PLANNING GUIDELINES FOR KOALA CONSERVATION AND RECOVERY

A guide to best planning practice

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The geographic range of the koala extends from tropical Queensland to western Victoria and south-east South Australia. Range contractions have occurred, especially in South Australia due to habitat loss, while koalas have experienced local extinctions within their range. Approximately 300 local government areas and over 30 catchment management authorities/ regional natural resource management bodies are responsible for planning decisions affecting koalas within their geographic range. Koalas are listed as vulnerable in South East Queensland and New South Wales.

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PREFACE

The information contained in the guide is a synthesis of four years research into the conservation and restoration of koala populations in fragmented landscapes of eastern Australia. The research was funded by the Australian Research Council and the Australian Koala Foundation, with in-kind support from the New South Wales Department of Environment and Conservation. The guidelines also capture a decade of practical research and planning experience by the Australian Koala Foundation in mapping koala habitat and developing koala conservation and management plans for local government areas in New South Wales. They draw on the collective knowledge of researchers who wanted to see their results put into action with practical outcomes for koala conservation. We acknowledge the constructive feedback from Brian Feeney and Hedley Thomson on draft versions of the guide. This document would not have been possible without the support of the Australian Koala Foundation and its Chief Executive Officer, Deborah Tabart.

Thank you to all the local councils who participated in our survey of koala conservation planning practices. This helped enormously to inform the development of these guidelines. These councils were: Caboolture Shire Council, Gold Coast City Council, Noosa Shire Council, Brisbane City Council, Lismore City Council, Port Stephens Council, Tweed Shire Council, Gunnedah Council, Coffs Harbour City Council, City of Ballarat, and Golden Plains Shire. Funding for the preparation of these guidelines was provided by the Australian Koala Foundation. This work followed-on from a collaborative ARC SPIRT research project involving the University of Queensland, the Australian Koala Foundation and the NSW Department of Environment and Conservation, investigating the conservation of koalas in fragmented landscapes.

FOREWORD

KOALAS CROSS HERE…These dramatic words set next to a silhouette of a koala appear on conspicuous black-and-yellow road signs that greet travellers on our coastal highways. More of these signs appear off the highways in larger urban coastal cities and suburbs. They provoke travellers to think about koalas, even if for just a moment. One of the common responses of travellers, when asked, is that they have never seen a koala in the wild. This is not surprising because koalas are a threatened species in New South Wales and Southeast Queensland and there are far fewer of them than we would like. If the travellers did see a koala, it may well have been a freshly-killed animal, either lying by the roadside or flattened on the road. These are grim and unpleasant memories. Occasionally, an alert driver has not only seen a koala, but has slowed down to let it cross the road safely. So, busy roads and koalas do not mix. The response can be to leave one's car at home, and simply walk, or ride a pushbike, or go by train, or drive more slowly and carefully. What we are really urging here is to take a deeper look at the meaning of the koala road sign and the planning implications. For planners, there is a powerful story to tell.

"Why did the koala cross the road?" "To get to the other side", seems to be the obvious answer to this common kids' riddle. Now enlarge that answer with an ecological twist, and it becomes "to get to the habitat on the other side". Either the koala was moving within its home range, or was dispersing from its mother's range to find a suitable patch of habitat in which to establish a territory. So, the traveller and the planner have essentially been looking at four of the most serious threats to the survival of koalas on Australia's east coast, even if that was not immediately apparent. These threats include the loss of habitat to coastal development, the fragmentation of what remains, exposure of resident koalas to death on roads, and attacks on koalas by roaming dogs when crossing ever-increasing open ground.

If a traveller stops in a koala shire and visits a known koala habitat area, patient scanning of trees may be rewarded with a koala sighting. The classical image is a koala sitting in a tree either at rest or slowly chewing a gum leaf. Not just any leaf will do, it will most likely be from one of a small list of preferred koala food trees for any given region. One of the most glorious sights is when a female koala has a young on its back. Such a sight confirms to the watcher that the koala is one of the world's most attractive and inspiring animals. The koala is an Australian icon, and it can also serve brilliantly as a shire planner's icon. If one agrees, then there are some rules to follow that are specific to a koala's needs. Those rules can be set in an ecological context that ranges in scale from the importance of a particular species of tree, to a stand of trees, to a patch of forest, and then to the surrounding landscape. This is now beginning to mesh koala ecology with the range of scales over which planners operate.

The planning guidelines in this document have placed the ecology of the koala at centre stage. We have written them as ecologists, keen to combine the ecology of koalas within the spatially-explicit framework commonly known as landscape ecology. **We offer these guidelines to all those responsible for conservation planning for koalas and the forest ecosystems they depend upon, in the interests of securing the long-term future of this Australian icon.**

HOW TO USE THIS GUIDE

The aim of these guidelines is to inform local government planners, regional planning bodies, community organisations, developers and environmental consultants how best to conserve and restore koala populations in fragmented landscapes. They specifically target the urban and semi-urban local governments and regions of Queensland, New South Wales and Victoria, although the general principles captured in the guidelines equally apply to rural areas. They recommend practical ways for dealing with issues of habitat management, road deaths and dog attacks. They are designed to produce a more consistent approach to koala conservation across all levels of planning. The guidelines are not meant to be prescriptive. Rather, the main purpose is to inform local government planners, decision makers, developers and the community on how to design and implement compatible developments within and around areas that still support koalas and to restore populations in suitable habitat where they may no longer be present. Given the wide range of threats facing koalas, there are no quick-fix solutions for long-term conservation and restoration. We see use of the *Planning Guidelines for Koala Conservation and Recovery* as an important step towards improved planning and management practises that will help ensure long-term conservation of this iconic species.

We recommend application of the guidelines to:

- Conserve koalas in their natural habitat;
- Bring koala conservation to the forefront in planning for key areas;
- Set minimum habitat area and connectivity requirements for koala population viability;
- Help mitigate the threats posed by vehicle collisions and dog attacks;
- Evaluate future development proposals and conservation initiatives by establishing minimum targets for habitat protection, restoration and management;
- Set standards for koala conservation and recovery planning that can be applied throughout much of the koala's geographic range; and
- Develop long-term monitoring programmes for koalas.

The guidelines are split into two spatial levels: the landscape and the site. **The landscape (1000s ha) is the level of strategic planning focus** and the reference point for assessing rezoning proposals and development applications at the site-level (1-100 ha), and for developing conservation strategies for whole local government areas or regions (Figure 2). **At the local-government-level, the guidelines can be applied by strategic planning across multiple-landscapes.** The guidelines concentrate on the habitat requirements for viable koala populations at the landscape-level, aiming to avoid the commonly recognised problem of "death by a thousand cuts", whereby the incremental loss and fragmentation of koala habitat makes populations unviable and ultimately leads to their local extinction. The objectives and guidelines specify the 'desired' landscape structure necessary to support what we consider likely to constitute a viable koala population. They do not automatically preclude development, but rather aim to achieve a balance between conservation and human land use in landscapes where koalas occur.

Urban planners regularly have to assess development applications and rezoning proposals covering individual or multiple parcels of land. Depending on the location and the type of development, each proposal has the potential to impact on local koala populations through clearing or degradation of habitat, new roads, increased traffic volumes and predation by domestic dogs. The site-level guidelines for development assessment and rezoning applications, that follow the landscape-level guidelines, detail key considerations aimed to minimise impacts on local koala populations. We urge users, when assessing local development applications or

rezoning proposals, to first evaluate the proposal in the context of the strategic landscape planning objectives. If the proposed development is in conflict with one or more of these criteria (e.g., critical habitat retention thresholds), then there is a strong case for not proceeding as proposed on the grounds of koala conservation concerns.

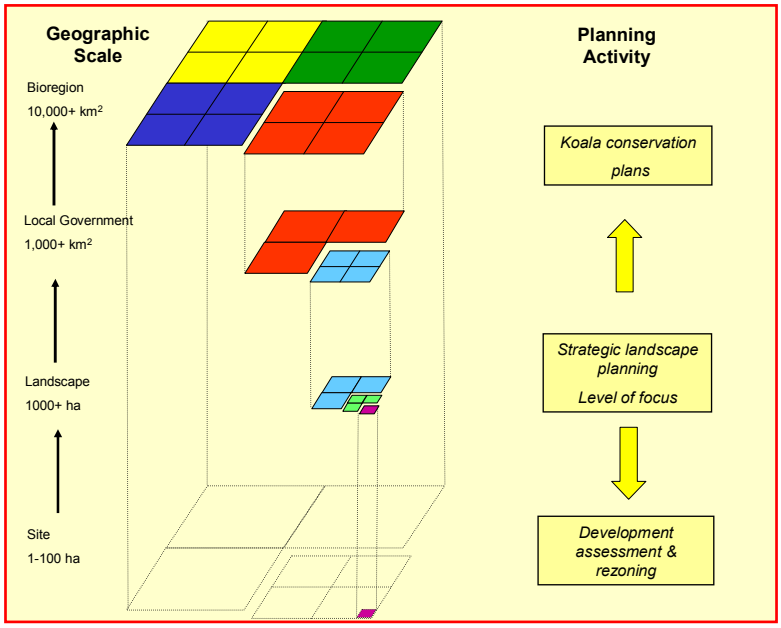


Figure 1. A multi-level framework for using the guidelines. The landscape is the building block for conserving viable koala populations. Start at the landscape level and work up or down the hierarchy. Strategic planning should also apply to the local government scale, where planning at this scale consists of planning across multiple landscapes.

The guidelines are structured into several sections or parts. First, we outline key terms and definitions used in the guidelines to help the reader understand the ecological terminology used in the guidelines proper. **In Part A**, we present strategic-planning guidelines for informing planning codes and policy at the landscape and local government (multiple-landscape) scales. Part A begins with background information on:

- What is a landscape? and
- How to map koala habitat?

It then presents specific guidelines for addressing the following planning and landscape management questions:

- How much habitat is enough?
- How big patches need to be?
- What shape should patches be?
- How to maintain the quality of koala habitat patches and linkages?
- How to maintain and restore habitat connectivity?
- How to minimise impacts from road networks? and
- How to minimise predation by dogs?

Each guideline consists of four sections: (1) the planning objective, (2) the planning guideline(s), (3) the planning action(s) and, (4) a summary of the supporting science, outlining the rationale behind the guideline(s) and action(s).

In Part B, we outline site-level guidelines for assessing:

- Rezoning proposals; and
- Planning and development applications.

In Part C, we outline monitoring protocols to inform future planning strategies for conserving koala populations and their habitat.

TERMS AND DEFINITIONS

Clearing: Process of anthropogenic destruction or substantial thinning of one or more strata of native vegetation using mechanical, chemical, manual or biological methods.

Connectivity: The degree to which all patches are spatially linked by corridors, small patches (stepping stones) or clumps of trees.

Corridor: A linear strip of habitat that differs from its surroundings.

Dispersal: One way movement of an individual away from its natal home range to its breeding home range.

Ecological integrity: An ecosystem with ecological integrity is one which possesses those structural and compositional elements that maintain its functioning within the bounds of natural disturbance regimes (e.g., fire) and are not subject to excessive human-induced disturbance such as grazing, logging, thinning or prescribed burning.

Forest: Areas of forest, including all the koala habitat categories as defined in Appendix 1.

Fragmentation: The breaking apart of a habitat or landscape into smaller, more isolated parcels.

GIS (Geographical Information System): Computer hardware and software used for storage, retrieval, mapping, and analysis of geographic data.

Habitat buffers: Areas of modified vegetation or cleared land that aim to conserve the habitat values of remnant habitat and protect from nutrient impacts, wind damage and weed invasion, as well as facilitating koala activity beyond areas of preferred habitat.

Habitat linking areas: Areas of modified vegetation (trees or clumps of trees) or cleared land that facilitate safe movement of koalas (e.g., natal dispersal and recruitment of sub-adults) between breeding populations or into areas of vacant preferred habitat.

Highly connected patches: Patches or clusters of patches that are less than 200 m apart. Intervening areas should preferably be cleared land or modified vegetation, and free from physical barriers such as roads, fences, water bodies and residential or industrial areas.

Home range: The area of an animal's home that is used for feeding and other daily activities.

Isolated patches: Patches or clusters of patches that are separated by more than 200 m and/or are divided by physical barriers such as roads, fences, water bodies and residential or industrial areas.

Koala habitat class: Primary, secondary (class A), secondary (class B), secondary (class C), tertiary, and unknown koala habitats.

Koala habitat atlas: Digital map of koala habitat classes based on the proportion of primary, secondary and supplementary tree species.

Likely primary or secondary food tree species: A eucalypt species considered highly likely to be of primary or secondary importance to koalas despite the absence, or scarcity, of koala faecal

pellet evidence from within the study area. Such a conclusion might be reached on the basis of other evidence such as historical records, information regarding browse selection from local koala welfare groups, or results from other local government areas .

