwave thermal camera and visual (RGB) camera must be attached to the drone. Enough batteries for at least 2 h of flight time is recommended.

The cameras used must be capable of capturing an image of a koala from approximately 30–40 m above the canopy, with ≥15 px resolution. Minimum equipment specifications are:

Thermal camera

- Thermal sensitivity: ≤50 mK
- Spectral range: LWIR or 8–14 μm
- Thermal resolution: ≥640 x 512 px
- Focal length: 9 mm, 13 mm or 19 mm
- Frame capture rate: ≥30 Hz

Visual (RGB) camera

- Video resolution: 3840 × 2160 px

Survey the full extent of suitable habitat, maintaining ≥30% side overlap between flight paths (Figure 9). The most appropriate flight path will depend on the shape and configuration of suitable habitat. Justification for flight path approach must be included in the BAR and the flight path GPS tracklog.

Flight altitude will depend on the vegetation and equipment specifications; however, flights should be approximately 30–40 m above the canopy. Height above ground level (AGL) will depend on the focal length of the sensor and the tree height. For trees that are approximately 30 m tall, a drone with a:

- 9 mm sensor, should fly at 65 m AGL
- 13 mm sensor, should fly at 70 m AGL
- 19 mm sensor, should fly at 75 m AGL or above.

A maximum speed of 8 m/s should be maintained throughout the flight. At all times, the drone must be kept within visual line-of-sight.

A qualified pilot, with prior flying experience in koala surveys, must operate the drone and have previous experience identifying koala heat signatures. A spotter may be used to help examine the real-time thermal videos for potential koala presence. Koalas are characterised by large, diffuse, circular thermal blooms within the vegetation canopy (Beranek et al. 2020). As best practice, where possible, record video continuously in MP4 format and archive with notes on detections.

Where a potential koala detection occurs, hover the drone directly over the detection location. Where it is safe to do so, the pilot may descend to capture images from closer to the animal, but must not come within 20 m. A screen shot of the thermal image should be collected for each potential detection. Screenshots must feature the GPS location information, video timecode and time captured.

Koala heat signatures may be confused with landscape features (e.g. exposed sandstone) and co-occurring arboreal species (e.g. flying-foxes, possums, birds, occupied hollows). All potential detections must be validated via one of the following:

- **Real-time validation.** If the drone is equipped with a spotlight, immediate validation may be possible by taking colour images of eye shine. If the pilot can safely descend closer to the animal, confirmation of koala presence with high confidence may be possible. Observing behaviour of the potential detection can be helpful as an indicator of the species to remove false positives. For example, flying-foxes and gliders are far more active than koalas and can be identified based on observation over time. Wellbeing of wildlife must be prioritised by limiting prolonged observations. Where the koala can be identified in real time, a screenshot or photo (visual or thermal) should be collected.
- **Post-survey validation (on-ground).** Following the drone survey, as soon as possible after first light, the surveyor navigates to the potential detection location. Presence is confirmed by directly sighting the koala. Where a koala is not visible at the potential detection location, the surrounding trees should be searched within a radius of approximately 80 m for approximately 15 min (Witt et al. 2020).
- **Post-survey validation (drone).** Following the drone survey, as soon as possible after first light, the drone is flown back to the potential detection location. Hover the drone over the location and re-acquire the potential detection using the thermal camera. Where the koala can be identified in real time, a colour photo should be collected (Figure 10). Where a koala is not visible at the potential detection location, the trees surrounding this location should be searched within a radius of approximately 80 m for approximately 15 min (Witt et al. 2020).

Koala presence within an area of suitable habitat is confirmed by a validated koala observation.

Where no potential koala detections are successfully validated, a second night of survey is required. If no potential koala detections are successfully validated following two nights of survey, this may be taken as absence for the purpose of the drone survey method. Imagery captured of the potential detections, with GPS coordinates, must be included with the BAR.

Importantly, care must be taken where surveys are conducted within the ranges of territorial bird species, particularly during breeding seasons (Lyons et al. 2018). The pilot should take evasive action to avoid harmful interactions and minimise hovering close to the canopy to avoid disturbing nesting birds (Lyons et al. 2018).

Details of drone surveys, for inclusion in the BAR, are outlined in Appendix F.

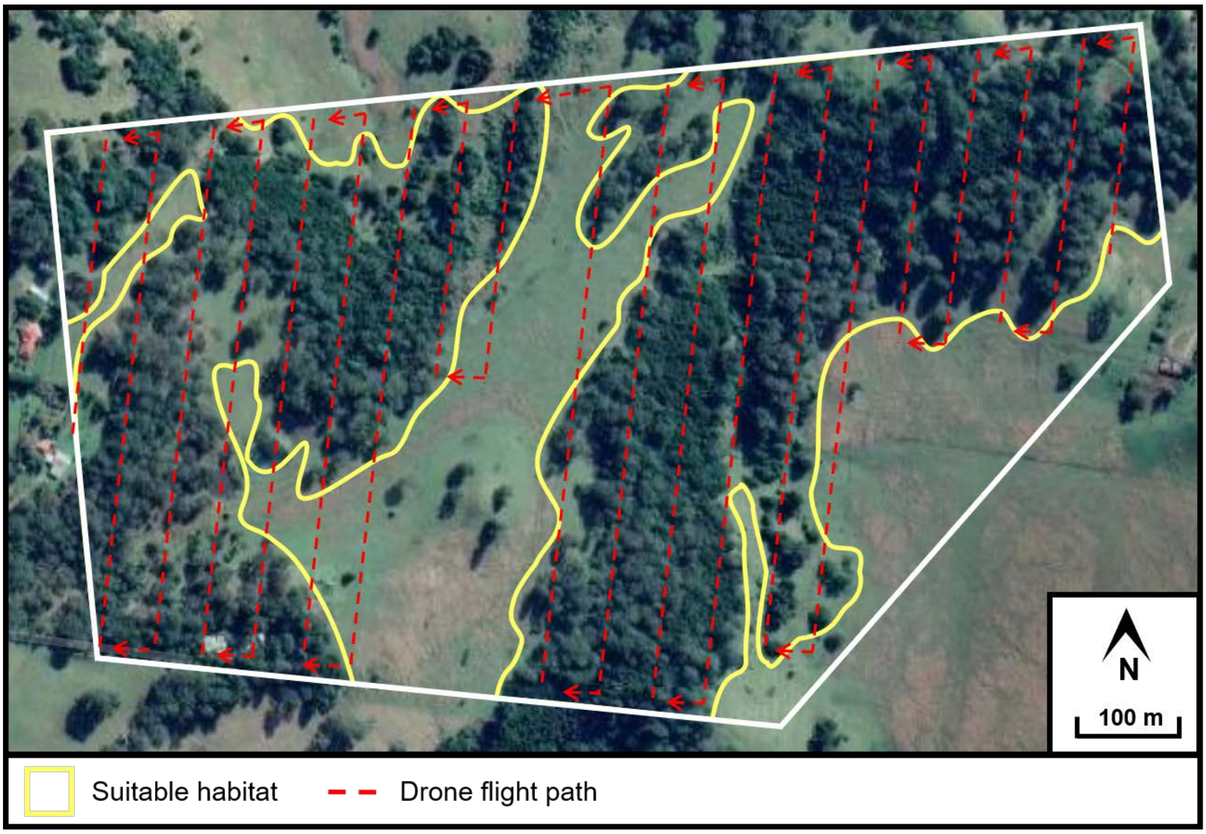

Figure 9 **Drone survey – use of a 'lawn-mower' flight path on a subject land with 28 ha of continuous suitable habitat**

