



DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

# Koala habitat revegetation guidelines

A practical guide to identify, connect and revegetate koala  
habitat in New South Wales



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Cover photo: Regenerating koala habitat along Byron Creek in Binna Burra, New South Wales. This community event was hosted by Bangalow Koalas and involved 180 volunteers who planted 2600 koala and rainforest trees. (Property Shot Photography)

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# 1. Introduction

The koala has suffered a dramatic decline in numbers and distribution since the arrival of Europeans in Australia. Most koala populations in New South Wales (NSW) now survive in increasingly degraded and isolated patches of habitat, which are subject to intense and ongoing pressures (Office of Environment and Heritage (OEH) 2018a).

In NSW, the koala is listed as vulnerable under the *Biodiversity Conservation Act 2016*. Koala populations in Hawks Nest/Tea Gardens, Pittwater, and between the Tweed River and Brunswick River east of the Pacific Highway face a higher risk of extinction and are listed as endangered. In 2012, the koala was also listed as vulnerable in Queensland, NSW and the Australian Capital Territory under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999*.

The NSW Koala Strategy 2018 (OEH 2018b) highlights the need to support local communities to deliver on-ground actions that reduce threats to and protect koala populations.

Threats to koalas include:

- loss, modification and fragmentation of habitat
- diseases such as retrovirus (immune deficiency syndrome) and chlamydia (can cause blindness, infertility, severe infection and death)
- vehicle strike
- predation by dogs
- heat stress due to drought and heatwaves
- intense bushfires that scorch or burn the tree canopy
- increased competition for food and territory
- human-induced climate change (OEH 2019).

This management guide provides evidence-based recommendations to help land managers, community groups and private landholders identify, connect and revegetate koala habitat using best-practice methods.

## 2. Koala management areas



**Figure 1** Koala management areas (KMAs) in New South Wales. Image: DPIE

There are seven koala management areas (KMAs) in New South Wales (NSW; Figure 1). KMAs were developed to broadly reflect the regional distribution of preferred koala use trees across NSW. They provide a basis for collecting information about koala tree use and facilitate koala conservation work such as monitoring, recovery, planning and assessment.

KMAs are based on:

- landscape characteristics, particularly the geographic distribution of tree species koalas prefer to eat
- local government area boundaries for ease of natural resource management (Department of Environment and Climate Change 2008).

Habitat characteristics and threats are relatively consistent within each KMA, although local variations occur. The most up to date information about the regional distribution of koala use trees across NSW is contained in the [Koala Habitat Information Base Technical Guide](#). Developed in consultation with koala experts, the technical guide includes nine koala tree use lists that reflect the latest data on which trees koalas prefer in different areas.

### 3. Koala habitat

Koalas live in eucalypt-dominated woodland and forests. These include:

- coastal forests
- woodlands of the tablelands
- woodlands of the western slopes
- riparian vegetation of the western plains.

Koalas also live in isolated paddock trees, trees planted as windbreaks and along fence lines.

#### 3.1 Habitat requirements

Koalas feed primarily, but not exclusively, on eucalypt leaves. In 2018, the former Office of Environment and Heritage (OEH) identified 137 koala tree species in A review of koala tree use across New South Wales (OEH 2018a). In 2019, consultation with koala experts led to the list being refined to 123 species in the Koala Habitat Information Base Technical Guide. However, their diets are quite specialised, and an individual koala will get most of its nutrition from one or a few species at a single site (Figure 2).

Food preferences can vary between regions and seasons. The palatability of individual trees within a single species may be influenced by soil properties (e.g. nutrients, salinity, clay/loam/sand), water availability (affecting leaf moisture), tree stress (disease, temperature) and/or tree genetics (OEH 2018a). There is still much to learn about what influences the nutritional quality of leaves koalas eat. Nutritional quality can vary within and between tree species, as well as from one area to the next.