Landscape: Mosaic of habitat patches that differ in quality and spatial properties.

Landscape composition: Proportion of different habitat types in the landscape.

Landscape configuration: The physical layout of all habitat patches within the landscape mosaic.

Matrix: The most extensive and most connected land use element present in the landscape. Also the land use element surrounding a habitat patch.

Non-eucalypts: For the purposes of these guidelines, and the Australian Koala Foundation Koala Habitat Atlas, significant use of non-eucalypt species is considered most likely to be associated with their shelter and general habitat value for koalas. It is acknowledged that non-eucalypt species also provide an important supplementary food resource.

Patch: A relatively homogeneous area of vegetation (native or exotic) that differs from its surroundings.

Patchiness: The density of patches or the fineness of the mosaic.

Population: A group of individuals of the same species located in a particular time and place, and which regularly exchange genes through reproduction.

Preferred koala food tree species: primary and secondary koala food trees.

Primary Habitat: Areas of forest or woodland where primary koala food tree species comprise at least 50% of the overstorey trees.

Primary food tree species: A eucalypt species that returns a strike rate (koala faecal pellets present) of generally 40% or greater which is significantly higher compared to that for other tree species on the basis of a stratified sampling protocol.

Remnant Habitat: Native forest or woodland habitat which is largely structurally intact. In Queensland, remnant vegetation is defined as vegetation where the dominant canopy has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and cover of that stratum and dominated by species characteristic of the vegetation's undisturbed canopy.

Regrowth Habitat: Secondary native forest or woodland that has regenerated after clearing or structural modification. Regrowth can include scattered trees or clumps of trees.

Secondary Habitat (Class A): Areas of forest or woodland where primary koala food tree species comprise less than 50% (but at least 30%) of the overstorey trees; or:

- Areas of forest and woodland where primary koala food tree species comprise less than 30% of the overstorey trees, but together with secondary food tree species comprise at least 50% of the overstorey trees; or

- Areas of forest or woodland where secondary food tree species alone comprise at least 50% of the overstorey trees (primary koala food tree species absent).

Secondary Habitat (Class B): Areas of forest or woodland where primary koala food tree species comprise less than 30% (but at least 10%) of the overstorey trees; or

- Areas of forest or woodland where primary koala food tree species together with secondary food tree species comprise at least 30% (but less than 50%) of the overstorey trees; or

- Areas of forest or woodland where secondary food tree species alone comprise at least 30% (but less than 50%) of the overstorey trees (primary koala food tree species absent).

Secondary Habitat (Class C): Areas of forest or woodland where koala habitat is comprised of secondary and supplementary food tree species (primary koala food tree species absent or less than 10%) where secondary food tree species comprise less than 30% of the overstorey trees.

Secondary food tree species: A eucalypt species that returns a strike rate of generally less than 40%, but which is significantly higher compared to that for other tree species, with the exception of those in the primary categories, on the basis of a stratified sampling protocol.

Supplementary food tree species: A eucalypt species that returns a strike rate less than that for species in either the primary or secondary food tree categories, but which is significantly higher compared to that for other tree species on the basis of a stratified sampling protocol. This class is ranked lowest when compared to primary and secondary species**.**

Tertiary Habitat: Areas of forest or woodland where primary and secondary koala food tree species are absent, but which have important supplementary koala habitat values such as habitat buffers and habitat linking areas. Such areas are considered to be necessary components of habitat for the overall conservation of koala populations. Tertiary habitat is not normally capable of supporting koala population/s in the absence of primary or secondary habitat.

Thinning: Process of partial removal of one or more strata of native vegetation using mechanical, chemical, manual or biological methods.

Viable Population: For planning purposes, a viable population is regarded as one which has adequate numbers and distribution of reproductive individuals to ensure its continued existence in the planning area (landscape). In order to insure that viable populations will be maintained, births must exceed deaths over an extended period. This requires maintaining adequate habitat and minimising mortality from dogs, vehicle collision and disease.

PART A - LANDSCAPE-LEVEL PLANNING

1. What Is A Landscape?

Standard dictionaries define "landscape" in terms of natural scenery or landform. However, landscapes also have an important ecological dimension for wildlife populations including the koala. **From a koala perspective, a landscape is an area of land 100s-1000s ha in area, and containing a mosaic of habitat patches of different quality, size and shape.** Habitat patches represent relatively discrete areas (well defined boundaries) of different habitat quality. Koala habitat quality is defined on the basis of the proportion of preferred eucalypt species and soil type, which collectively affect leaf chemistry including nutrient levels and toxins. Koalas demonstrate marked preferences for a relatively small number of the eucalypt species, especially those occurring on more fertile soils with a higher nutrient status, in any given area. Eucalypt communities on fertile soils have a higher nutrient status. However, many of these communities have been severely depleted by historical and ongoing clearing for agriculture and urban development. Therefore, many landscapes in which koalas now occur are highly fragmented by human land use and/or occur on lower quality soils.

The first step in implementing these guidelines is to define landscapes and landscape boundaries that are meaningful for koala conservation. The simplest method is to visually interpret a habitat or vegetation map, aerial photograph or satellite image, delimiting areas with similar topography, vegetation and land use patterns. Recurring patterns and spatial discontinuities in habitat and land use, topographic barriers such as major rivers and cliff-lines, and main roads are key criteria for delimiting landscapes for koala conservation.

Landscapes differ in the quality, amount and spatial configuration of remaining koala habitat. These factors are critical for the survival of individual koalas and the viability of local populations, whether consisting of 100s or 1,000s of individuals. Without suitable habitats (primarily eucalypt forests), individual koalas are unable to survive and reproduce and local populations will soon become extinct. In Figure 2a, mature eucalypt forests (shaded green) form the most extensive land use, referred to as the matrix. As the landscape is modified, forest habitats are replaced by urban land uses and roads, which become the matrix as development progresses (Figure 2b, c and d). While the urban matrix provides habitat for people, it provides very limited habitat resources for koalas. Rather, the risk of koala mortality from dog attacks and vehicle collisions is high as koalas move into and through urban areas and cross roads.

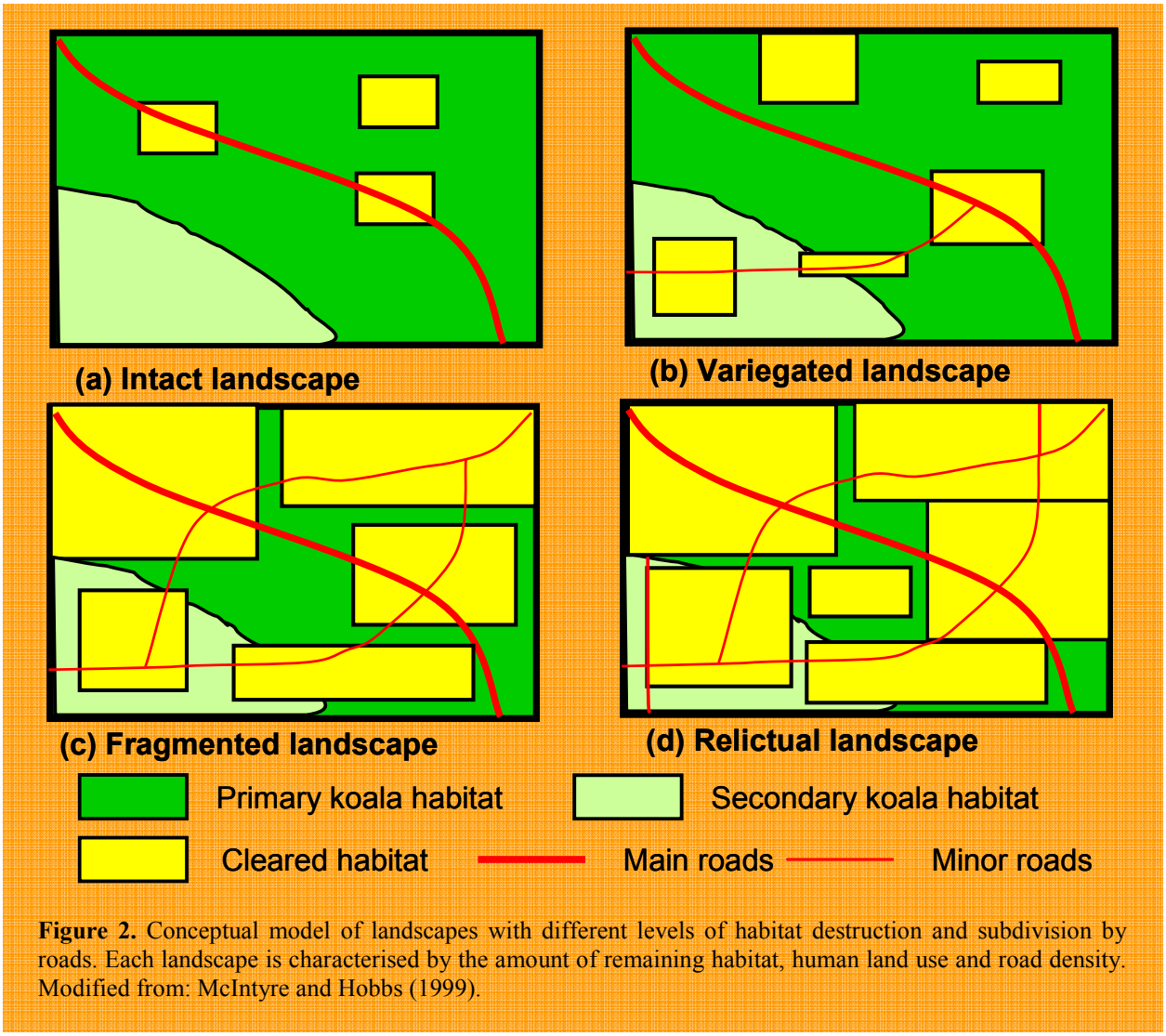


Figure 2. Conceptual model of landscapes with different levels of habitat destruction and subdivision by roads. Each landscape is characterised by the amount of remaining habitat, human land use and road density. Modified from: McIntyre and Hobbs (1999).

Intact landscapes are areas of predominantly native forest (>90%) that are free from major highways (Figure 2a). Intact landscapes may have a low proportion (<10%) of urban and rural land use, but provide almost continuous native forest habitat for koalas. Threats from road traffic and dog attacks are generally low.

Variegated landscapes have 60-90% native forest with an expanding human land use and road network perforating and subdividing the original forests (Figure 2b). Koalas face increasing pressures from habitat loss, fragmentation, vehicle collisions and dog attacks.

Fragmented landscapes are landscapes with 10-60% of the original forest habitat remaining (Figure 2c). In urban and semi-urban landscapes, road densities and traffic volumes are high as the human population increases. The remaining koalas are forced to live in small remnants surrounded by urban and rural land use and roads. Movement of individuals is more hazardous, especially in urban areas, although koalas may move more easily through rural areas if scattered trees are present.

Relictual landscapes are landscapes have <10% native forest remaining and are dominated by human land uses (Figure 2d). They have a high density of roads and high traffic volumes. The likelihood of koalas surviving in these landscapes is low, especially if urban land use dominates.

2. Koala Food Tree Species and Mapping Habitat

The identification of koala food tree species preferences should be based upon adequate field research and data analysis. This work should be undertaken by researchers/consultants with appropriate ecological qualifications and relevant experience. For Koala Habitat Atlas mapping, habitat utilisation and tree species preferences of koalas in each Local Government Area (LGA) are assessed using a plot-based faecal pellet survey methodology developed by the Australian Koala Foundation. This methodology involves the following steps.

Field Surveys

First, field survey sites should be randomly stratified to sample the range of soil and vegetation floristic variables within each LGA to the fullest extent possible according to vegetation communities and soil landscapes or geology. Targeted or adaptive approaches may be required in order to generate statistically valid datasets for particular tree species as the sampling progresses.

Pellet searches should be undertaken within pre-selected plot survey sites by searching for pellets within 1 metre of base of each tree, with 30 trees surveyed per site. Sites affected by recent bushfire should not be surveyed. Plot sites are 20 m in radius and are located in the field using handheld GPS units and topographic maps. All live trees (with the exception of tree ferns, palms and cycads) with a dbh (diameter at breast height) of at least 100 mm within each plot site are flagged and systematically searched for evidence of koala faecal pellets. The search area includes a 1 metre catchment around the base of each tree, searched for two-person minutes, or until a koala pellet is found. A "presence" is recorded for each tree where one or more koala pellets are found. In addition to tree species, dbh and presence/absence of pellets, completed data sheets for each plot site also include vegetation descriptions and any evidence of disturbance, and any koalas observed in the site.

Identifying Preferred Koala Food Tree Species

Second, tree species are grouped into primary, secondary and supplementary preference classes according to the level of utilisation.