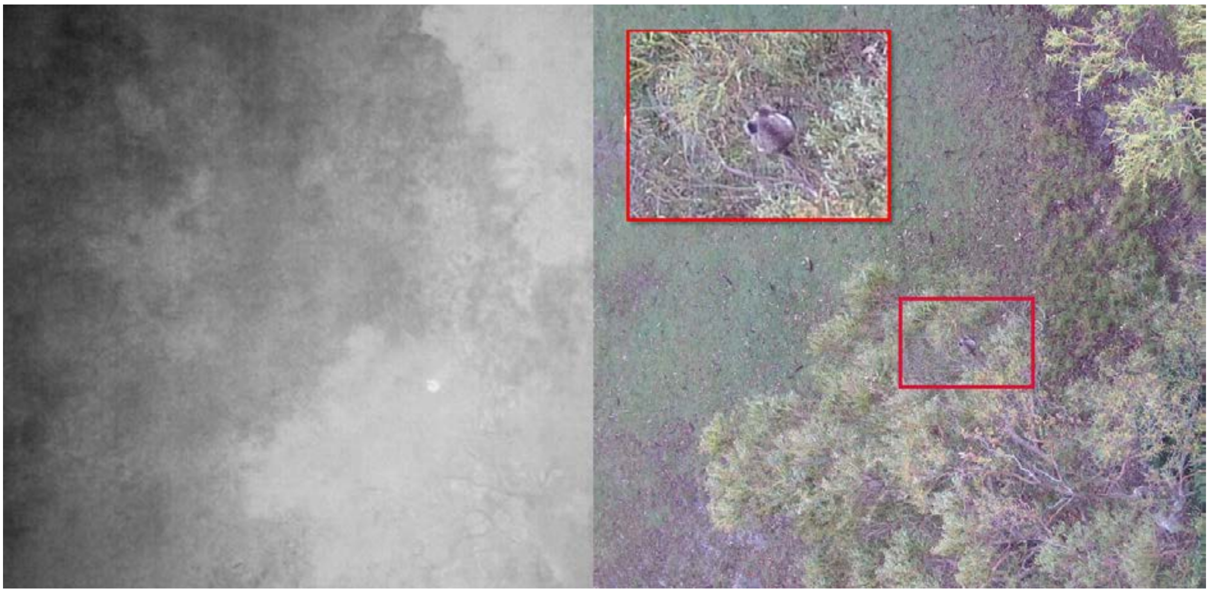

Figure 10 Drone survey – example of a koala thermal signature validated against 4K colour photo (DPE/Adam Roff)

5. Species polygon

Where a targeted survey confirms koala presence, a species polygon must be mapped in accordance with BAM 2020 (Subsection 5.2.5).

Use best available ortho-rectified aerial imagery of the subject land to identify:

- locations of all koala detections
- vegetation zones considered suitable habitat, and
- area of the species polygon.

Where koala presence is confirmed, begin by mapping the vegetation zone in which the species was detected as the species polygon. All vegetation zones that are continuous suitable habitat with this vegetation zone should be included (refer to Section 3.2). If areas of suitable habitat are discontinuous, koala presence must be confirmed in each by targeted survey, for inclusion in the species polygon. Refer to the examples in Box 5.

For BSA sites, areas where management actions will restore suitable habitat for koalas may be included in the species polygon. Where suitable habitat or an area separating suitable habitat is highly degraded or isolated, active restoration might be appropriate. For example, management actions might include supplementary planting of koala use trees (particularly those ranked 1 and 2, refer to Appendix C).

Where koala presence is assumed, the full extent of all PCTs on the subject land determined to be suitable habitat (as per Section 3.2) are mapped as the species polygon.

Box 5. Mapping a koala species polygon

Continued from the examples detailed in Box 2.

Example 1 – Impact assessment site

A targeted koala survey on the development site confirmed presence in VZ1 and VZ4 (Figure 11). As all suitable habitat on the subject land is considered continuous, the full extent of the suitable habitat is mapped as the species polygon.

Example 2 – Biodiversity stewardship agreement site

A targeted koala survey on the BSA site confirmed presence in VZ1 and VZ2 of continuous suitable habitat (area 1) (Box 2, Figure 12 and Figure 13). The koala was not detected in continuous suitable habitat (area 2) (refer to suitable habitat mapping in Figure 4).

Without active restoration

If no active restoration management actions are proposed to support koala presence on the subject land, the full extent of continuous suitable habitat (area 1) is mapped as the species polygon (Figure 12). Koala presence must be confirmed in continuous suitable habitat (area 2) for its inclusion in the species polygon.

With active restoration

Active restoration management actions are proposed to improve koala habitat on the subject land. Selected areas of cleared vegetation will be restored to their original PCT B (highlighted in green, Figure 13). Supplementary planting will target all the highest weighted growth form groups for this PCT (e.g. tree growth form group). Koala use trees typically found in PCT B will be planted. Species ranked 1 or 2 (Appendix C) are targeted to ensure a food source for koalas. Similarly, supplementary planting of koala use trees (ranked 1 and 2) will also be undertaken in PCT B of continuous suitable habitat (area 2).

These active restoration management actions will restore connectivity between continuous suitable habitat (area 1) and continuous suitable habitat (area 2). Consequently, both areas of continuous suitable habitat and the restored areas of PCT B will comprise the species polygon (Figure 13).

Where active restoration management actions are proposed to expand the area of suitable habitat for koalas, evidence-based justification that koalas are likely to disperse unassisted into, and use, the restored habitat must be included in the BSSAR. This should be discussed with the BCT.