**Figure 2** Ribbon gum (*Eucalyptus viminalis*), a preferred koala tree species. Photo: Nicki Taws/Greening Australia.



Our KMA revegetation fact sheets list tree species koalas are known to use in each KMA.

- KMA 1: [North Coast Koala Management Area fact sheet](#)
- KMA 2: [Central Coast Koala Management Area fact sheet](#)
- KMA 3: [South Coast Koala Management Area fact sheet](#)
- KMA 4: [Northern Tablelands Koala Management Area fact sheet](#)
- KMA 5: [Central and Southern Tablelands Koala Management Area fact sheet](#)
- KMA 6: [Western Slopes and Plains Koala Management Area fact sheet](#)
- KMA 7: [Far West and South-west Koala Management Area fact sheet](#).

The revegetation fact sheets incorporate the tree use lists included in the [Koala Habitat Information Base Technical Guide](#).

Koalas can live sustainably in areas where:

- annual rainfall is above 500 millimetres per year (except the Murray and Darling rivers)
- maximum daily temperatures do not exceed 40°C for more than a few days (causing koala stress and mortality)
- altitude is less than 1200 metres above sea level (Australian Koala Foundation 2019).

Koalas prefer areas that have:

- at least 30% of total canopy trees that are preferred food trees (McAlpine et al. 2007)
- non-eucalypt trees and shrubs for shelter and other behavioural purposes; plants with dense foliage help koalas stay cool in summer (Mitchell 2015)
- young and old food trees, with most trees having a diameter at breast height between 26 and 80 centimetres (Department of Environment and Climate Change 2008); koalas prefer resting in larger trees, but will eat foliage from young trees
- water nearby (Smith et al. 2013) to provide trees with higher leaf moisture and water to drink
- a minimum habitat patch size of 2 hectares, although larger than 50–100 hectares is preferable to support a sustainable population (McAlpine et al. 2007); these values can vary greatly depending on the quality of the habitat and the region. In some areas (such as Canyonleigh in the Southern Highlands), minimum patch sizes are 100 hectares
- good connectivity to other habitat patches, however this is not always necessary as koalas can cover distances of several kilometres across open ground
- quality habitat adjacent to preferred feed tree patches that includes rainforest, non-eucalypt swamp forests, wetlands, heathlands, grasslands, open paddocks and cropland without scattered eucalypts to provide for movement and connectivity across the landscape, places of refuge in time of heatwave and fire, and in some cases non-eucalypt food (OEH 2018a).

## 3.2 How to identify active and potential habitat

It is important to understand the habitat preferences and distribution of a local koala population.

In 2019 the NSW Government released the [Koala Habitat Information Base](#) to support decision-making about koala conservation. The database captures information about the distribution of koala populations, where koala preferred trees are located, and koala sightings in NSW. This includes spatial layers such as the Koala Habitat Suitability Model (Figure 3), which measures the probability of finding koala habitat at a location, and the Koala Likelihood Map, which predicts the likelihood of finding a koala at a location.

Active and potential koala habitat can be identified by:

- the presence of preferred koala tree species, as listed in our KMA fact sheets (see section 3.1)
- historical or recent koala records, for example [NSW BioNet](#)
- the presence of koalas in trees
- the presence of koala faecal pellets (scats) under trees
- the presence of koala scratches on trees; scratches made by possums and goannas are similar to those made by koalas and scratches alone should not be considered a definitive indication of koalas.

More information on monitoring techniques for koala presence and activity is provided in section 6.

## 4. Considerations when revegetating koala habitat

### 4.1 Aims of habitat revegetation

Koala habitat revegetation aims to reduce threats to koalas, increase available habitat and help to conserve populations.