A primary koala food tree is a *Eucalyptus* species with a significantly higher proportion of trees having one or more koala faecal pellets (an indicator of use), compared to other tree species. Similarly, a secondary food tree is a *Eucalyptus* species that registers a significantly higher proportion of trees with pellets compared to that observed for remaining species (excluding the primary category). A third category, supplementary food tree species, records a significantly lower proportion of trees with pellets than for secondary species, but greater than for other tree species, which generally lack evidence of use by koalas. It is acknowledged that non-*Eucalyptus* species often provide supplementary food resources, as well as shelter for koalas. Primary tree species commonly demonstrate density independence (i.e. the strike rate of pellets does not vary significantly in response to different densities of that species recorded within plot sites). Conversely, the strike rate for secondary tree species tends to decline with increasing density of that species, suggesting a density dependent relationship.

Vegetation Mapping

The third step involves "scaling up" the koala food tree preferences from the site scale to LGA or study area scale. This step requires an accurate vegetation map of the LGA showing vegetation communities/regional ecosystems and the dominant species in each map polygon. Vegetation mapping at 1:25,000 scale is considered to be the minimum standard useful for derivation of the Koala Habitat Atlas, although in areas with greater vegetation homogeneity 1:50,000 scale may be adequate. Floristic descriptions of vegetation communities should include, at a minimum, dominant and sub-dominant species, and other species found in the community. If vegetation mapping is commissioned specifically for a Koala Habitat Atlas, the actual percentages of each species in each vegetation community will greatly assist the classification of each community into a koala habitat category. An example of suitable vegetation mapping is Victoria's State Forest Resource Inventory mapping program which enables approximate species percentages to be derived from the polygon code. Regional ecosystem mapping by the Queensland Herbarium provides similar information.

The Minimum Mapping Unit (MMU), or polygon size, is an important consideration in vegetation mapping. Primary koala food trees often occur in quite small patches or narrow strips, for example higher-fertility soils adjoining wetlands and watercourses. It is desirable to separate these small patches from surrounding vegetation communities. Australian Koala Foundation vegetation mapping employs a MMU of 0.2 ha for patches containing primary food trees. Remnant primary and secondary food trees in farmland are mapped when the total groundcover (on an aerial photo) exceeds 10%.

Recent experience indicates that a "rapid-assessment" approach to collection of field sites for vegetation mapping yields the best mapping result. A 20-metre radius site is selected, and stem counts of trees with dbh over 100 mm are recorded. The stem-count method thereby matches the data collected for spot faecal pellet assessments, and is much more rapid than estimating foliage projective cover. A greater number of field sites can then be collected within budgetary or time constraints.

Preparation of a Koala Habitat Atlas Map

A Koala Habitat Atlas is derived by firstly assigning habitat categories to each vegetation community or ecosystem according to the proportional abundance of the identified preferred koala food tree species. The assigned habitat category for a given vegetation community may be subsequently upgraded or downgraded according to GIS modelling outcomes for identified key factors such as soil types or proximity to watercourses.

The final habitat category or class is then added to the vegetation map attribute table allowing convenient presentation of the vegetation map as a Koala Habitat Atlas, and providing a means to calculate total areas for each habitat class, and derive landscape metrics such as habitat area, connectivity and fragmentation using the appropriate software. The Koala Habitat Atlas may then be used to inform planning guidelines outlined below.

Habitat buffers

Habitat buffers can contribute to the long-term survival of koalas in high quality primary and secondary (class A) koala habitat by ensuring that incompatible *uses, developments* or *activities* do not occur on immediately adjacent lands. Habitat buffers include lands that may be a source of threats that need to be managed through effective planning and design strategies, to minimise or eliminate impacts on koalas (Kozlowski and Peterson 2005). Buffers can also help protect remnants

from nutrient impacts, wind damage and weed invasion. Widespread clearing and fragmentation of the landscape results in patches of remnant vegetation wherein the surrounding environment imposes a range of different physical, microclimatic and biological conditions (Saunders et al. 1991; Murcia 1995). These conditions are often most apparent at the abrupt transition between the remnant vegetation and the surrounds and are referred to as "edge effects" (Murcia 1995). These can include: i) abiotic (non-living) factors such as changes in air moisture or temperature, solar radiation levels, soil moisture or temperature, soil chemical composition (Murcia 1995), or wind speed and pattern (Saunders et al. 1991); and ii) biological edge effects such as changes in species abundance and distribution, either directly due to changed environmental conditions or indirectly through changes in species interactions such as predation, herbivory, competition and seed dispersal (Murcia 1995). Native vegetation can be protected from edge effects to varying degrees by retaining or replanting buffers, and thus moving detrimental edge effects further out (Hobbs 1993). Some Australian examples of the distance to which edge effects have been reported to penetrate into remnants include: canopy damage up to 150m inside remnant tropical rainforest in northeast Queensland (Laurance 1991); changes in floristic composition up to 16m inside remnant temperate rainforest in NSW (Fox et al. 1997); higher proportions of exotic plant species and higher mean basal area of the native weed *Pittosporum undulatum* within 30m of suburban edges in dry sclerophyll forest and woodland on the Hornsby Plateau, NSW (Rose and Fairweather 1997; Rose 1997); and increased phosphorous levels up to 20m into dry sclerophyll woodland in Western Australia (Scougall et al. 1993). One of the most comprehensive reviews undertaken to date, by Murcia (1995), noted that most edge effects were reported to have disappeared within 50m of the remnant edge, whilst a review by Laurance (2000) concluded that most empirical studies of edge effects reported distances of penetration less than 150m.

As well as assisting to minimise edge effects, koala habitat buffers provide for the likely extension of significant koala activity beyond patches of preferred koala habitat. Even habitat buffers that extend over mainly cleared land containing only scattered trees can help to facilitate koala activity within preferred koala habitat areas and safe koala movement between adjoining habitats. Such areas should be considered a priority for habitat restoration projects where feasible. Buffer areas may be suitable for other land uses in addition to habitat protection and restoration, as long as these are compatible with koala conservation, such as open space and passive recreation. Whilst bushfire Asset Protection Zone requirements should ideally be met outside of ecological buffer areas, it may be feasible in some situations for bushfire outer protection areas to coincide with the outer section of ecological buffers, to the extent that this does not drastically impede natural regeneration processes and restoration programs.

We recommend that **a minimum buffer width of 50 m** should be applied to areas of preferred koala habitat; larger where adjoining future development is likely to pose significant threats to koalas such as high density residential development where domestic dog ownership is allowed or where traffic speeds in excess of 40km/hr are permitted. Habitat buffers warrant protection and management through performance standards equivalent to those recommended in Part B of these guidelines for secondary (class B) and secondary (class C) koala habitat.

Habitat linking areas may provide opportunities for the successful movement of koalas (e.g., dispersal and recruitment of sub-adults) between breeding populations or into areas of vacant preferred koala habitat. Habitat linking areas may also be used as part of established koala home ranges, depending upon factors such as the vegetation associations and/or species of scattered trees they contain and their location relative to other habitat areas. Development within habitat linking areas should aim to retain any preferred koala food trees (primary and secondary food trees) that may be present and not compromise the safe use of such areas by koalas. Such areas should also be considered a priority for habitat restoration projects. Habitat linking areas over existing native vegetation also warrant protection and management through performance

standards equivalent to those recommended in Part B of these guidelines for secondary (class B) and secondary (class C) koala habitat.

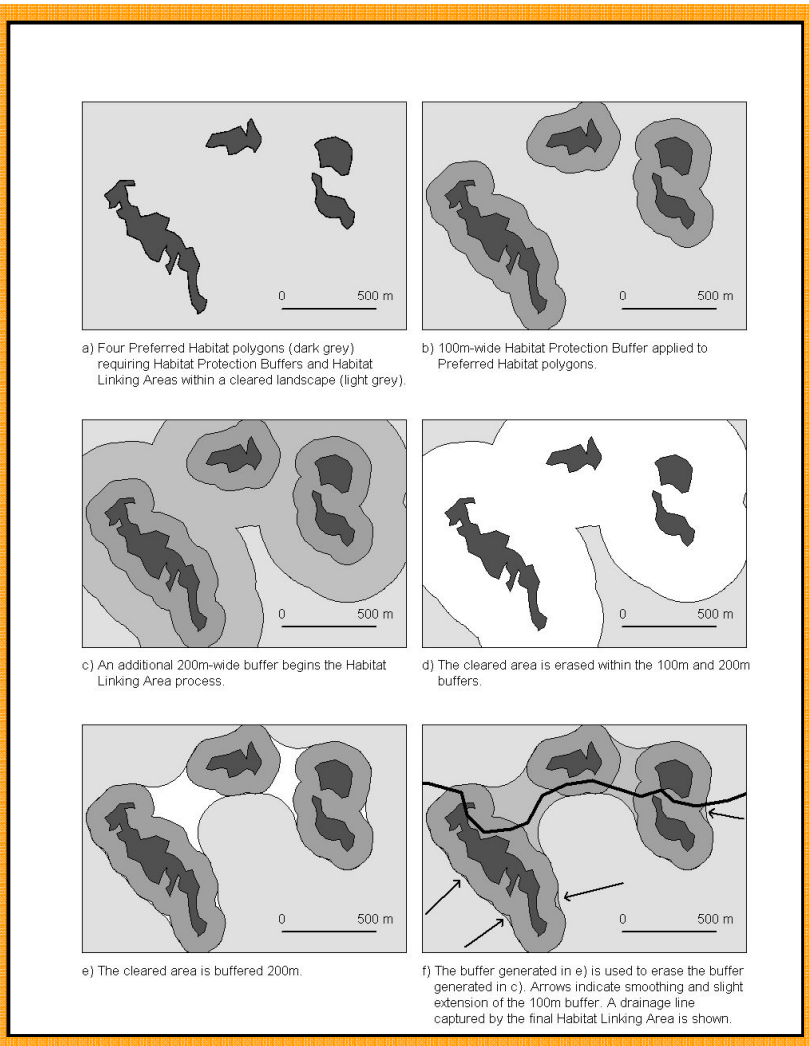


Figure 3. Steps to generate habitat buffers and habitat linking areas.

DETAILED GUIDELINES

3. How Much Habitat is Enough?

Planning Objective

To maintain and conserve a landscape that contains a sufficient amount of habitat to sustain a viable koala population.

Guideline 1.1

Maintain at least 40- 50% of the landscape as primary and secondary koala habitat across landscape extents 1 kilometre radius around where koalas occur. The protection of primary and secondary (class A) habitats should be the top priority.

Scale of application: whole landscape or multiple landscapes within local government area.

Actions

i) Identify and map areas of primary and secondary habitat of each class using a transparent and repeatable approach, preferably within a GIS and at an appropriate scale.

ii) Map areas of koala habitat using a transparent and repeatable approach, preferably within a GIS and at an appropriate scale.

iii) Conserve and maintain the ecological integrity of areas of primary and secondary habitat. Give priority to primary and secondary (class A) habitat and habitat of all classes that exists in contiguous blocks. Priority should also be afforded to areas that are known to contain existing koala populations. However, the apparent absence of koalas should not preclude the protection of such areas wherever possible as koala populations may be present intermittently over time as they shift focus through the landscape. These areas may also be a critical resource for the recovery of local populations.

iv) Implement revegetation programs, especially where the amount of primary and secondary habitat in the landscape is close to, or below 50%, or is highly fragmented. Priority should be given to revegetating areas adjacent to contiguous blocks of existing habitat. Revegetation should involve planting of local eucalypt species and other local native species consistent with the pre-existing forest types and the koala's preferred tree species for the area.

Guideline 1.2

Where detailed koala habitat mapping is not currently available or possible, maintain at least 50-60% of the landscape as forest (preferably native forest) across landscape extents 1 kilometre square where koalas occur. This guideline is not necessarily expected to be applied at the scale of the whole local government area, but rather for landscapes where koalas occur.

Scale of application: whole landscape or multiple landscapes within local government area.

Actions

i) Map areas of forest using a transparent and repeatable approach, preferably within a GIS and at an appropriate geographic scale.

ii) Conserve and maintain the ecological integrity of areas of forest. Give priority to eucalypt forests occurring in contiguous blocks and which contain existing koala populations.

iii) Implement revegetation programs, especially where the amount of forest in the landscape is close to, or below 40% or is highly fragmented. Give priority to the revegetation of areas adjacent to contiguous blocks of forest. Revegetation should involve planting of local eucalypt species and other local native species consistent with the pre-existing forest types and the koala's preferred tree species for the area.

The Science

As the amount of natural habitat in a landscape is reduced, the size of wildlife populations declines and the chance of extinction increases. However, there can be a threshold amount of habitat, below which population sizes decline rapidly and the chance of extinction increases rapidly, rather than a gradual decline. **For koalas, habitat loss is one of the primary threatening processes.** However, few studies have attempted to identify the minimum amount of habitat required to support a viable koala population. This is difficult because it is dependent on a range of interrelated factors, including the level of fragmentation, clearing history, level of disease, birth rates and mortality rates. Studies in South East Queensland suggest that up to 4,000 ha is required to support a viable koala population of at least 500 individuals, depending on population density. Hence, where the density of koalas is low, the area of habitat required may be much higher than where the density of koalas is high.