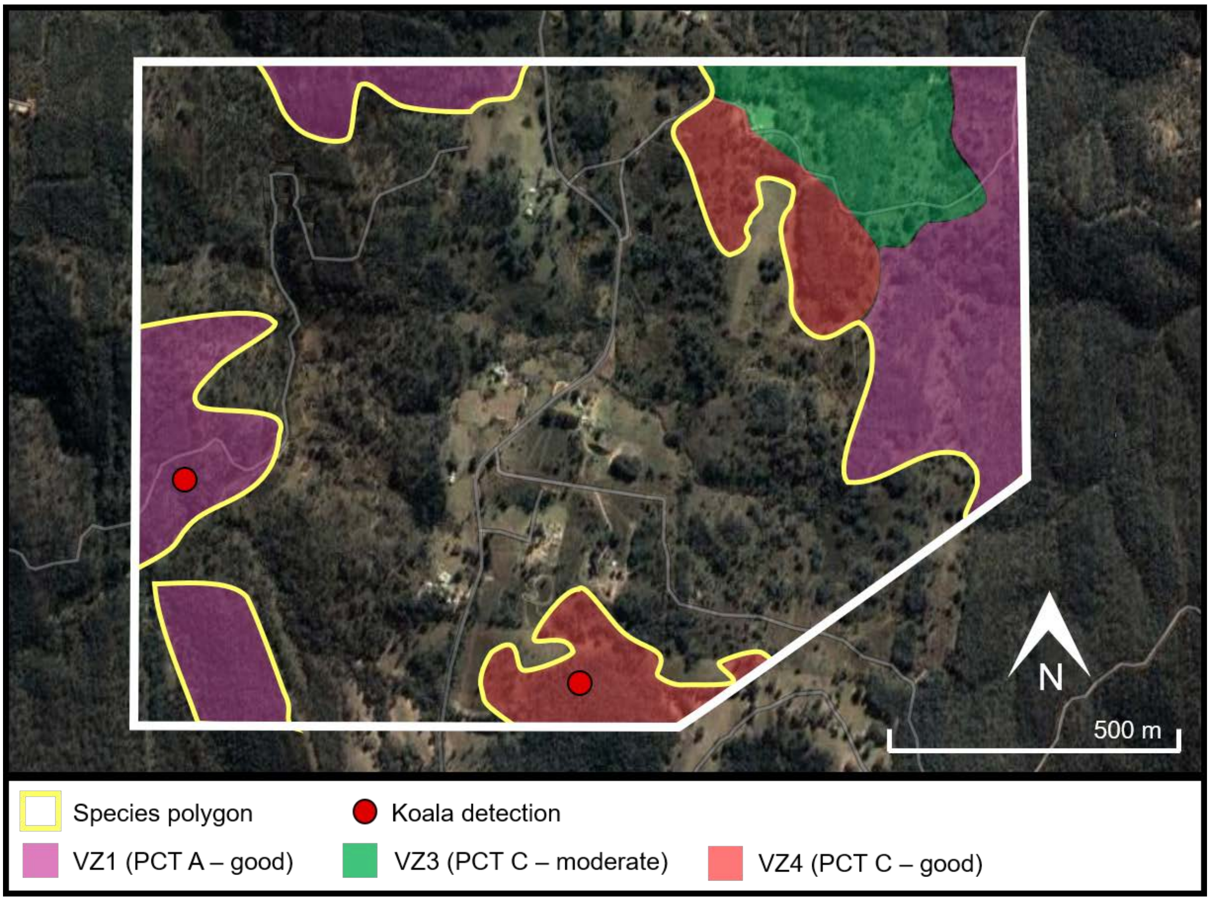

Figure 11 Example 1: mapping a koala species polygon

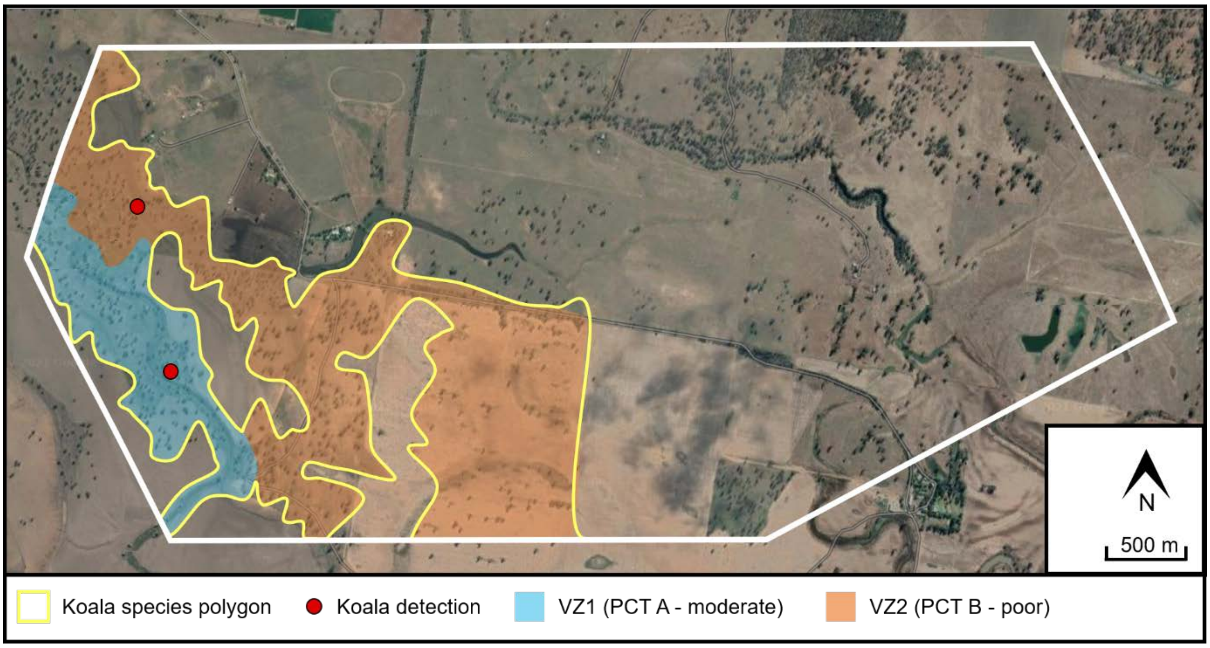

Figure 12 Example 2: mapping a koala species polygon

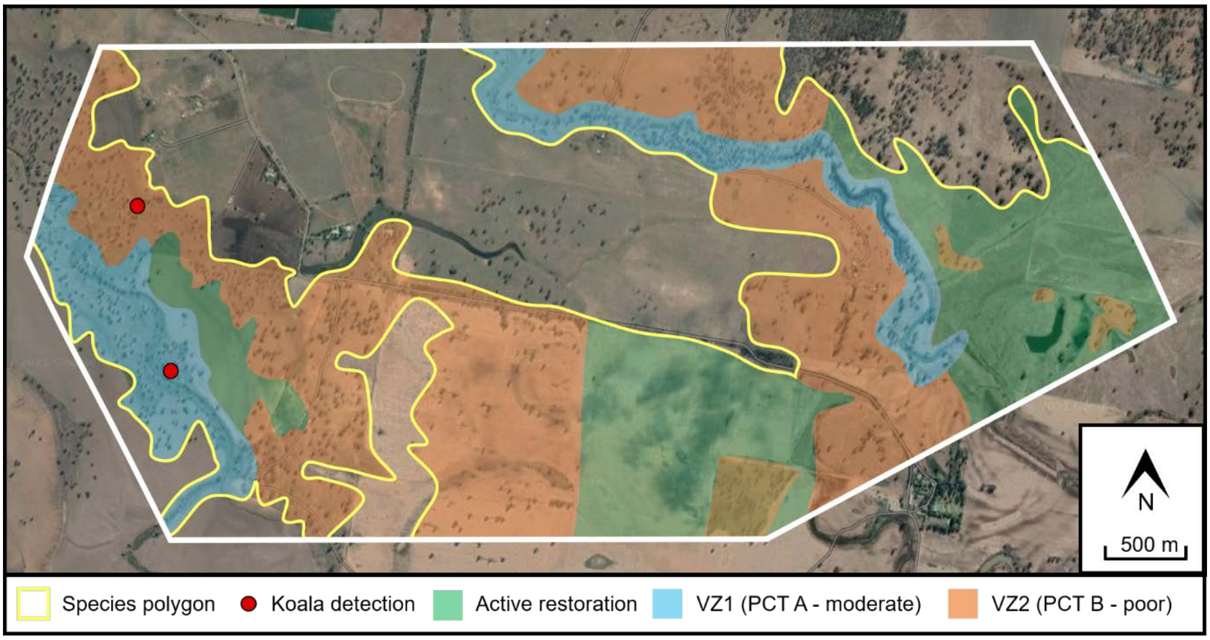

Figure 13 **Example 2: mapping a koala species polygon, including areas of active restoration**

6. Documentation

The BAR must be prepared in accordance with the BAM (see BAM 2020, Appendices K and M) and BAM Operational Manuals. For targeted species surveys, this will include reference to design, method, timing, effort and results. A summary of the documentation required for a targeted koala survey is provided in Appendix F.

Digital GIS files (ESRI compatible) for all spatial data underpinning maps must be submitted with the BAR.