Revegetation will be easier, cheaper and quicker where impacts on habitat have been low. Therefore, the first principle in revegetation is to protect existing habitat, even if it is individual mature trees. Revegetation, in order of increasing effort, could then include:

- protection of existing koala habitat
- expansion of existing patches of koala habitat through natural regeneration and/or tree planting
- improvement of degraded koala habitat, including increasing the number of preferred trees within and adjacent to habitat areas
- increasing habitat connectivity by establishing vegetated corridors and 'stepping-stone' habitat patches
- revegetation of cleared areas to create new habitat patches.

Different areas in the landscape will require different revegetation approaches based on threats that are present. Where possible it is best to work outwards from existing habitat. Connectivity is also important because an isolated koala population that is unable to disperse and breed with other populations is at risk of loss of genetic diversity and this can lead to lower resilience (Sherwin et al. 2000).

For more information about habitat restoration, including details about restoration of compositional, structural and functional ecosystem attributes, see the Standards for the Practice of Ecological Restoration in Australia (Society for Ecological Restoration Australasia (SERA) 2017).

### 4.2 Priority areas

Priority areas for koala habitat revegetation should be identified based on the:

- aim of revegetation works (see section 4.1)
- presence of nearby remnant native vegetation
- shape of existing habitat patches
- quality of existing koala habitat
- appropriate soil type for growing local preferred koala use trees
- presence of nearby bodies of water (especially relevant in during dry periods and heatwaves)
- size of koala populations, or presence of extant populations in the area
- existence of threats to koalas
- effort required for revegetation and maintenance
- current land tenure and land-use zoning.

## 4.3 How much habitat do koalas need?

To maintain a viable koala population, at least 40–60% of the landscape should be native forest or woodland for a 1-kilometre radius around where koalas occur, preferably dominated by high- and frequent-use koala habitat trees (McAlpine et al. 2007). Koala populations occur in areas with less vegetation, such as the Liverpool Plains around Gunnedah. However, these populations are subject to greater impacts from a range of threats including exposure to heat and drought, dog attack and vehicle strike. Access to sufficient food and water may also be restricted where there is less vegetation.

### 4.3.1 Patch size

Ideally, patches of habitat should be 50–100 hectares or more in size. If a habitat patch is smaller than this, but well-connected to other patches (less than 100 metres apart) then the total area of the connected patches should be larger than 100 hectares (McAlpine et al. 2007).

Note that minimum patch sizes and home ranges depend on habitat quality and fragmentation, and the species of trees present. It is important to understand your local koala population and home ranges. Koala tracking studies in your area can help with this (e.g. Goldingay & Dobner 2014).

### 4.3.2 Patch shape

Habitat patches should be large enough to reduce edge effects that can lead to increased predation, influx of weeds into planting sites and heat stress. Koala home ranges tend to be rounded (Crowther, pers comm), allowing them to travel quickly between favourite trees. Koalas will also use wide corridors or patches that are square.

### 4.3.3 Connecting habitat patches

Increasing connectivity between existing koala habitat is essential. This can be done with corridors of vegetation, preferably corridors at least 20 metres wide. Any increase in connectivity is valuable.

Narrow tree lines also have a place in habitat revegetation. Tree lines can connect larger patches. When planted along waterways provide valuable koala habitat (see section 4.5).

Koalas can easily move 100–200 metres between patches provided there are no barriers (e.g. roads, fences, buildings, water bodies, other structures) or threats (e.g. predators). On floodplains in northern NSW, female koalas have been known to travel more than 500 metres between koala food trees, across cleared grazing paddocks. Some tracked koalas have walked several kilometres cross-country (Lunney et al. 2012a). Although covering these distances is possible, they come at the cost of energy and risk to the koala. Any reduction in distance between habitat patches provided by corridors or small stepping-stone patches can help koalas move more safely through the landscape.

## 4.4 How to minimise threats

Most koala populations live in fragmented habitat and many of these areas are subjected to ongoing pressures. Loss, modification and fragmentation of habitat, vehicle strike and predation by domestic dogs are some of the major threats koalas currently face.