There is good evidence from Noosa Shire in Queensland that the chance of koalas being present declines rapidly as the percentage of koala habitat or forest falls below around 60-70% of the landscape (Figure 4). Similar evidence from Port Stephens on the New South Wales central coast suggests that the probability of koalas being present falls as the percentage of koala habitat or forest falls below around 40% (Figure 4). Where the percentage of primary and secondary habitat of the landscape is less than around 20% for Ballarat, 30% for Port Stephens to 50% for Noosa, then there is a greater likelihood of koalas being absent than present. Although the amount of primary and secondary habitat is crucial, the importance of the total amount of forest in the landscape indicates that having adequate amounts of marginal or low quality habitat, in conjunction with primary and secondary habitat, is an important component for maintaining viable koala populations. It is likely that marginal habitat performs an important buffering function for primary and secondary habitat as well as providing supplementary food and shelter resources and habitat connections. **The landscapes discussed here are typical of coastal eastern Australia and these results suggest that the amount of habitat, as a percentage of the landscape, required to sustain viable koala populations may be much higher than the commonly recognised 20-30% for mammals and birds. This will particularly be the case for populations highly affected by road traffic, dog attacks, bushfires, and disease, all of which reduce the potential for population growth.**

Further, the studies used to identify these thresholds are based on the occurrence of koalas at a single point in time. Over time, populations of koalas in some habitat patches will become extinct because of the effects of past clearing. This lag between clearing and the impact on animal population is know as an 'extinction debt' and suggests that the real thresholds may indeed occur at lesser clearing extents than generally detected. This emphasises the need to adopt

a precautionary approach by protecting more habitat than indicated by thresholds whenever possible.

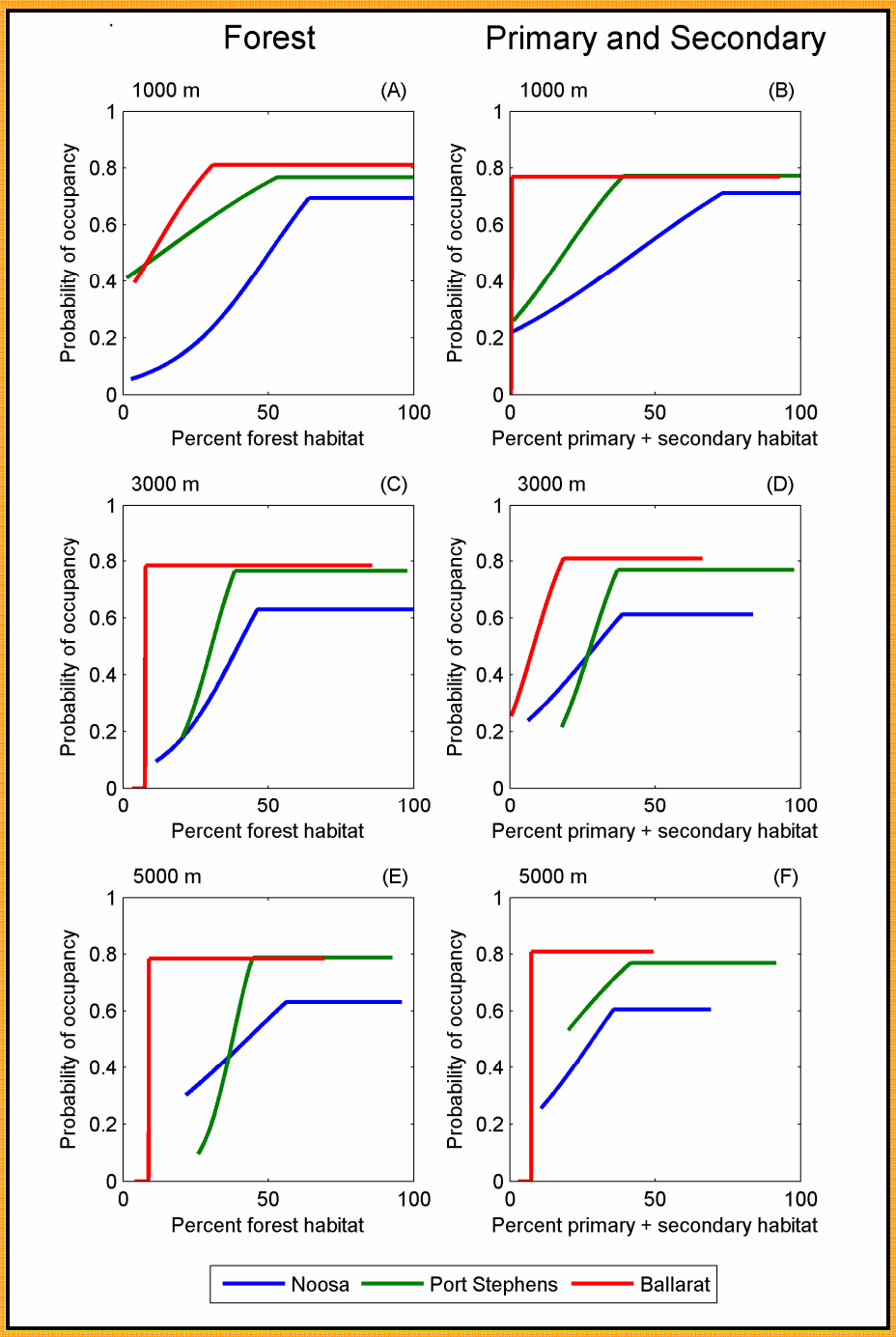


Figure 4. The relationship between the probability of koalas being present and (1) the percentage of forest, and (2) the percentage of primary and secondary habitat. Graphs show relationship for Noosa Shire, Port Stephens Shire and Ballarat for 1 km (314 ha), 3 km (2827 ha) and 5 km (7867 ha) radii circular buffers surrounding koala survey sites. Lines show two-phase (broken-stick) logistic regression models fitted to the data with the break points indicating critical thresholds in the amount of habitat below which there is an increased probability of koalas being absent. Threshold levels tend to decrease at larger spatial extents from a survey site, indicating a hierarchy effect with habitat proximate to where koalas occur more important than more distant habitat.

4. How Big do Patches Need to Be?

Planning Objective

To maintain and restore koala habitat patches, or clusters of highly connected patches, that are large enough to sustain viable koala populations.

Guideline 2.1

Primary and secondary koala habitat patches should be larger than 50-100 ha in size, unless they are part of a cluster of highly connected patches (*see Guideline 2.2*).

Scale of application: whole landscape or multiple landscapes within local government area.

Actions

i) Conserve and maintain the ecological integrity of habitat patches, with priority given to patches larger than 50 ha. Give lower priority to very small (less than 2 ha in size) habitat patches, unless these patches are part of a cluster of highly connected patches (see Guideline 3.2 below) or currently contain koalas.

ii) Implement revegetation programs to enlarge the size of remnant koala habitat patches. Priority should be given to revegetating habitat patches 10- 50 ha, with the aim of increasing their size. Give lower priority to revegetation of areas adjacent to very small (< 2 ha in size) habitat patches. Revegetation should involve planting local eucalypt species and other local native species consistent with the pre-existing forest types and the koala's preferred tree species for the area.

Guideline 2.2

Clusters of koala habitat patches that are highly connected (i.e., separated by less than 100-200 m) should be larger than 100 ha in total area.

Scale of application: whole landscape or multiple landscapes within local government area.

Actions

i) Conserve and maintain the ecological integrity of clusters of highly connected habitat patches. Prioritise the protection of clusters that are larger than 100 ha and give lower priority to very small clusters, unless they currently contain koalas.

ii) Implement revegetation programs to enlarge the size and improve the connectivity of clusters of koala habitat patches. Give priority to clusters that are smaller than 100 ha in total size, but lower priority to very small clusters. Within these clusters, give priority to the revegetation of areas adjacent to and between large and medium sized patches. Revegetation should involve planting eucalypt species and other native species consistent with the pre-existing forest types for the area and the locally preferred tree species of koalas. As an illustration in Figure 5, the striped areas indicate possible priority areas (adjacent to the large patches) for revegetation, as opposed to areas adjacent to small patches.

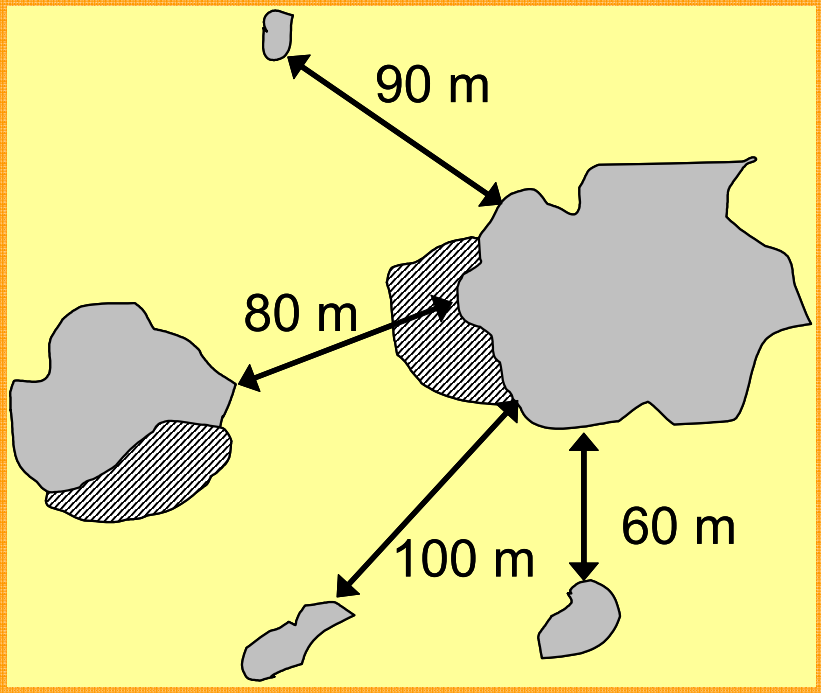


Figure 5. Hypothetical example of a cluster of highly connected (< 100 m apart) patches (grey areas) and possible priority areas for revegetation (striped areas) adjacent to the larger patches.

The Science

As a general rule, as the area of a habitat patch is reduced, population sizes fall and the chance of a species going extinct in the patch increases. At some point the patch size will become too small to support a viable population of the species. This is particularly the case for isolated patches because there is then limited opportunity for small, declining populations in these patches to be 'rescued' by immigration from adjacent patches. In fact, as habitat patch sizes become smaller, patches often also become more isolated which in turn increases the chance of local extinction. Small isolated patches are also subject to much higher edge effects than large patches, which can also increase the chance of extinction, especially for edge sensitive species.

The minimum patch size, below which a viable koala population cannot be supported, will depend to some extent on the level of patch connectivity. For example, if several small patches are very close together they may function as a single larger patch if koalas can move freely and safely between them. However, if a patch is highly isolated, then it would need to be much larger to support a viable population. Isolated habitat patches of 2 ha in size, for example, are likely to be of little use as breeding habitat for koalas as this equates roughly to the smallest home range size for an individual koala in high quality habitat. In a fragmented coastal landscape in Noosa Shire evidence of critical patch size requirements have been shown, with koalas more likely (probability <0.5) to be absent in patches less than 50 ha in size. Further, there is some evidence to suggest that once patches become smaller than around 150 ha the chance of koalas being present starts to decline (Figure 6). Although in some landscapes, for example in Port Stephens, New South Wales, patch size appears to be less critical, although habitat amount remains important.

If habitat patches are close enough to each other for koalas to move freely between them on a daily basis then they are considered to be highly connected, providing there are no major barriers such as roads, fences, or significant threats such as wild dogs or roaming domestic dogs. In general, koalas could be expected to move between habitat patches on a daily basis if they are separated by distances no greater than 100-200 m and provided there are no significant barriers or threats. In Port Stephens, the median daily movement distances of female koalas was found to be just less than 100 m, with males moving slightly longer daily distances.