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Appendix A. Websites and online resources

Assessor resources

https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/accredited-assessors/assessor-resources

Australasian Conservation Dog Network
https://conservationdognetwork.com.au/

Biodiversity Assessment Method (BAM)
https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/biodiversity-assessment-method

Biodiversity Assessment Method Calculator (BAM-C)
www.lmbc.nsw.gov.au/bamcalc

Biodiversity Assessment Method Calculator (BAM-C) – User Guide
www.lmbc.nsw.gov.au/bamcalc/app/assets/BAMTools_UserGuide.pdf (PDF 3.0MB)

Biodiversity Assessment Method Operational Manual – Stage 1
www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/biodiversity-assessment-method-operational-manual-stage-1-180276.pdf (PDF 1.3MB)

Biodiversity Assessment Method Operational Manual – Stage 2
www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/biodiversity-assessment-method-operational-manual-stage-2-190512.pdf (PDF 1.3MB)

Biodiversity Assessment Method Operational Manual – Stage 3

https://www.environment.nsw.gov.au/research-and-publications/publications-search/biodiversity-assessment-method-operational-manual-stage-3

Biodiversity Conservation Act 2016
www.legislation.nsw.gov.au/~/pdf/view/act/2016/63/whole (PDF 1.0MB)

Biodiversity Conservation Regulation 2017
www.legislation.nsw.gov.au/regulations/2017-432.pdf (PDF 513KB)

Biodiversity experts
https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/biodiversity-offsets-scheme/experts

BioNet Atlas
https://www.environment.nsw.gov.au/wildlifeatlas/about.htm

BioNet Atlas – Application for login access
www.environment.nsw.gov.au/atlaspublicapp/Registration.aspx

BioNet Atlas (Species Sightings) Search
www.environment.nsw.gov.au/atlaspublicapp/UI_Modules/ATLAS_/AtlasSearch.aspx

BioNet – How to access the BioNet Web Service using Excel and Power Query
www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/BioNet/bionet-access-using-excel-power-query-quick-guide-160403.pdf (PDF 1.0MB)

BioNet Systematic Flora Survey
www.environment.nsw.gov.au/research/VISplot.htm

BioNet quick guides, manuals, and datasheets
www.bionet.nsw.gov.au/bionet-guides-manuals.htm

BioNet Threatened Biodiversity Data Collection (TBDC)
www.environment.nsw.gov.au/asmslightprofileapp/Account/Login

BioNet Vegetation Classification
www.environment.nsw.gov.au/research/Visclassification.htm

BioNet Vegetation Classification user manual
www.environment.nsw.gov.au/resources/bionet/bionet-vegetation-classification-user-manual-170340.pdf (PDF 4.1MB)

BioNet Vegetation Map Collection (previously Vegetation Information System Maps)
www.environment.nsw.gov.au/research/VISmap.htm

BioNet Web Services
https://data.bionet.nsw.gov.au/

Civil Aviation Safety Authority (CASA)
www.casa.gov.au

Consolidated State Environmental Planning Policies
https://www.planning.nsw.gov.au/policy-and-legislation/state-environmental-planning-policies/consolidated-state-environmental-planning-policies

Ecosounds
https://www.ecosounds.org/

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
www.legislation.gov.au/Series/C2004A00485

EPBC Act Condition-setting Policy
https://www.environment.gov.au/epbc/publications/condition-setting-policy

EPBC Act listed threatened species and ecological communities
www.environment.gov.au/epbc/what-is-protected/threatened-species-ecological-communities

EPBC Act referral guidelines for the vulnerable koala
https://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala

Koala Modelling Regions
https://datasets.seed.nsw.gov.au/dataset/koala-modelling-regions

Native Vegetation Interim Type Standard
www.environment.nsw.gov.au/resources/nativeveg/10060nvinttypestand.pdf (PDF 1.6MB)

NSW (Mitchell) Landscapes – Version 3.1
https://datasets.seed.nsw.gov.au/dataset/nsw-mitchell-landscapes-version-3-1

NSW (Mitchell) Landscapes Descriptions
www.environment.nsw.gov.au/resources/conservation/LandscapesDescriptions.pdf (PDF 1.2MB)

NSW Threatened Species
www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species

PlantNET NSW
http://plantnet.rbgsyd.nsw.gov.au/

SEED (Sharing and Enabling Environmental Data) portal
www.seed.nsw.gov.au

State Environmental Planning Policy (Koala Habitat Protection) 2019
https://www.legislation.nsw.gov.au/view/html/inforce/current/epi-2019-0658

State Vegetation Type Map
www.environment.nsw.gov.au/vegetation/state-vegetation-type-map.htm

Streamlining NSW and Australian Government Biodiversity Assessments
https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/assessment-bilateral-agreement

Sunrise and Sunset
www.timeanddate.com/sun/

Appendix B. Decision key – koala survey

1. **Do I need to survey for koalas?**
   a. Are koalas likely to occur on the subject land, as per the BAM-C candidate species list?

      No .... go to 1b

      Yes .... go to 1c

   b. Do any previous records or incidental sightings of one or more koalas exist on the subject land?

      No .... survey not required

      Yes .... add koala to candidate species list – go to 1c

   c. For any PCT associated with koalas in the TBDC, was one (or more) koala use tree identified in the BAM floristic and/or vegetation integrity assessments?

      No .... go to 1d

      Yes .... these PCTs are suitable habitat – survey required, go to 2a

   d. For any PCT associated with koalas in the TBDC, was one (or more) koala use tree identified from the parallel field traverses?

      No .... survey not required

      Yes .... these PCTs are suitable habitat – survey required, go to 2a

2. **Koala survey steps:**
   a. Choose the approach for assessing koala presence:

      Targeted survey .... go to 2b

      Expert report .... go to 2e

      Assume present (impact assessment sites only) .... go to 2e

   b. Are any vegetation zones (determined suitable habitat) separated by >500 m or a barrier to koala movement?

      No .... map suitable habitat as continuous – go to 2c

      Yes .... map suitable habitat as discontinuous – go to 2c

   c. Select the scat detection survey method most suitable for the subject land:

      Spot Assessment Technique .... go to 2d

      Detection dogs .... go to 2d

   d. Select the second survey method most suitable for the subject land:

      Spotlighting .... go to 2e

      Passive acoustic .... go to 2e

      Drone .... go to 2e

   e. Was one or more koalas confirmed present?

      No .... document in BAR

      Yes .... map species polygon – document in the BAR

Appendix C. Koala use tree lists

The Koala Habitat Information Base Technical Guide (DPIE 2019) tree species lists were developed from *A review of koala tree use across NSW* (OEH 2018). This review detailed relevant tree species for each koala management area (KMA) based on evidence of koala tree use in written reports, published research articles, and from personal communications with local koala carers and experts. With additional expert feedback, the OEH (2018) lists were further refined (both species and their rankings) to accommodate the koala modelling region (KMR) boundaries used in the Koala Habitat Information Base (Figure 14).

The Koala Habitat Information Base Technical Guide (DPIE 2019) lists tree species used by koala for each KMR. These species were used to develop the Koala Tree Index layer. For the purpose of this guide, the species listed for each KMR (Tables 3–11) are referred to as koala use trees and inform the assessment of suitable habitat on the subject land. A mapping layer of the KMRs is available in the SEED portal (Appendix A).

Each tree is given a regional ranking to indicate:

- Rank 1 = high preferred use (feed trees)
- Rank 2 = high use (feed trees)
- Rank 3 = significant use (feed or shelter trees)
- Rank 4 = irregular or low use (feed or shelter trees).

For the purpose of this guide, tree rankings are **not** used to determine suitable habitat. They are included to support assessor decision-making; for example, identifying tree species for supplementary planting on a BSA site. In these cases, suitability of a tree species in relation to the associated PCT should be considered.