#### 4.4.1 Road networks and fences

Koala death from vehicle strike is a significant contributor to koala population decline in certain areas of NSW. Roads also create barriers to movement and contribute to fragmentation of habitat.

Avoid planting near main roads when restoring habitat (Lunney et al. 2012b). When constructing new roads or obstacles, avoid putting them within and between koala habitat patches.

Fences can also create barriers to koala movement. Avoid planting feed trees around fences.

#### 4.4.2 Predation by dogs

Landowners should be aware of the risk dogs pose to koalas. Don't plant koala feed trees near houses where koalas would be at higher risk of predation. Dogs should be kept on leads where possible and be restrained at night. See our publication [Protecting wildlife from domestic dogs](#) for more information.

### 4.5 Climate change impacts

Climate change is likely to be a significant stressor to koalas and their habitat. As the climate becomes hotter, drier, and more variable, significant impacts may occur. Some of the likely impacts are listed in this section, along with recommended habitat revegetation actions that may reduce those impacts.

**Impact:** Extreme heat events are likely to be more common with climate change and may cause heat stress and even koala death (Lemon et al. 2012).

**Response:** Ensure revegetation includes dense shade tree species, for example *Acacia* species, turpentine (*Syncarpia glomulifera*), and kurrajong (*Brachychiton populneus*). Prioritise larger block plantings as these will be cooler on hot days than small-area plantings. Consider local microclimates, such as revegetating south-facing slopes and gullies, which remain cooler on hot days.

**Impact:** Changes to plant community structures are likely, including increased incidence of dieback.

**Response:** In addition to planting trees of local provenance, consider using local trees of varied provenances (Prober et al. 2015). For example, use species from drier/hotter regions further north or west and try planting non-local native species. Use tools like the [NSW Flora: Ecological Niche Finder](#) or the Australian Network for Plant Conservation's [Climate-ready revegetation](#) to carefully inform your decisions. Trees from seeds with non-local provenance may become invasive or not survive. However, having a diverse mix of species and/or provenances may increase the likelihood that some will be palatable to koalas as well as survive in future climate conditions.

**Impact:** Extreme heat events will likely cause vegetation stress, potentially resulting in higher leaf toxicity and lower palatability for koalas.

**Response:** Consider using a diversity of local species to increase the likelihood that some will survive future climate conditions and be palatable to koalas.

**Impact:** Eucalyptus leaf nutrition is likely to change with increased carbon dioxide in the atmosphere (Lunney et al. 2012a).

**Response:** Research is ongoing in this area. Currently there is no single solution to this issue. However, preferred koala food trees tend to be higher in digestible nitrogen, so planting more of these preferred species should result in more palatable trees.

**Impact:** In high rainfall regions, rainforest pioneer invasion of koala habitat is accelerated by increased atmospheric CO<sub>2</sub> (Bowman et al. 2010) and may potentially suppress feed tree recruitment (Ashton and Chinner 1999) or cause premature feed tree dieback (Harvest et al. 2008; Horton et al. 2013; Stone et al. 2008).

**Response:** Avoid using rainforest trees in koala habitat plantings and ensure appropriate fire regimes in koala habitat areas.

**Impact:** Drier conditions: Koalas seldom drink water because they get enough water from eating leaves. However, the presence of available water in koala habitat is becoming increasingly important, especially during dry periods and heatwaves.

**Response:** Plant or revegetate on soils with greater moisture availability (valleys, riparian areas), especially in more arid regions, and plant near bodies of free water.