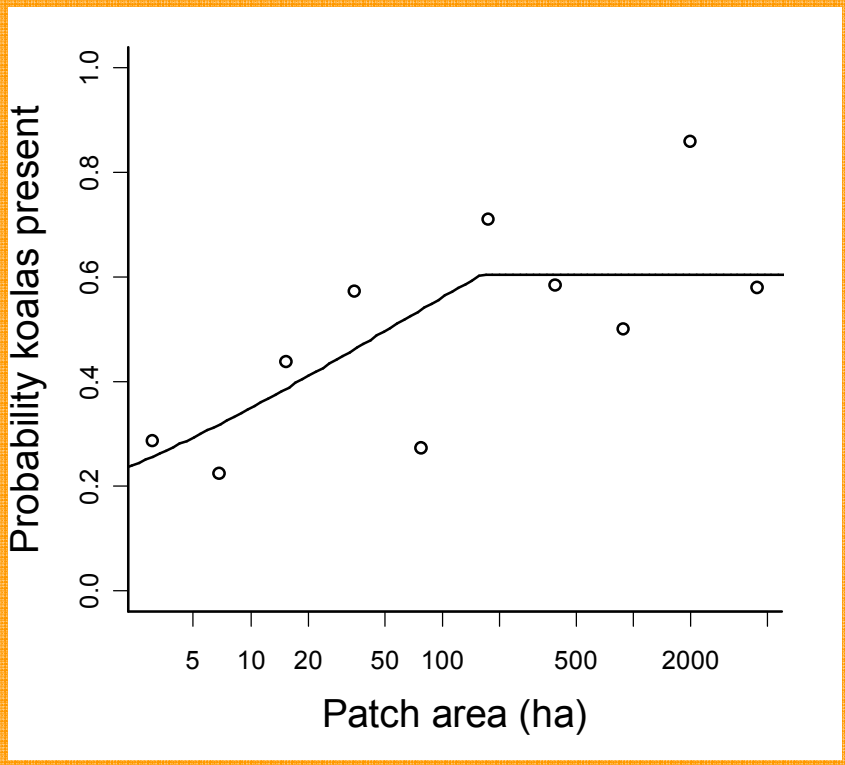


Figure 6. Relationship between the probability of koalas being present in a patch of primary or secondary habitat and the patch size for Noosa Shire, Queensland. Circles show actual data and the line shows a two-phase logistic regression model fitted to the data.

5. What Shape Should Patches Be?

Planning Objective

To maintain and restore a landscape that contains patches of koala habitat with shapes that minimise edge effects.

Guideline 3.1

Koala habitat patches should be more circular than linear in shape so as to minimise edge effects.

Scale of application: whole landscape or multiple landscapes within local government area.

Actions

i) Development should avoid creation of narrow linear strips, especially for small habitat patches. This may be particularly important in deciding where habitat should be retained on a development site. However, some habitat patches, such as riparian habitat along water courses, may be linear by definition and this must also be taken into account. Linear riparian habitats often provide important forage trees for koalas as well as conduits for movement.

ii) Revegetation programs should aim to consider the shape of the area being revegetated and avoid constructing narrow linear patches.

The Science

As habitat patches become smaller, the amount of edge, relative to the area of each patch (the perimeter-area ratio) increases. Therefore, small patches are generally more subject to edge effects than large patches. Edge effects have negative consequences for many species. For a given patch size, the amount of edge is smallest for a circular shape, but largest for a narrow linear shape. Therefore, edge effect may be minimised by maintaining habitat patches that are more circular than linear in shape.

For koalas, edge effects may lead to increased predation risk by dogs or increased stress leading to disease. In Noosa Shire, koalas tend to be absent in small habitat patches with high perimeter to area ratios, especially those less than 100 ha in size (Figure 7). This suggests that the shape of small patches should be an important consideration in planning for koala conservation, while the shape of large patches is probably less important with regard to edge effects.

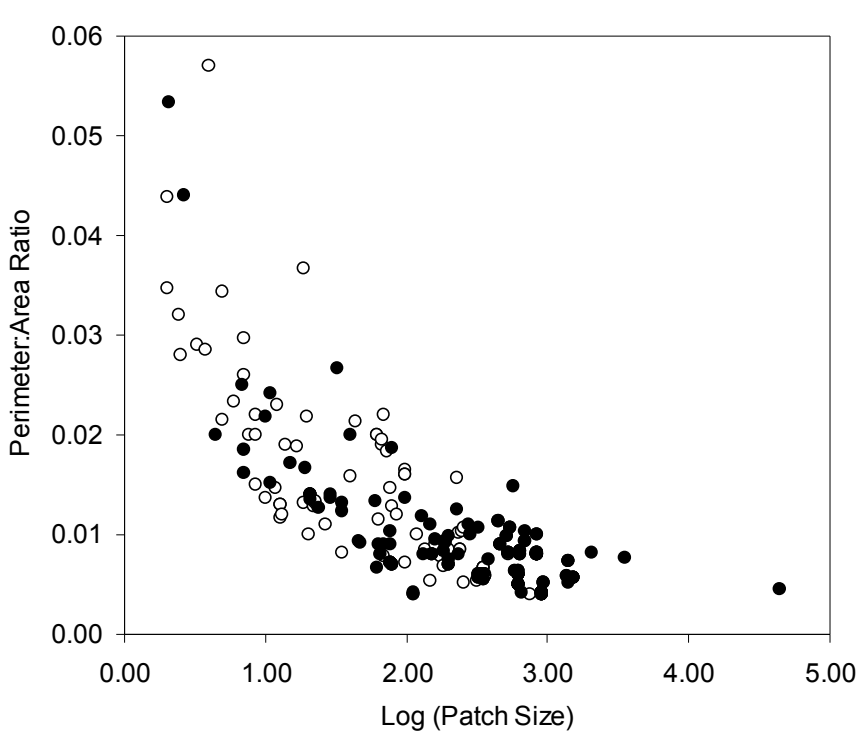


Figure 7: Graph of log patch size (ha) against the perimeter-area ratio for primary and secondary habitat in Noosa Shire, Queensland. Solid circles show patches with evidence of koala use and empty circles show patches with no evidence of use. Source: McAlpine et al. (2005).

6. How to Maintain the Quality of Koala Habitat Patches and Linkages?

Planning Objective

To maintain the integrity and quality of koala habitat patches and linkages.

Guideline 4.1

Within koala habitat patches, or corridors, maintain sufficient proportions of mature preferred koala food tree species (i.e., greater than 30%).

Scale of application: whole patches or multiple patches within landscape.

Actions

i) Maintain koala habitat patches, and linkages, in as natural a state as possible.

ii) Avoid the removal of preferred koala food tree species and other trees known to be used by koalas. This is particularly important for patches with low proportions of koala food trees.

iii) Consider planting additional preferred food trees where they are in low proportions within habitat patches or linkages.

Guideline 4.2

Avoid the internal fragmentation of koala habitat patches and linkages, and any reductions in tree density.

Scale of application: whole patches or multiple patches within landscape.

Actions

i) Avoid construction of roads and barriers, such as walls and fences within koala habitat patches or linkages.

ii) Avoid clearing and thinning trees within koala habitat patches, or linkages that would substantially increase the distance between mature trees. If clearing of trees is unavoidable then this should be done so that the distance between remaining mature trees is at most 20-30 m.

Guideline 4.3

Maintain the structural and species diversity of trees within koala habitat patches and linkages.

Actions

i) Avoid clearing and thinning tree species (particularly preferred koala food trees) within koala habitat patches that would result in a decline in the number and age distribution of tree species.

ii) Retain a variety of age classes of trees, both young and mature trees, and other vegetation in koala habitat patches. Avoid clearing that would result in a substantial loss of koala food trees of all age classes (Figure 8).

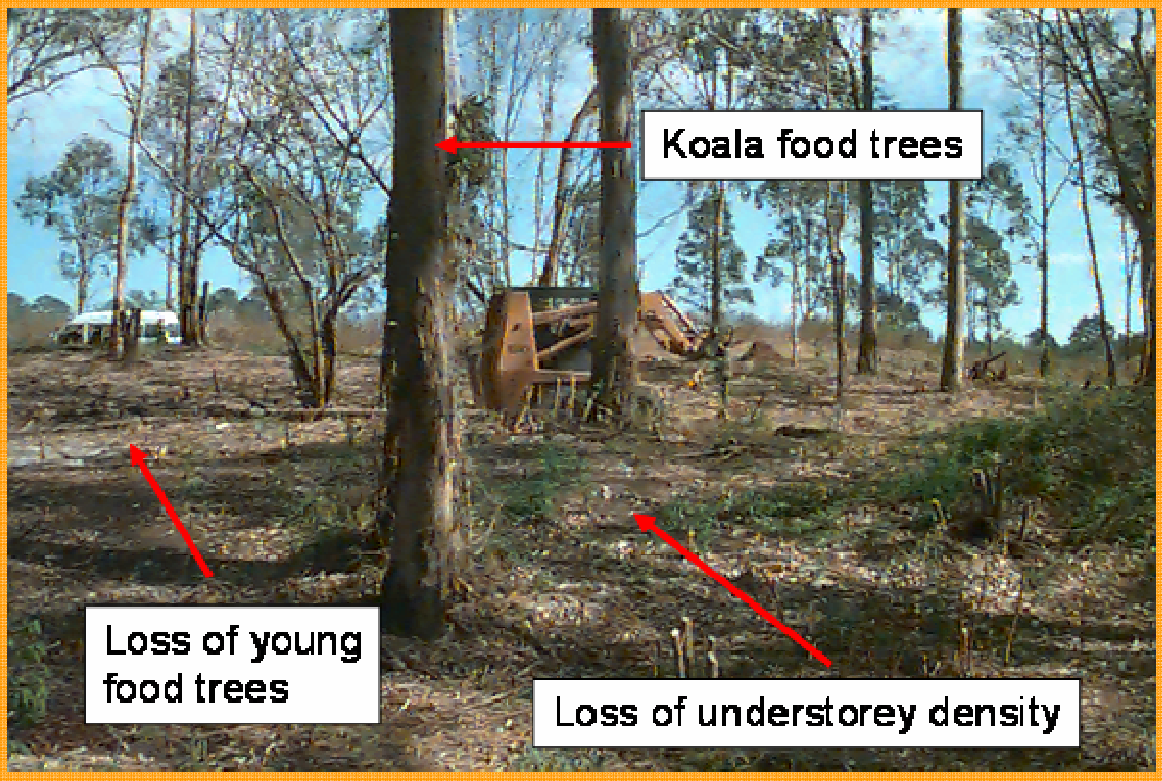


Figure 8: Development within koala habitat that results in reductions in the proportion of koala food tree species, tree density, species diversity, the size of trees and structural diversity should be avoided**.** (Photo: Clive McAlpine)

The Science

The tree is the basic unit of koala survival and therefore habitat quality within koala habitat patches will depend largely on the nature of the trees present in that patch. Koalas demonstrate regional preferences for particular tree species. The quality of koala browse is thought to relate primarily to nutritional value and chemical composition, which depends on factors such as the tree species, nutrient status of the soil and water availability. Within the constraints imposed by soil nutrients and water availability, the proportion and abundance of preferred food tree species appears to be the most important determinant of koala habitat quality. However, the presence of large trees and high tree species diversity can also enhance koala habitat quality. Forests that have high densities of preferred tree species potentially have greater carrying capacity and could support more viable koala populations, compared to forests that have low densities of preferred tree species. Hence, forests with low proportions of preferred tree species, or low densities of trees, tend to constitute poorer quality koala habitat (see Appendices B and C). At least for the coastal areas of Queensland and New South Wales, once the proportion of preferred koala food trees falls below around 30% of total trees, the habitat appears to be lower-secondary to marginal quality for koalas. For corridors, the spacing between mature trees should be no greater than 20-30 m apart, although for breeding habitat higher densities will certainly be more appropriate.

7. How to Maintain and Restore Habitat Connectivity?

Planning Objective

To maintain and conserve a landscape in which patches of koala habitat are sufficiently connected to sustain a viable koala population.

Guideline 5.1

Maintain a network of habitat patches and corridors linking blocks of koala habitat.

Scale of application: whole landscapes or multiple landscapes within LGA.

Actions

i) Identify patches, or corridors, of forest that act as important links between blocks of habitat. For example, whilst the patches between the two larger patches may be too small to support koalas on their own, they act as valuable stepping stones connecting the two larger patches (see Figure 9).

ii) Conserve and maintain the ecological integrity of habitat identified as providing important linking functions between larger blocks of habitat. A continuous restored habitat corridor between the two larger patches could greatly enhance connectivity. This will be particularly important where the blocks of habitat are separated by up to 3-4 km, as this appears to be a typical dispersal distance for koalas.

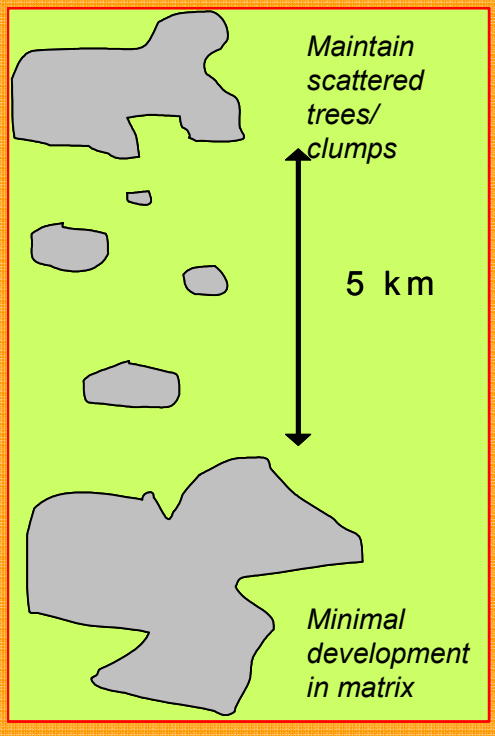


Figure 9. Hypothetical example of two large patches connected by smaller patches acting as 'stepping stones'.

iii) Where blocks of habitat, especially those separated by up to 3-4 km, have no linking habitat between them, the restoration of habitat corridors or habitat patches should be considered. Habitat corridors should ideally be 100s of metres wide to avoid large edge effects. Irregular-shaped patches of habitat that act as 'stepping stones' may suffer less from edge effects than a linear corridor and for this reason may be preferable when restoration of a wide corridor is impractical. Threats to koalas, such as road traffic and dogs should be sufficiently reduced prior to restoration of linking habitat.