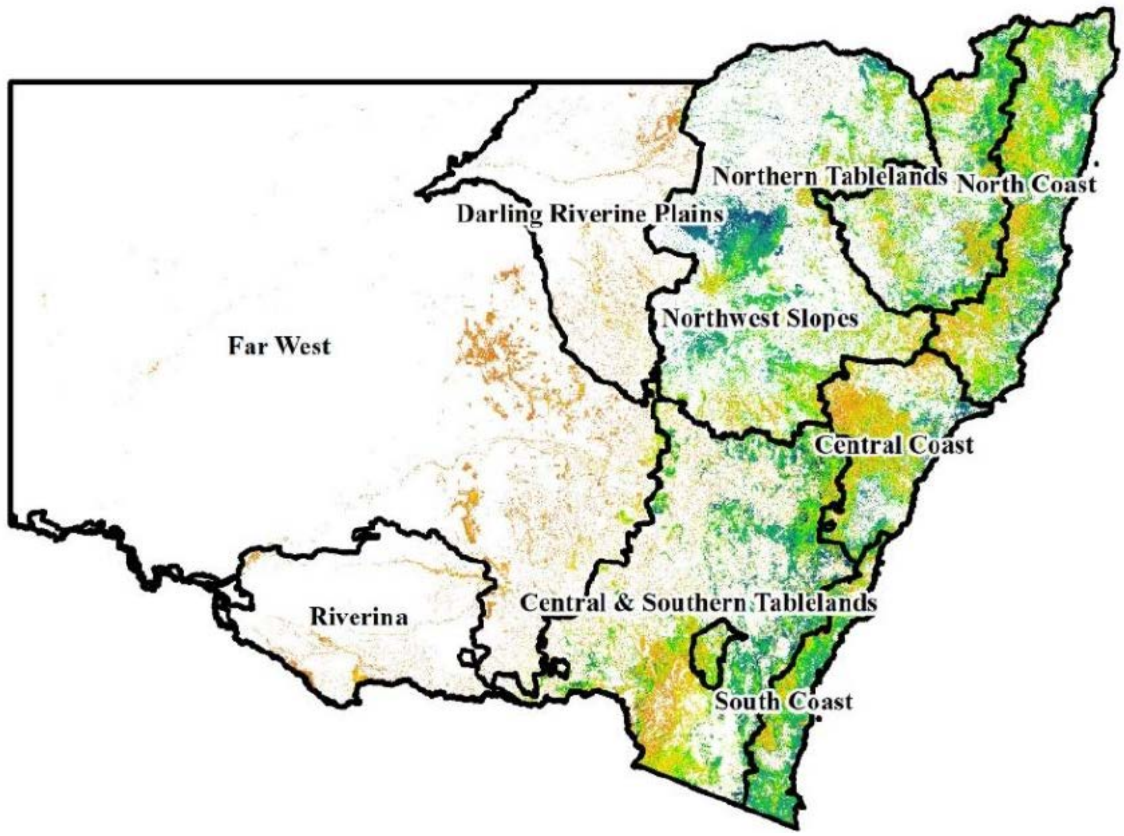

Figure 14 Koala modelling regions in NSW (DPIE 2019)

Table 3 Koala use trees – North Coast koala modelling region

Scientific name	Common name	Rank
Allocasuarina torulosa	Forest Oak	3
Angophora floribunda	Rough-barked Apple	4
Corymbia gummifera	Red Bloodwood	4
Corymbia henryi	Large-leaved Spotted Gum	4
Corymbia intermedia	Pink Bloodwood	4
Corymbia maculata	Spotted Gum	3
Eucalyptus acmenoides	White Mahogany	3
Eucalyptus amplifolia	Cabbage Gum	2
Eucalyptus bancroftii	Orange Gum	2
Eucalyptus biturbinata	Grey Gum	1
Eucalyptus campanulata	New England Blackbutt	4
Eucalyptus canaliculata	Large-fruited Grey Gum	1
Eucalyptus carnea	Thick-leaved Mahogany	4
Eucalyptus crebra	Narrow-leaved Ironbark	4
Eucalyptus eugenioides	Thin-leaved Stringybark	3
Eucalyptus fibrosa	Red Ironbark	4
Eucalyptus glaucina	Slaty Red Gum	2
Eucalyptus globoidea	White Stringybark	3
Eucalyptus grandis	Flooded Gum	2
Eucalyptus laevopinea	Silver-top Stringybark	3
Eucalyptus largeana	Craven Grey Box	2
Eucalyptus microcorys	Tallowwood	1
Eucalyptus moluccana	Grey Box	1
Eucalyptus nobilis	Forest Ribbon Gum	4
Eucalyptus pilularis	Blackbutt	4
Eucalyptus placita		4
Eucalyptus planchoniana	Bastard Tallowwood	4
Eucalyptus propinqua	Small-fruited Grey Gum	1
Eucalyptus psammitica	Bastard White Mahogany	4
Eucalyptus punctata	Grey Gum	1
Eucalyptus racemosa	Narrow-leaved Scribbly Gum	3
Eucalyptus resinifera	Red Mahogany	2
Eucalyptus robusta	Swamp Mahogany	1
Eucalyptus rummeryi	Steel Box	4
Eucalyptus saligna	Sydney Blue Gum	2
Eucalyptus scias	Large-fruited Red Mahogany	4

Scientific name	Common name	Rank
Eucalyptus seeana	Narrow-leaved Red Gum	3
Eucalyptus siderophloia	Grey Ironbark	3
Eucalyptus signata	Scribbly Gum	3
Eucalyptus tereticornis	Forest Red Gum	1
Eucalyptus tindaliae	Stringybark	3
Eucalyptus umbra	Broad-leaved White Mahogany	4
Melaleuca quinquenervia	Broad-leaved Paperbark	4

Table 4 Koala use trees – Central Coast koala modelling region

Scientific name	Common name	Rank
Allocasuarina littoralis	Black She-Oak	4
Allocasuarina torulosa	Forest Oak	3
Angophora bakeri	Narrow-leaved Apple	4
Angophora costata	Sydney Red Gum	3
Angophora floribunda	Rough-barked Apple	4
Casuarina glauca	Swamp Oak	4
Corymbia eximia	Yellow Bloodwood	3
Corymbia gummifera	Red Bloodwood	3
Corymbia maculata	Spotted Gum	4
Eucalyptus acmenoides	White Mahogany	4
Eucalyptus agglomerata	Blue-leaved Stringybark	4
Eucalyptus albens	White Box	1
Eucalyptus amplifolia	Cabbage Gum	4
Eucalyptus beyeriana		2
Eucalyptus blakelyi	Blakely's Red Gum	1
Eucalyptus bosistoana	Coast Grey Box	1
Eucalyptus botryoides	Bangalay	3
Eucalyptus camaldulensis	River Red Gum	2
Eucalyptus camfieldii	Camfield's Stringybark	4
Eucalyptus canaliculata	Large-fruited Grey Gum	1
Eucalyptus capitellata	Brown Stringybark	4
Eucalyptus carnea	Thick-leaved Mahogany	4
Eucalyptus consideniana	Yertchuk	4
Eucalyptus crebra	Narrow-leaved Ironbark	3
Eucalyptus cypellocarpa	Monkey Gum	1
Eucalyptus deanei	Mountain Blue Gum	2
Eucalyptus eugenioides	Thin-leaved Stringybark	4

Scientific name	Common name	Rank
Eucalyptus fibrosa	Red Ironbark	3
Eucalyptus glaucina	Slaty Red Gum	4
Eucalyptus globoidea	White Stringybark	2
Eucalyptus grandis	Flooded Gum	2
Eucalyptus haemastoma	Broad-leaved Scribbly Gum	4
Eucalyptus imitans		4
Eucalyptus largeana	Craven Grey Box	2
Eucalyptus longifolia	Woollybutt	1
Eucalyptus macrorhyncha	Red Stringybark	4
Eucalyptus melliodora	Yellow Box	1
Eucalyptus michaeliana	Brittle Gum	4
Eucalyptus microcorys	Tallowwood	1
Eucalyptus moluccana	Grey Box	1
Eucalyptus oblonga	Stringybark	3
Eucalyptus paniculata	Grey Ironbark	2
Eucalyptus parramattensis	Parramatta Red Gum	1
Eucalyptus pilularis	Blackbutt	3
Eucalyptus piperita	Sydney Peppermint	3
Eucalyptus propinqua	Small-fruited Grey Gum	1
Eucalyptus punctata	Grey gum	1
Eucalyptus quadrangulata	White-topped Box	2
Eucalyptus racemosa	Narrow-leaved Scribbly Gum	3
Eucalyptus resinifera	Red Mahogany	3
Eucalyptus robusta	Swamp Mahogany	1
Eucalyptus saligna	Sydney Blue Gum	3
Eucalyptus scias	Large-fruited Red Mahogany	3
Eucalyptus sclerophylla	Hard-leaved Scribbly Gum	3
Eucalyptus siderophloia	Grey Ironbark	4
Eucalyptus sideroxylon	Mugga Ironbark	4
Eucalyptus sieberi	Silvertop Ash	4
Eucalyptus signata	Scribbly Gum	3
Eucalyptus sparsifolia	Narrow-leaved Stringybark	4
Eucalyptus squamosa	Scaly Bark	4
Eucalyptus tereticornis	Forest Red Gum	1
Eucalyptus umbra	Broad-leaved White Mahogany	4
Eucalyptus viminalis	Ribbon Gum	3
Melaleuca quinquenervia	Broad-leaved Paperbark	4

Scientific name	Common name	Rank
Syncarpia glomulifera	Turpentine	3

Table 5 Koala use trees – South Coast koala modelling region

Scientific name	Common name	Rank
Allocasuarina littoralis	Black She-Oak	4
Angophora floribunda	Rough-barked Apple	4
Corymbia gummifera	Red Bloodwood	4
Corymbia maculata	Spotted Gum	4
Eucalyptus agglomerata	Blue-leaved Stringybark	4
Eucalyptus baueriana	Blue Box	4
Eucalyptus bosistoana	Coast Grey Box	2
Eucalyptus consideniana	Yertchuk	2
Eucalyptus cypellocarpa	Monkey Gum	1
Eucalyptus elata	River Peppermint	4
Eucalyptus eugenioides	Thin-leaved Stringybark	2
Eucalyptus fastigata	Brown Barrel	4
Eucalyptus globoidea	White Stringybark	1
Eucalyptus longifolia	Woollybutt	1
Eucalyptus maidenii	Maiden's Gum	1
Eucalyptus muelleriana	Yellow Stringybark	4
Eucalyptus obliqua	Messmate	3
Eucalyptus paniculata	Grey Ironbark	4
Eucalyptus pilularis	Blackbutt	4
Eucalyptus piperita	Sydney Peppermint	4
Eucalyptus punctata	Grey gum	1
Eucalyptus saligna	Sydney Blue Gum	3
Eucalyptus sclerophylla	Hard-leaved Scribbly Gum	4
Eucalyptus sieberi	Silvertop Ash	4
Eucalyptus tereticornis	Forest Red Gum	1
Eucalyptus tricarpa		2
Eucalyptus viminalis	Ribbon Gum	4

Table 6 Koala use trees – Central and Southern Tablelands koala modelling region

Scientific name	Common name	Rank
Eucalyptus agglomerata	Blue-leaved Stringybark	3
Eucalyptus albens	White Box	1
Eucalyptus amplifolia	Cabbage Gum	4

Scientific name	Common name	Rank
Eucalyptus blakelyi	Blakely's Red Gum	1
Eucalyptus bosistoana	Coast Grey Box	3
Eucalyptus bridgesiana	Apple Box	3
Eucalyptus camaldulensis	River Red Gum	1
Eucalyptus conica	Fuzzy Box	3
Eucalyptus cypellocarpa	Monkey Gum	1
Eucalyptus dalrympleana	Mountain Gum	3
Eucalyptus dealbata	Tumbledown Red Gum	3
Eucalyptus dives	Broad-leaved Peppermint	3
Eucalyptus elata	River Peppermint	3
Eucalyptus eugenioides	Thin-leaved Stringybark	3
Eucalyptus fibrosa	Red Ironbark	4
Eucalyptus globoidea	White Stringybark	2
Eucalyptus goniocalyx	Bundy	3
Eucalyptus macrorhyncha	Red Stringybark	3
Eucalyptus maidenii	Maiden's Gum	3
Eucalyptus mannifera	Brittle Gum	1
Eucalyptus melliodora	Yellow Box	3
Eucalyptus microcarpa	Western Grey Box	3
Eucalyptus nortonii	Large-flowered Bundy	3
Eucalyptus obliqua	Messmate	4
Eucalyptus oblonga	Stringybark	4
Eucalyptus paniculata	Grey Ironbark	4
Eucalyptus pauciflora	White Sally	3
Eucalyptus piperita	Sydney Peppermint	3
Eucalyptus polyanthemos	Red Box	3
Eucalyptus punctata	Grey gum	1
Eucalyptus quadrangulata	White-topped Box	3
Eucalyptus radiata	Narrow-leaved Peppermint	3
Eucalyptus rossii	Inland Scribbly Gum	2
Eucalyptus rubida	Candlebark	4
Eucalyptus sclerophylla	Hard-leaved Scribbly Gum	2
Eucalyptus sideroxylon	Mugga Ironbark	4
Eucalyptus sieberi	Silvertop Ash	4
Eucalyptus tereticornis	Forest Red Gum	1
Eucalyptus viminalis	Ribbon Gum	1

Table 7 Koala use trees – Northern Tablelands koala modelling region

Scientific name	Common name	Rank
Allocasuarina littoralis	Black She-Oak	4
Angophora floribunda	Rough-barked Apple	3
Angophora subvelutina	Broad-leaved Apple	3
Callitris glaucophylla	White Cypress Pine	4
Eucalyptus acaciiformis	Wattle-leaved Peppermint	1
Eucalyptus albens	White Box	1
Eucalyptus amplifolia	Cabbage Gum	3
Eucalyptus biturbinata	Grey Gum	1
Eucalyptus blakelyi	Blakely's Red Gum	1
Eucalyptus bridgesiana	Apple Box	2
Eucalyptus brunnea		2
Eucalyptus caleyi		3
Eucalyptus caliginosa	Broad-leaved Stringybark	2
Eucalyptus camaldulensis	River Red Gum	1
Eucalyptus campanulata	New England Blackbutt	4
Eucalyptus crebra	Narrow-leaved Ironbark	4
Eucalyptus dalrympleana	Mountain Gum	1
Eucalyptus dealbata	Tumbledown Red Gum	1
Eucalyptus eugenioides	Thin-leaved Stringybark	4
Eucalyptus laevopinea	Silver-top Stringybark	2
Eucalyptus macrorhyncha	Red Stringybark	3
Eucalyptus melanophloia	Silver-leaved Ironbark	4
Eucalyptus melliodora	Yellow Box	1
Eucalyptus michaeliana	Brittle Gum	4
Eucalyptus microcorys	Tallowwood	1
Eucalyptus moluccana	Grey Box	1
Eucalyptus nicholii	Narrow-leaved Black Peppermint	1
Eucalyptus nobilis	Forest Ribbon Gum	2
Eucalyptus nova-anglica	New England Peppermint	3
Eucalyptus obliqua	Messmate	4
Eucalyptus pauciflora	White Sally	1
Eucalyptus prava	Orange Gum	3
Eucalyptus radiata	Narrow-leaved Peppermint	2
Eucalyptus saligna	Sydney Blue Gum	4
Eucalyptus sideroxylon	Mugga Ironbark	4
Eucalyptus stellulata	Black Sally	2

Scientific name	Common name	Rank
Eucalyptus tereticornis	Forest Red Gum	1
Eucalyptus viminalis	Ribbon Gum	1
Eucalyptus williamsiana		3
Eucalyptus youmanii	Youman's Stringybark	2