Guideline 5.2

Maintain areas between separate blocks of koala habitat free from barriers to koala movement.

Scale of application: whole landscapes or multiple landscapes within LGA.

Action

Avoid the construction of major new roads, fences, buildings, sheer retaining walls, or other barriers that will impede the movement of koalas between habitat patches. This will be particularly important for patches within 3-4 km of each other.

Guideline 5.3

Blocks of koala habitat separated by more than 10 km, or by significant barriers to koala movement, should be managed as separate populations.

Scale of application: whole landscapes or multiple landscapes within LGA.

Action

i) Where blocks of habitat are separated by more than 10 km with no linking habitat between, successful koala dispersal between the blocks will be rare. In these cases, the guidelines should be applied independently to each habitat block, as if they were separate populations and separate management units.

The Science

Small populations that are highly isolated tend to suffer much higher extinction risks than populations that are connected to each other via animal movement. This is because immigration into a population from other areas can 'rescue' the population from extinction and can prevent loss of genetic diversity. The survival of metapopulations (a group of spatially structured populations or sub-populations connected by dispersal) actually relies on the ability of animals to recolonise habitat patches where a sub-population has gone extinct. Although, habitat patches that are further apart are often considered to be less connected than habitat patches close together, connectivity also depends upon the nature of the matrix and the existence of barriers to movement. Although the construction of corridors has been advocated as a means of connecting habitat patches, the effectiveness of such measures remains unclear.

Prior to establishing a home range (or territory), koalas can disperse relatively long distances, up to around 10 km, although distances of around 3-4 km are more commonly observed. Therefore, in theory, patches separated by distances of up to 3-4 km may remain relatively well connected for a koala sub-population, depending on the level of forest cover and potential threats or barriers

between patches. **However, despite the fact that koalas are relatively mobile, the isolation of patches is an important predictor of koala occurrence, with koalas more likely to occur in patches close to other patches than in isolated patches.** This highlights the connectivity role of the landscape matrix. In urban and semi-urban landscapes, koalas may suffer elevated mortality due to dog attacks and vehicle collisions, reducing their ability to successfully move between patches. In addition, barriers such as fences, buildings and major roads can reduce connectivity. Some studies suggest that corridors of trees may be of little use to koalas, while others show some evidence for the use of corridors of sparse trees by koalas. However, linear corridors may need to be 100s of metres wide to avoid excessive edge effects, such as an increased incidence of dog attacks.

Defining habitat connecting or linking areas may provide opportunities for the successful movement of koalas (e.g., dispersal and recruitment of sub-adults) between breeding populations or into areas of vacant preferred koala habitat. Habitat linking areas may also be used as part of established koala home ranges, depending upon factors such as the vegetation associations and/or species of scattered trees they contain and their location relative to other habitat areas. Development within habitat linking areas should aim to retain any preferred koala food trees (as defined in Appendix 1) that may be present and not compromise the safe use of such areas by koalas. Such areas should also be considered a priority for habitat restoration projects. Habitat linking areas over existing native vegetation also warrant protection and management through performance standards equivalent to those recommended for secondary (class B) and secondary (class C) koala habitat.

8. How to Maintain and Develop Road Networks?

Planning Objective

To minimise the impacts of roads on koala populations.

Guideline 6.1

Do not construct new roads or expand existing roads within and between koala habitat patches.

Scale of application: whole landscapes or multiple landscapes within LGA.

Actions

i) Do not construct new roads, or increase the traffic volume on existing roads, within koala habitat patches, especially if this habitat contains high proportions of primary and secondary habitat (Figure 10).

ii) Do not construct new roads, or increase the traffic volume on existing roads, in areas that adjoin koala habitat patches, especially if these patches contains high proportions of primary and secondary habitat.

iii) Avoid the construction of new roads, or increases in traffic volume on existing roads, between large (> 50 ha) blocks of habitat that are within 3-4 km of each other.

iv) If required, accommodate increased traffic volumes by upgrading existing roads, or rerouting traffic on existing roads away from koala habitat, rather than by building new roads within or near to patches of koala habitat.

Guideline 6.2

Minimise the risk of koala-vehicle collisions on roads.

Scale of application: whole landscapes or multiple landscapes within LGA.

Action

i) Existing roads in close proximity to koala habitat, or adjacent to blocks of koala habitat (especially blocks of habitat within 3-4 km apart) should be managed in such a way as to minimise the risk of koala-vehicle collisions. **Blackspot-analysis should be conducted to identify road segments/sections with high rates of koala mortality. Blackspots often equate to roads with high traffic volumes, high speed limits, and/or poor roadside visibility.** This will allow spatial-prioritisation of management actions to ensure infrastructure investment delivers 'maximum' benefits in reducing koala road mortality. Potential mitigation measures include low speed limits (e.g., 40-60 kph) and engineering designs to reduce traffic speed (traffic calming devices), warning signage, wildlife overpasses and underpasses, roadside lighting, clear road verges, and exclusion fencing (for some extreme risk situations).

The Science

The direct effect of roads on wildlife populations are wide ranging and include the destruction and modification of habitat, modification of animal behaviour, fragmentation of habitat by the formation of barriers and elevated mortality due to vehicle collisions. These effects can have substantial negative implications for wildlife populations. Increased mortality and habitat fragmentation imposed by roads is a serious concern for long-term koala survival. This is particularly the case in rapidly urbanising coastal areas of New South Wales and South East Queensland. In the Koala Coast area of South East Queensland, at least 250-300 koalas are known to be involved in vehicle collisions annually, of which ~ 80% do not survive. With an estimated population size of around 6,000 koalas in this region, this equates to a significant threat. Recent studies in Port Stephens and Noosa show that the presence of koalas is greatly reduced by high road densities, especially in areas within or adjacent to koala habitat. Attempts to reduce koala-vehicle collisions by measures such as reduced speed limits and underpasses have generally only shown limited success. Therefore, a combination of these measures together with careful design of road networks and traffic flow to minimise impacts on koalas is necessary. This should include careful consideration of placement of new roads, to avoid areas within or adjacent to koala habitat. Further, upgrading existing roads to carry greater traffic volumes or for improved safety is likely to be less detrimental to koala populations than building new roads, although the location of roads remains a crucial consideration (see Figure 10).

Not only do roads increase koala mortality rates, they also tend to form barriers to movement because either few koalas can successfully cross without suffering mortality, or because of physical barriers, such as fences or retaining walls. These effects reduce connectivity between patches and increase habitat fragmentation. On existing roads, with very high traffic volumes, and/or high traffic speeds, it may be appropriate to construct exclusion fencing in known black spot areas. This measure creates a physical barrier to movement, offset by the benefit of reducing direct mortality rates. However, this could potentially have the negative effect of isolating parts

of a population. The preferred approach should always be to avoid the construction of new roads that bisect koala habitat or that are located between blocks of habitat.

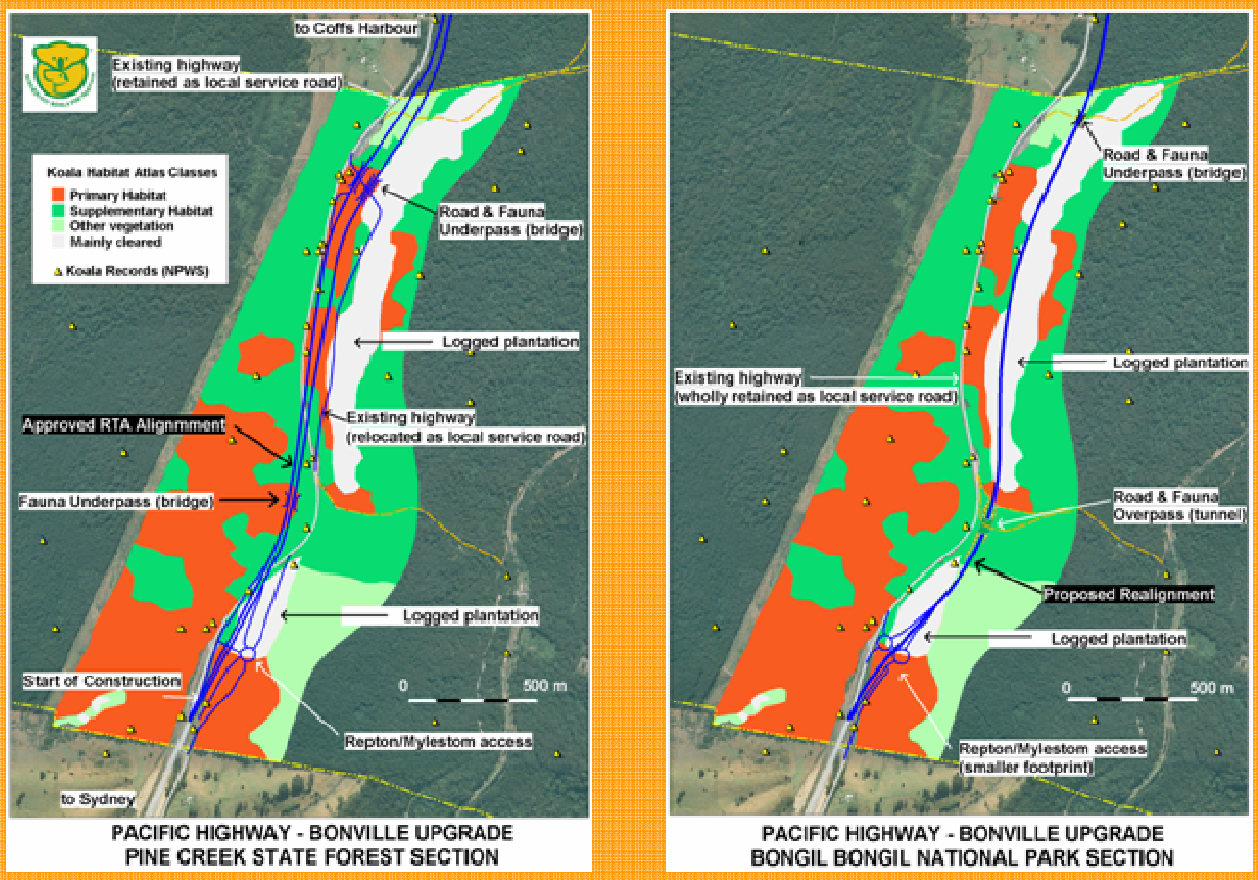


Figure 10: Alternative Pacific Highway alignment through Bongil Bongil National Park, south of Coffs Harbour. The NSW Road Transit Authority alignment (left-hand side picture) was approved prior to transfer of Pine Creek State Forest to National Park Estate, with two flooded gum (*E. grandis*) plantations logged pre-transfer. The alternative alignment avoids as much primary koala habitat as possible by utilising a route through the logged plantations. A smaller ecological "footprint" is achieved with smaller roundabouts at the southern end, a single north-south divided carriageway, retention of recently-upgraded existing highway, and by avoiding a deep gully on the western side of the existing Highway. Through adopting the alternative route, primary habitat loss is reduced from 15.2 ha to 2.5 ha, supplementary habitat from 12.5 ha to 2.5 ha. Maps compiled from Road Transit Authority, State Forests NSW and AKF data.

9. How to Minimise Predation by Dogs?

Planning Objective

To minimise predation on koalas by domestic and wild (feral) dogs.

Guideline 7.1

Minimise potential contact between domestic dogs and koalas. Whilst medium and large-sized dogs are of particular concern, even small dogs can be capable of inflicting serious or fatal injuries to koalas.

Scale of application: whole landscapes or multiple landscapes within LGA.

Actions

i) Identify areas where existing high dog ownership densities coincide with or are adjacent to koala habitat, or existing koala populations as priorities for measures such as those outlined below.

ii) Within koala habitat areas or adjacent neighbourhoods, implement measures to effectively reduce the incidence of roaming domestic dogs, especially at night. Areas where high dog ownership densities coincide with koala habitat should be a priority. Measures might include increased policing of dog control and registration requirements, education programs for dog owners, prohibiting dog ownership in new residential areas adjacent to koala habitat, impounding roaming dogs, requiring dogs to be kept within an enclosure or inside dwellings at night, provision of additional off-leash dog exercise areas away from koala habitat (see Part B: Site Level Planning).

Guideline 7.2

Minimise the size of populations of wild dogs within areas containing koala habitat.

Actions

i) Identify areas of koala habitat that contain wild (feral) dogs. This may be achieved through monitoring approaches, such as predator scat surveys and community sightings.

ii) Where wild dogs occur in koala habitat, implement appropriate feral animal management control measures.

The Science

Elevated mortality due to dog attacks is a key conservation concern for koalas, especially in the rapidly urbanising coastal areas of Queensland and New South Wales. Studies from areas with relatively high human populations report that dog attacks account for between 5% and 40% of total recorded mortalities. This can have significant negative consequences for the viability of koala populations near urban areas. **Elevated mortality rates in koalas due to dog attacks is a key contributor to the decline in koala populations**. Therefore, reducing dog attack mortality should be a key goal of planning to conserve koala populations. Dog attack mortality will particularly be a problem where high densities of dog ownership coincide with koala habitat and koala populations (see Figure 11). These areas should be identified and prioritised for implementation of measures to reduce dog attacks on koalas, especially for large and medium-sized dogs, but even small dogs can kill or seriously injure koalas (Figure 12). Although domestic dogs contribute significantly to dog attacks, in some areas wild dogs will also be a problem. In these cases it is important that appropriate pest animal control measures are also implemented.

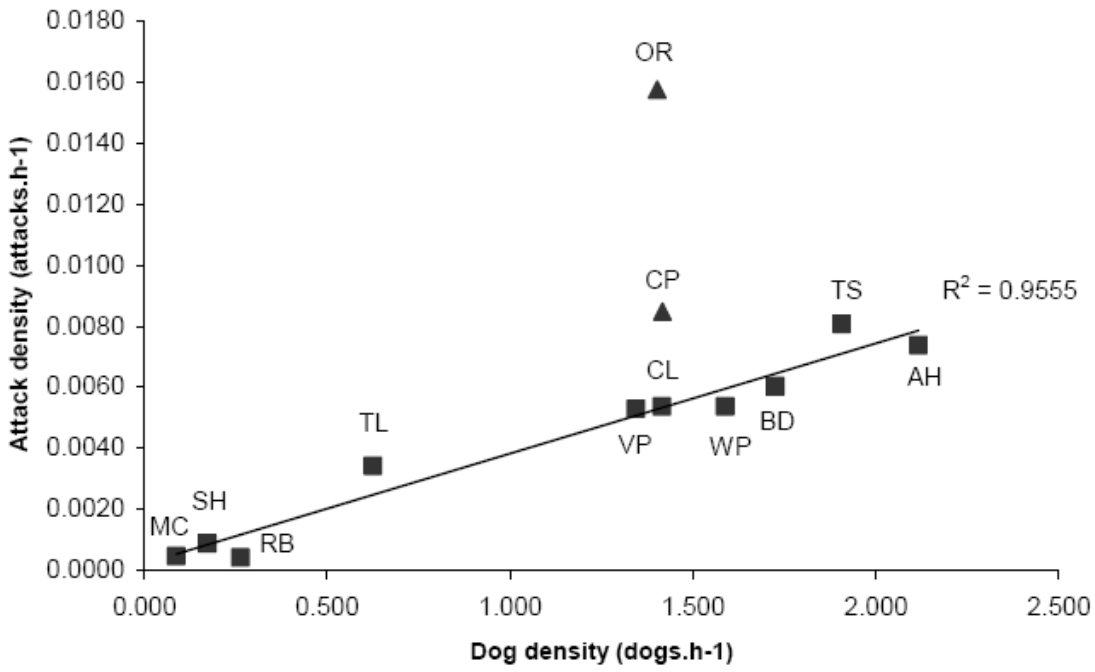


Figure 11: Koala mortality caused by dogs in south-east Queensland: domestic dog attacks in the Koala Coast: Source: Deidré L. de Villiers, Harriet J. Preece and David S. Dique. Queensland Environmental Protection Agency.

Figure 12: Even small to medium sized dogs can kill or seriously injure a koala, especially juveniles. (Photo: C Parkinson)

PART B - SITE-LEVEL PLANNING

The following site-level planning guidelines are aimed to inform local government planners and other consent authorities on measures to help protect koalas and koala habitat when assessing rezoning proposals and development applications. We recommend that, wherever possible, these measures should be incorporated into a regulatory framework such as a local environmental planning scheme in order to ensure consistent application.

10. Rezoning Proposals

Objective

To guide councils in assessing compatibility with koala conservation planning requirements when assessing rezoning proposals.

Scale of application: Site of proposed development and adjacent areas.

Guideline 8.1: Performance Standards for Rezoning Proposals

Consideration should be given to the following matters when assessing the appropriateness of rezoning requests (here rezoning refers to any amendments to a Local Environmental Plan or Planning Scheme), **other than** those that propose rezoning to an appropriate Environmental Protection Zone or a Conservation Area.

Actions

Prior to approving any rezoning proposal, it is recommended that the local government should be satisfied that possible future development or activity in accordance with the requested rezoning would:

i) not allow for an intensification of landuse or development within areas of Primary and Secondary (Class A) Koala Habitat or Habitat Buffers;

ii) allow for only *low impact development* (*i.e.* consistent with the following Performance Standards for Development Applications) within areas of Secondary (Class B) and Secondary (Class C) Koala Habitat or Habitat Linking Areas over existing native vegetation;

iii) be unlikely to result in the removal of any primary or secondary koala food trees, wherever they occur on the site;

iv) not result in development that would impede or stop koala movement across the site. This should include consideration of the need for maximising tree retention and for minimising the likelihood of impediments to safe/unrestricted koala movement. Potential impediments

include medium-high density residential and industrial development, roads and other urban infrastructure which create barriers to koala movement; and

v) be consistent with the above (Part A) Strategic Planning Guidelines.

The required information to support a rezoning request should include an investigation of the site by an appropriately qualified and experienced ecologist.

11. Planning and Development Applications

Objective

To guide councils in assessing compatibility with koala conservation planning requirements when assessing planning and development applications.

Guideline 9.1: Performance Standards for Planning and Development Applications

Specific aims of the performance standards are as follows:

i) To ensure that koala populations are sustainable over the long-term;

ii) To protect koala habitat areas from any development that would compromise habitat quality or integrity;

iii) To ensure that any development within or adjacent to koala habitat areas occurs in an environmentally sensitive manner;

iv) To ensure that acceptable levels of investigation are undertaken, considered and approved prior to any development within or adjacent to koala habitat;

v) To encourage koala habitat restoration;

vi) To maintain connectivity between areas of koala habitat and minimise threats to safe koala movement between such areas;

vii) To ensure that development does not further fragment habitat areas either through the removal of habitat or habitat linking areas or through the imposition of significant threats to koalas;

viii) To provide guidelines and standards to minimise impacts on koalas during and after development, in conjunction with any monitoring requirements; and

ix) To provide readily understandable advice for proponents preparing development applications.

Regulation of development via the assessment of Planning and Development Applications represents an important means by which koala habitat can be protected and effectively managed.

It is recommended that all Planning and Development Applications (including subdivision proposals) should demonstrate that they are consistent with the above aims and objectives.

Scale of application: Site of proposed development and adjacent areas.

Actions

The following standards are recommended for all developments proposed on sites that contain or are adjacent to primary or secondary koala habitat, habitat buffers or habitat linking areas. For the purposes of these standards, native vegetation is defined as any of the following types of indigenous vegetation: trees (including saplings and shrubs), understorey plants, groundcover or plants occurring in a wetland.

A proposed *use, development* or *activity* (including subdivision proposals) should:

a) Not result in the removal or degradation of native vegetation within primary or secondary (class A) koala habitat;

b) Maximise retention and minimise degradation of native vegetation within secondary (class B) and secondary (class C) koala habitat, habitat buffers and habitat linking areas;

   i. Development assessments to be accompanied by a recent air photograph (1:2500 or larger) with an overlay to show impacts on trees.

   ii. Inspection by suitably qualified ecologist immediately prior to any tree removal activities.

c) Not result in the removal of any primary or secondary koala food trees, wherever they occur on a development site.

   i. Locations of all these trees to be accurately surveyed and mapped and submitted with development assessment.

   ii. All these trees to be fenced or clearly flagged prior to commencement of any construction activity.

d) Allow for **a minimum buffer width of 50m** to be applied to areas of preferred koala habitat; larger where adjoining future development is likely to pose significant threats to koalas such as high density residential development where domestic dog ownership is allowed or where traffic speeds in excess of 40km/hr are permitted.

e) Streetscape and landscape plantings to include at least one preferred koala food tree for every residential allotment (with species and locations for plantings nominated by a suitably qualified ecologist for inclusion in a *Statement of Landscape Intent* to accompany each planning and development application).

f) Make provision, where appropriate, for restoration of protected primary and secondary koala habitat areas including habitat buffers and habitat linking areas. In instances where Council approves the removal of koala habitat (in accordance with the ***Waive Provisions*** below), and where circumstances permit, this should include measures that result in a *net gain* of koala habitat on the site and/or adjacent land.

g) Ensure preparation of a Habitat Rehabilitation and Restoration Plan for the site and wherever feasible, ensure plantings under the Plan are propagated from locally collected seed.

h) Any necessary Bushfire Asset Protection Zones or Fire Protection Overlay should be located within the developable lands and not within adjoining habitat protection or restoration areas.

i) Make provision for long-term management and protection of koala habitat, including both existing and restored habitat. For example, it may be possible to apply a "Special Rate" to generate funding for allocation by a Management Committee.

j) Not compromise the potential for safe movement of koalas across the site. This should include maximising tree retention and restoration and minimising the likelihood that the proposal would result in the creation of barriers to koala movement, such as would be imposed by certain types of fencing. The preferred option for a development within or adjacent to primary or secondary koala habitat, habitat buffers or habitat linking areas that would minimise restrictions to safe koala movement would be:

- ❖ No fencing within the site; or
- ❖ Fencing of a sort that would not preclude koalas, and
- ❖ Prohibition on dog ownership.

Suitable fencing within these areas could include:

i. fences where the bottom of the fence is a minimum of 300 mm above ground level to allow koalas to move underneath;

ii. fences that facilitate easy climbing by koalas; for example, sturdy chain mesh fences, or solid style fences with timber posts on both sides at regular intervals of approximately 20 m; or

iii. open post and rail or post and wire (preferably not barbed wire).

iv. *where keeping of domestic dogs is permitted* within or adjacent to Primary or Secondary Koala Habitat, Habitat Buffers or Habitat Linking Areas, fencing of a type that would effectively contain dogs (and which would ideally also preclude koalas) should be restricted to the designated building envelope. Fences that are intended to preclude koalas should be located away from any trees that could allow koalas to cross the fence.

j) Be restricted to identified 'building envelopes' that contain all buildings and infrastructure. In general, there should be no clearing outside these envelopes, other than that which may be required for bushfire asset protection. In the case of applications for subdivision, such envelopes should be registered as a restriction on the title; and

k) Include measures to effectively minimise the threat posed to koalas by dogs, motor vehicles and swimming pools by adopting the following minimum standards:

i. The development should include measures to effectively abate the threat posed to koalas by dogs through restrictions or prohibitions on dog ownership. Restrictions on title may be appropriate;

ii. The development should include measures to effectively minimise the threat posed to koalas from traffic by restricting motor vehicle speeds where appropriate to 40 kph or less; and

iii. Appropriate measures for swimming pools could include: trailing a length of floating stout rope (minimum diameter of 50mm) secured to a stable poolside fixture, in the swimming pool at all times; designing the pool in such a way that koalas can readily escape (e.g. with a shallow ramp area); or enclosing the pool with a fence that precludes koalas. This last option should include locating the fence away from any trees that koalas could use to cross the fence.

l) Ensure that adequate space is allowed surrounding individual protected preferred koala food trees so that they will not pose a future hazard to persons or property.

m) Ensure that any essential removal of koala habitat and other native vegetation is adequately offset by measures such as by securing the protection of equivalent habitat off-site or by compensatory habitat restoration programs. These measures should be incorporated into an overall conservation offsets package as part of conditions of approval issued by the consent authority.

n) Be consistent with the above (Part A) Strategic Planning Guidelines.

Waive Provisions

The following waive provisions have been designed in order to allow for the construction of a dwelling and associated access on bush-covered blocks (where there is no alternative but to remove some native vegetation), so as to identify the location likely to cause least impacts on koalas and koala habitat. This provision is not intended for the purpose of allowing for subdivisions.