Table 8 Koala use trees – North West Slopes koala modelling region

Scientific name	Common name	Rank
Angophora floribunda	Rough-barked Apple	3
Callitris glaucophylla	White Cypress Pine	3
Casuarina cristata	Belah	4
Eucalyptus albens	White Box	1
Eucalyptus blakelyi	Blakely's Red Gum	1
Eucalyptus bridgesiana	Apple Box	4
Eucalyptus caleyi		4
Eucalyptus caliginosa	Broad-leaved Stringybark	3
Eucalyptus camaldulensis	River Red Gum	1
Eucalyptus canaliculata	Large-fruited Grey Gum	1
Eucalyptus chloroclada	Dirty Gum	1
Eucalyptus conica	Fuzzy Box	1
Eucalyptus coolabah	Coolibah	1
Eucalyptus crebra	Narrow-leaved Ironbark	2
Eucalyptus dalrympleana	Mountain Gum	4
Eucalyptus dealbata	Tumbledown Red Gum	1
Eucalyptus dwyeri	Dwyer's Red Gum	1
Eucalyptus exserta	Peppermint	1
Eucalyptus fibrosa	Red Ironbark	4
Eucalyptus goniocalyx	Bundy	4
Eucalyptus laevopinea	Silver-top Stringybark	3
Eucalyptus largiflorens	Black Box	2
Eucalyptus macrorhyncha	Red Stringybark	3
Eucalyptus mannifera	Brittle Gum	4
Eucalyptus melanophloia	Silver-leaved Ironbark	2
Eucalyptus melliodora	Yellow Box	1
Eucalyptus microcarpa	Western Grey Box	1
Eucalyptus moluccana	Grey Box	1
Eucalyptus nobilis	Forest Ribbon Gum	4
Eucalyptus parramattensis	Parramatta Red Gum	1

Scientific name	Common name	Rank
Eucalyptus pauciflora	White Sally	1
Eucalyptus pilligaensis	Narrow-leaved Grey Box	1
Eucalyptus polyanthemos	Red Box	4
Eucalyptus populnea	Bimble Box	1
Eucalyptus prava	Orange Gum	2
Eucalyptus punctata	Grey gum	1
Eucalyptus quadrangulata	White-topped Box	4
Eucalyptus sideroxylon	Mugga Ironbark	3
Eucalyptus viminalis	Ribbon Gum	4

Table 9 Koala use trees – Darling Riverine Plains koala modelling region

Scientific name	Common name	Rank
Callitris glaucophylla	White Cypress Pine	3
Eucalyptus albens	White Box	3
Eucalyptus camaldulensis	River Red Gum	1
Eucalyptus chloroclada	Dirty Gum	3
Eucalyptus conica	Fuzzy Box	2
Eucalyptus coolabah	Coolibah	1
Eucalyptus crebra	Narrow-leaved Ironbark	3
Eucalyptus dealbata	Tumbledown Red Gum	1
Eucalyptus dwyeri	Dwyer's Red Gum	2
Eucalyptus largiflorens	Black Box	1
Eucalyptus melanophloia	Silver-leaved Ironbark	2
Eucalyptus melliodora	Yellow Box	1
Eucalyptus microcarpa	Western Grey Box	2
Eucalyptus pilligaensis	Narrow-leaved Grey Box	3
Eucalyptus populnea	Bimble Box	1
Eucalyptus sideroxylon	Mugga Ironbark	4

Table 10 Koala use trees – Far West koala modelling region

Scientific name	Common name	Rank
Angophora floribunda	Rough-barked Apple	4
Callitris glaucophylla	White Cypress Pine	3
Casuarina cristata	Belah	4
Eucalyptus albens	White Box	2
Eucalyptus blakelyi	Blakely's Red Gum	2
Eucalyptus camaldulensis	River Red Gum	1

Scientific name	Common name	Rank
Eucalyptus chloroclada	Dirty Gum	4
Eucalyptus coolabah	Coolibah	2
Eucalyptus crebra	Narrow-leaved Ironbark	4
Eucalyptus dealbata	Tumbledown Red Gum	2
Eucalyptus intertexta	Gum Coolibah	4
Eucalyptus largiflorens	Black Box	2
Eucalyptus melanophloia	Silver-leaved Ironbark	3
Eucalyptus melliodora	Yellow Box	3
Eucalyptus microcarpa	Western Grey Box	3
Eucalyptus moluccana	Grey Box	4
Eucalyptus pilligaensis	Narrow-leaved Grey Box	4
Eucalyptus populnea	Bimble Box	2
Eucalyptus sideroxylon	Mugga Ironbark	4
Geijera parviflora	Wilga	4

Table 11 Koala use trees – Riverina koala modelling region

Scientific name	Common name	Rank
Callitris glaucophylla	White Cypress Pine	3
Casuarina cristata	Belah	4
Eucalyptus albens	White Box	4
Eucalyptus camaldulensis	River Red Gum	1
Eucalyptus intertexta	Gum Coolibah	4
Eucalyptus largiflorens	Black Box	2
Eucalyptus melliodora	Yellow Box	2
Eucalyptus microcarpa	Western Grey Box	2
Eucalyptus populnea	Bimble Box	3

Appendix D. Supporting information

This appendix provides additional details and background to the recommended approaches in this guide.

Home ranges and movement

Home range size varies considerably across the koala's distribution, from less than 10 hectares to several hundred (Davies et al. 2013; Ellis et al. 2009; Ellis et al. 2011; Goldingay & Dobner 2014; Kavanagh et al. 2007; Kavanagh & Stanton 2012; Matthews et al. 2016; Phillips 2016; Whisson et al. 2020). Males typically have larger home ranges, overlapping with females and other males (Matthews et al. 2016; White 1999).

Movement patterns of radio-collared koalas demonstrate temporal and spatial variation, as well as differences between sexes and individuals (Davies et al. 2013; Matthews et al. 2016; Rhodes et al. 2005; Rus et al. 2020). Mean daily movement distances range from 100–320 m, with several studies demonstrating koalas' ability to move hundreds of meters in relatively short periods (Davies et al. 2019; de Oliveira et al. 2014; Marsh et al. 2013; Matthews et al. 2016; Whisson et al. 2020).

Koalas can traverse a range of environments, including cleared or agricultural areas, urban developments and roads (White 1999; Whisson et al. 2020). However, unless trees overlap, koalas must travel by ground between habitat patches (Marsh et al. 2013). In fragmented habitat, this movement through a hostile matrix can pose an increased risk of mortality from vehicle collisions, dog attacks and even cattle attacks (Beyer et al. 2018; de Oliverira et al. 2014; Dique et al. 2003; Jiang et al. 2021; McAlpine et al. 2006b; White 1999).

Evidence for koalas crossing waterbodies is mostly anecdotal. In their study, Dique et al. (2003) considered two koalas likely drowned while attempting to cross a waterbody approximately 200 m wide. Similarly, in their genetic study, Dudaniec et al. (2013) assumed large waterbodies (>100 m in width) would be a barrier to koala movement.

Habitat use and tree preferences

Variables operating at the scale of individual trees, patches and landscapes influence how koalas use their habitat (McAlpine et al. 2015; OEH 2018). These include availability of suitable habitat and water, soil fertility and habitat configuration (Dargan et al. 2019; Davies et al. 2013; McAlpine et al. 2006a; McApline et al. 2006b). In cleared and modified landscapes, koala habitat is highly fragmented. Small patches of vegetation, paddock trees and roadside vegetation are used by koalas (Bath et al. 2020, Dargan et al. 2019; White 1999). In highly fragmented habitat, many of these patches may be required to meet resource needs (Rus et al. 2020).

As specialist folivores, koalas feed predominantly on a range of *Eucalyptus* species, but show regional, seasonal and even individual variation in species preferences (Higgins et al. 2011; Hindell & Lee 1987; Marsh et al. 2013; Melzer et al. 2014; Phillips & Callaghan 2000; Phillips et al. 2000; Smith 2004; Woodward et al. 2008). They access a range of other tree species for shelter, thermoregulation and social behaviours (Crowther et al. 2014; DECC 2008; Woodward et al. 2008). With a changing climate, those trees offering shelter from increasing temperatures are likely to represent important habitat resources (Crowther et al. 2014; Ellis et al. 2010; Reckless et al. 2017). Despite their preference for larger trees (Callaghan et al. 2011; Gallahar et al. 2021; Rhind et al. 2014), koalas use a range of sizes from 1 cm to >200 cm dbh (Cristescu et al. 2013; Gallahar et al. 2021; Lollback et al. 2018; Matthews et al. 2007; Moore et al. 2010; Rhind et al. 2014).