On this basis, the provisions of a), b) and c) above could be waived for the purposes of establishing a building envelope and associated works, where the proponent demonstrates that:

a) The building envelope and associated works **cannot** be located so as to avoid the removal of native vegetation within Primary or Secondary Koala Habitat, Habitat Buffers, or Habitat Linking Areas, or the removal of preferred koala food trees;

b) The location of the building envelope and associated works **minimises** the need to remove native vegetation as per l) above;

c) The most suitable location for building envelopes and associated works should be assessed by a suitably qualified independent ecologist with experience in koala surveys. A standard, reportable survey technique that allows koala habitat utilisation to be quantified, such as the faecal pellet-based 'Spot Assessment Technique' should be employed to identify the extent of any Koala Activity Levels across the site. When using the Spot Assessment Technique for this purpose, the recommended density of spot assessment survey sites is 1 site per 100m X 100m (10,000m^2) over land that contains native trees within the areas where building envelopes and associated works could potentially be located. Survey sites should be located systematically using a grid approach, with precise locations for sites within grid cells selected to ensure maximum sampling of preferred koala food trees.

d) Wherever possible, building envelopes and associated works should be positioned away from areas that return evidence of Koala Activity or suspected home-range trees. Where this is not possible, building envelopes and associated works should be positioned in areas that return lowest Koala Activity Levels; and

Figure 13. A combination of measures together with careful design of road networks and traffic flow is necessary to minimise impacts of vehicle collisions on koalas. (Photo: Koala Beach Estate, Tweed Shire on the north coast of NSW - Australian Koala Foundation)

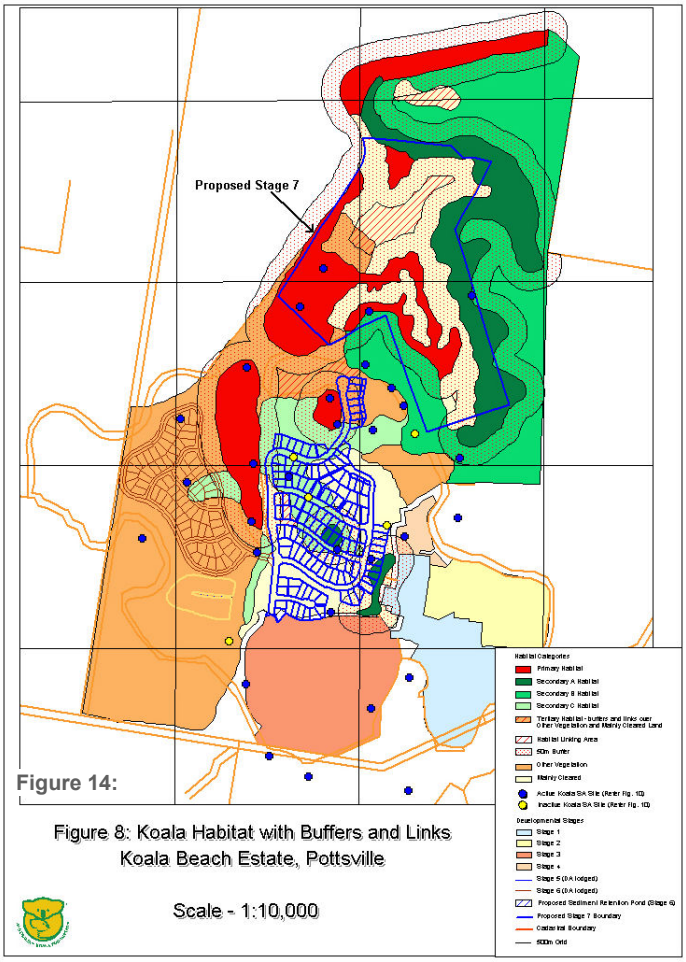
Background and Examples

The above standards for assessing Planning and Development Applications in koala areas have been modelled on provisions applied as conditions of development consent for the Koala Beach Estate at Pottsville in Tweed Shire on the far north coast of New South Wales, and incorporated into the Port Stephens (CKPoM) Comprehensive Koala Plan of Management, the draft Greater Taree City Council CKPoM and the draft Campbelltown City Council CKPoM.

The Koala Beach Estate totals 365 ha with residential development on approximately 90 ha over seven stages. It was agreed that the undeveloped sections of the site would be handed over to Tweed Shire Council for Environmental Protection zoning. The koala conservation measures that were built into the Koala Beach development were set out in a (KPoM) Koala Plan of Management, updated by the Australian Koala Foundation in 2004 (See Figure 14). The KPoM was approved and adopted under NSW *State Environmental Planning Policy No. 44-Koala Habitat Protection* (SEPP 44), providing a legislative framework for measures such as koala habitat protection and restoration, population monitoring, resident education and involvement in ongoing management. A "Special Rate" or Environmental Levy applies to all residents of the Estate to fund ongoing environmental management, habitat restoration, and implementation of threatened species management and monitoring programs. A Wildlife and Habitat Management Committee was established as a provision of the KPoM, chaired by Tweed Shire Council with representatives from the residents, the Australian Koala Foundation, the local koala carer group, and the NSW Department of Environment and Conservation. Some of the key provisions of the KPoM include:

- Protection of preferred koala food trees by Covenant on title;
- Maximised protection of other native vegetation;
- Developers required to prepare a Habitat Restoration Plan for all protected areas;
- Landscape plantings to include at least one preferred koala food tree for every allotment;
- Prohibited domestic dog and cat ownership by Covenant;
- Restriction of traffic speed to 40 km/hr throughout the Estate;
- Traffic speed mitigation measures including speed humps with koala crossing signs;
- Minimum ground clearance of 300mm for any necessary fencing (except around pools);
- Stout rope (minimum 50mm diameter) to be installed in all swimming pools;
- Preparation of a koala monitoring program; and
- Review of the KPoM each five years.

Monitoring surveys aimed to detect population trends at the Koala Beach Estate using the Spot Assessment Technique, since the development of Stages 1 and 2, have not as yet detected any significant changes in overall habitat utilisation. There are some indications that the koala population at the site may have declined marginally from ~ 30-40 individuals estimated during baseline studies. However, the results of other surveys and examination of koala records suggest that this may be indicative of a broader koala population decline within the Tweed coastal zone. Pressures on the Koala Beach koala population will increase to some extent as the Estate becomes fully occupied over the next few years, although streetscape plantings and habitat restoration works should contribute positively. Monitoring over the course of a further 10 years or more may be necessary before any conclusive trends in the population become apparent. However, at this stage the provisions implemented at the Koala Beach Estate appear to be successful in allowing for the continuation of a breeding population of koalas at the site, which is encouraging for the potential broader adoption of such measures as a minimum standard for other developments. It is clear that such measures should be supported by corresponding landscape-scale planning standards in order to provide realistic chances of success over the long-term.



PART C - MONITORING KOALA POPULATION TRENDS

Planning Objective

To develop monitoring protocols to inform future planning strategies for conserving koala populations and their habitat.

Guideline 10.1

Develop and implement monitoring programs capable of detecting changes in koala populations over time (e.g., changes in population size and distribution within whole landscapes, patches or sites).

Scale of application: Multiple landscapes within LGA.

Actions

i) Undertake koala faecal pellet surveys at fixed monitoring stations at regular intervals (e.g., every year for patch or site scale surveys and every five years for landscape to local government scale surveys) using the AKF faecal pellet survey methodologies (Spots). The number of monitoring stations required will depend on the specific survey objectives and the level of statistical confidence required. However, for landscape-scale monitoring at least 50 stations are likely to be required to detect even quite large changes in the abundance of koalas. Ideally, a statistical power analysis should be conducted to determine sample size requirements prior to commencement of the monitoring program. Studies have also show that it may be best to concentrate these survey stations in high to medium quality habitat (e.g., primary and secondary habitat classes) rather than in low quality habitat.

ii) Undertake line or strip transect koala surveys at fixed monitoring stations at regular intervals (e.g., yearly to five yearly for site scale surveys and five yearly to ten yearly for landscape to local government scale surveys). Given that transect surveys tend to be much more costly and time consuming to complete than faecal pellet surveys they are likely to be most useful for monitoring population trends at specifically selected sites, rather than across whole landscapes. Once again, a statistical power analysis should be conducted to determine sample size requirements prior to commencement of the monitoring program. The aim of the transect surveys is to complement the faecal pellet surveys, rather than being an alternative.

iii) Maintain a koala sightings records database through regular (e.g., five yearly) community surveys.

iv) Regularly report monitoring outcomes in the scientific/planning literature, to the planning authorities and the local community.

Guideline 10.2

Develop and implement monitoring programs capable of detecting changes in koala habitat quality and extent over time.

Scale of application: Multiple landscapes within LGA.

Actions

i) Where possible, obtain the latest available satellite imagery at two to four-year intervals to identify changes in the extent of koala habitat resulting from incremental habitat loss, degradation or fragmentation and over the longer term, with ongoing habitat restoration.

ii) Maintain a detailed register of incremental habitat loss and ongoing habitat restoration.

iii) Regularly report monitoring outcomes in the scientific/planning literature, to the planning authorities and the local community.

Guideline 10.3

Develop and implement monitoring programs capable of detecting changes in koala mortality threats over time.

Scale of application: Multiple landscapes within LGA.

Actions

i) Maintain a record of changes to road networks and traffic volumes in areas containing koala habitat.

ii) Maintain a record of dog ownership in areas containing koala habitat.

iii) Maintain a record of dog attacks and traffic collisions with koalas.

iv) Regularly (e.g., five yearly) conduct surveys of feral dog populations in areas containing animal populations (e.g., using faecal pellet surveys).

iv) Regularly report monitoring outcomes in the scientific/planning literature, to the planning authorities and the local community.

Overview

Well designed monitoring programs can provide planners, researchers and the community with ongoing information concerning the size, distribution and health of local koala populations, changes in koala habitat, changes in other threats and feedback on the effectiveness of management strategies and actions.

A number of performance indicators would need to be identified to provide a means to determine the level to which the key outcomes have been achieved and to quantify the success or failure of implemented measures. Monitoring programs should also specify a procedure to be followed in the event that performance indicators are not met. Management strategies and actions should be

regularly reviewed and amended where necessary to reflect findings of the ongoing monitoring program. A funding proposal for ongoing monitoring should also be outlined.

The status of koala populations should be assessed on the basis of estimated koala numbers, evidence of breeding activity, signs of disease, records of mortality, and local distribution. The monitoring program should seek to record changes in the amount and quality of available koala habitat, as well as changes in habitat utilisation. The impact of threatening processes should also be monitored to determine the level of success or failure of measures designed to minimise threats. The relative significance of each threatening process should be regularly assessed to ensure resources are continually focused on the highest priorities.

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APPENDIX 1

Summary of primary, secondary and supplementary tree species for each study area, as identified by the Australian Koala Foundation.(*based on taxonomic affiliation and evidence from other areas)

Noosa

Preference Category	Species name	Common name
Primary	*E. microcorys*	Tallowwood
Primary	*E. robusta*	Swamp Mahogany
Primary	*E. robusta x E. tereticornis*	Hybrid
Primary	*E. tereticornis*	Forest Red Gum
Primary	*E. bancroftii*	Bancroft's Red Gum*
Secondary	*E. propinqua*	Small-fruited Grey Gum
Secondary	*E. racemosa*	Scribbly Gum
Secondary	*E. resinifera*	Red Mahogany
Secondary	*E. siderophloia*	Grey Ironbark
Supplementary	*E. acmenoides*	White Mahogany
Supplementary	*E. grandis*	Flooded Gum

Port Stephens

Primary	*E. parramattensis*	Parramatta Red Gum
Primary	*E. robusta*	Swamp Mahogany
Primary	*E. robusta x E. tereticornis*	Hybrid
Primary	*E. tereticornis*	Forest Red Gum
Primary	*E. microcorys*	Tallowwood*
Secondary	*E. canaliculata*	Large-fruited Grey Gum
Secondary	*E. mollucana*	Gum-topped Box
Secondary	*E. propinqua*	Small-fruited Grey Gum
Secondary	*E. resinifera*	Red Mahogany
Supplementary	*E. agglomerata*	Blue-leaved Stringybark
Supplementary	*E. capitellata*	Brown Stringybark
Supplementary	*E. eugenioides*	Thin-leaved Stringybark
Supplementary	*E. globoidea*	White Stringybark
Supplementary	*E. piperita*	Sydney Peppermint

Ballarat

Primary	*E. viminalis viminalis*	Manna Gum
Primary	*E. camaldulensis*	River Red Gum*
Primary	*E. globulus globulus*	Tasmanian Blue Gum*
Secondary	*E. viminalis cygnetensis*	Rough-barked Manna Gum
Secondary	*E. obliqua*	Messmate
Secondary	*E. baxteri*	Brown Stringybark
Secondary	*E. melliodora*	Yellow Box
Supplementary	*E. aromaphloia*	Scent Gum
Supplementary	*E. dives*	Broad-leaved Peppermint
Supplementary	*E. ovata*	Swamp Gum
Supplementary	*E. radiata*	Narrow-leaved Peppermint
Supplementary	*E. rubida*	Candlebark