Appendix E. Survey methods – summary

Survey area:	Per ≤50 ha of suitable habitat					
Method	**Survey period**	**Survey timing**	**Weather**	**Sampling area**	**Survey replicates**	**Limitations**
Spot Assessment Technique (SAT)	All year round	Daylight	Rain: 0 mm in previous 3 days	>5 ha: 1 SAT site / 2.25 ha ≤5 ha: 3 SAT sites	1	Less suitable in dense ground cover and low quality koala habitat
Conservation detection dogs	All year round	Daylight	Rain: 0 mm in previous 3 days Not in extreme temperatures Not in high wind	>2 ha: 3 x 200 m transect / 5 ha ≤2 ha: 1 x 200 m transect	1	Less suitable in dense vegetation (e.g. post-fire regrowth) Not to be used near feral predator baiting
Spotlighting	All year round	Night	Rain: 0 mm Not in extreme temperatures Not in high wind	>4 ha: 2 x 200 m transect / 5 ha ≤4 ha: 1 x 200 m transect	2	Less suitable in dense vegetation, tall forests, steeply sloping land, and deep gullies
Passive acoustic	Sep. – Dec.	Sunset – sunrise	Rain: ≤3 mm / night Temperature: ≤35°C Not in high wind	Where max. detection range of recording unit is: 100 m: 1 unit / 5 ha 300 m: 1 unit / 25 ha	7 nights	Less suitable near roads or waterbodies with frogs May detect koalas beyond suitable habitat or subject land Biased towards male detection
Drones	Mar. – Dec. (approx.)	21:00 – dawn	Rain: 0 mm rain No dense fog Temperature: ≤18°C Wind: <10.5 m/s	Flight path to cover all suitable habitat	1 – 2	Dense vegetation may affect detection Potential disruption to nesting territorial bird species Dependent on ambient temperature CASA regulations must be followed

Appendix F. Biodiversity Assessment Report – required information

Section	Details
Threatened species	**Information:** • If koalas are removed from the candidate species list, include justification • If koalas are added to the candidate species list (manually), include justification • Document any koala records on the subject land (e.g. from previous surveys)
Suitable habitat	**Table.** Assessment of suitable habitat, detailing: • all PCTs on the subject land associated with koalas in the TBDC • presence of koala use trees in each PCT (present / absent) **Map.** Suitable habitat for koalas, identifying: • PCTs and vegetation zones • areas of continuous and discontinuous suitable habitat • barriers to koala movement **Information:** • If no suitable habitat is identified, include justification (for impact assessment sites) • Describe extent of suitable habitat, including justification for areas of continuous and discontinuous suitable habitat • Document and justify exclusion of any vegetation zones (on basis of condition) from suitable habitat • Describe any barriers to koala movement creating discontinuous suitable habitat • Identify the KMR regional koala use tree list(s) used **Data.** Parallel field traverses GPS tracklog (where koala use trees were not detected for a PCT associated with koala)

Survey methods	**Table.** Survey summary, detailing:
	• dates
	• start and finish time
	• survey method
	• meteorological conditions, including:
	  ○ rainfall (mm) for the 72 hours prior to survey
	  ○ rainfall (mm) for each day or night of the survey
	  ○ minimum and maximum temperature (°C) for each day or night of the survey
	  ○ relative humidity (%) for each day or night of the survey
	  ○ mean wind speed (km/h), for each day or night of the survey

<table>
<tr><th>Section</th><th>Details</th></tr>
<tr><td></td><td>Table. Incidental koala detections, detailing:
GPS coordinates
estimated age, sex and health condition
Information. Describe methods used, including:
justification for the survey methods selected (i.e. suitability for the subject land)
describe any limitations or assumptions to surveys and how these were overcome
details of any variations from the recommended approach, with justification and information sources
meteorological conditions – document use of weather station (include details) or portable device
groupings for any multi-species searches
koala surveyor – name and credentials (as per Section 2.3)
supporting personnel (for field surveys) – name(s)
other specialists – name and credentials</td></tr>
<tr><td>Spot Assessment Technique</td><td>Map. Survey site locations, identifying:
suitable habitat (identify vegetation zones and PCTs)
locations of all SAT sites
locations of all koala detections
Table. Koala detections, detailing:
SAT sites, including:
GPS coordinates
number of trees sampled
tree species sampled
scat present / absent
estimated age, sex and health condition (where observed)
Information:
Description of grid spacing used
Justification for any variation to the minimum sampling effort (30 trees)</td></tr>
<tr><td>Detection dogs</td><td>Map. Survey site locations, identifying:
suitable habitat (identify vegetation zones and PCTs)
locations of all transects
locations of all koala detections</td></tr>
</table>

Section	Details

	Table. Koala detections, detailing:
	• GPS coordinates
	• estimated age, sex and health condition (where observed)
	Information:
	• Detection dog and handler – name and credentials, including:
	  ○ prior field survey experience of the detection dog and handler (as a team)
	  ○ details of the detection dog and handler's (as a team) most recent competency assessment, including testing protocol, testing authority, results

Spotlighting	**Map.** Survey site locations, identifying: • suitable habitat (identify vegetation zones and PCTs) • locations of all transects • locations of all koala detections **Table.** Koala detections, detailing: • GPS coordinates • estimated age, sex and health condition **Information:** • Spotlight – make, model, year of manufacture, intensity (lm or W) • Justification for any adjustments to the transect length/configuration • Justification for use of vehicle (where relevant)

Passive Acoustic	**Map.** Survey site locations, identifying:
	• suitable habitat (identify vegetation zones and PCTs)
	• locations of all recording units
	• locations of all koala detections
	Table. Koala detections, detailing:
	• GPS coordinates
	Information:
	• Recording units – make, model, year of manufacture
	• Recording units – detection range/microphone sensitivity (m), with reference to:
	  ○ manufacture's specifications or published literature
	  ○ justification for its suitability for the subject land
	• Recording units – settings used, including sampling frequency, resolution and sensitivity
	• Justification for recording unit locations

Section	Details
	• Details of any equipment malfunctions and adjustments to survey design, including justification • Bioacoustics specialist – name and credentials • Bioacoustics software used to visualise and analyse the recordings – including evidence of its performance

Drone surveys	**Map.** All potential koala detections, identifying:
	• suitable habitat (identify vegetation zones and PCTs)
	• confirmed detections
	Table. All potential koala detections, including:
	• GPS coordinates, time of capture, video timecode
	• validation method, time of validation, outcome (confirmed/not confirmed)
	• estimated age, sex and health condition (for confirmed detections)
	• potential false positives from occupied hollows and other arboreal mammals
	Information:
	• Drone pilot – name and credentials, including:
	  ○ licence/certificate details, flight history, prior koala survey experience
	• Drone and camera description, including:
	  ○ make, model and year of manufacture
	  ○ thermal camera – sensitivity, spectral range, resolution, focal length, frame capture rate
	  ○ visual camera resolution
	  ○ additional settings used (e.g. noise reduction, contrast, sharpening, etc.)
	• Justification for flight path approach
	• Any variations to flight altitude, with justification
	• Details of any interactions with birds
	Data:
	• Potential detections – images with GPS coordinates (where koalas are determined not present)
	• Flight path GPS tracklog

Species Polygon	**Map.** Koala species polygon, including: • area of suitable habitat representing the species polygon (identify vegetation zones and PCTs) • location of all koala detections • unit of measure **Information:** • Justification for area of species polygon, including any areas targeted for active restoration of koala habitat