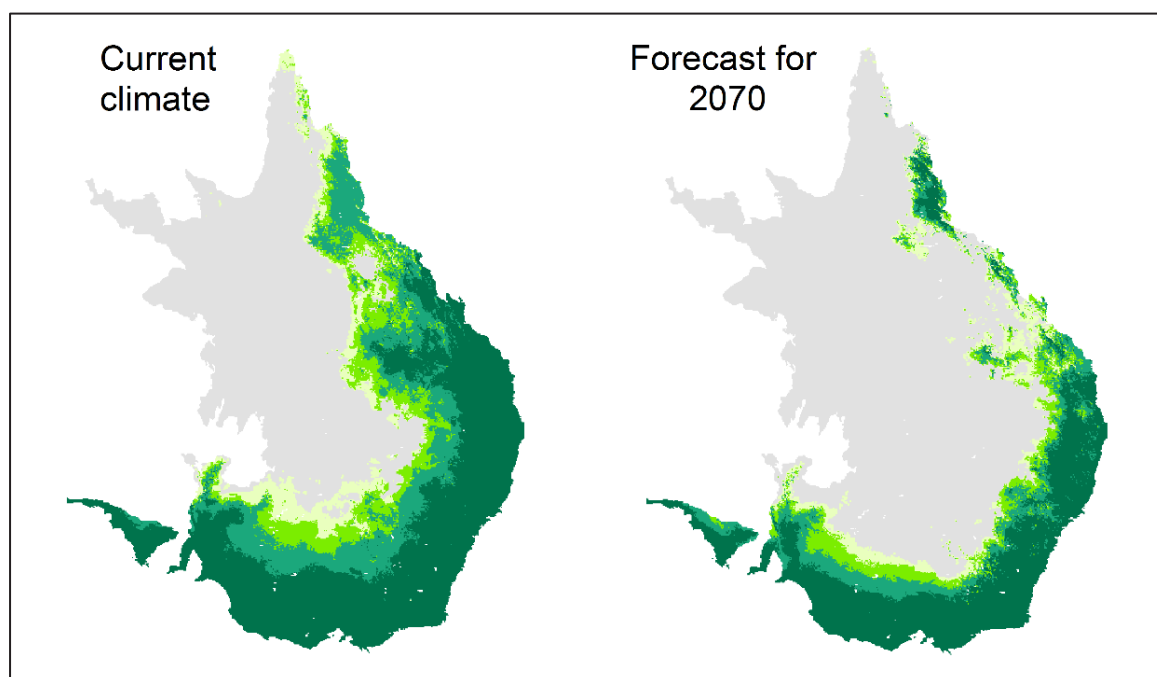
**Impact:** Lower survival rates of plantings may occur due to drought and temperature extremes.

**Response:** Good site preparation and follow-up maintenance of plantings are critical to their long-term viability. Some sites may require several years of watering and weed management.

**Impact:** Sea level rise may reduce available koala habitat in coastal areas.

**Response:** Consider planting on slightly higher ground. Identify priority revegetation areas to support landward migration of koala habitat on floodplains.

For more information on climate change and revegetation refer to Hancock et al. (2018) and Prober et al. (2015).



**Figure 3** Predicted potential distribution of koala habitat under the current and 2070 climate predicted by Niche Mapper, based on energy and water requirements. This and other models in Briscoe et al. 2016 predicted a substantial decline in suitable koala habitat in central and northern inland regions by 2070. Dark green indicates highly suitable, lighter greens less suitable, and white/grey unsuitable habitats for koalas. Source: Briscoe et al. 2016

### 4.5.1 Fire management

Fire is a natural and important ecological process in koala habitat. It is essential for maintaining forest health and the regeneration of koala feed trees.

Inappropriate fire regimes can be catastrophic for koalas and their habitat, especially high intensity wildfires or the long-term exclusion of fire. Carefully applied planned burns can help to address these issues by reducing wildfire hazard and restoring appropriate fire frequency.

High-intensity fires that burn the tree canopy can be fatal. Koalas can die directly through burns and smoke inhalation, or indirectly through starvation from temporary loss of food, dehydration, disorientation, or joey separation from mother.

Koalas can also be injured from falls or jumping from burning trees. Koalas that manage to escape a fire are likely to return to their original home range once trees start to regenerate.

In many high rainfall regions, there are areas of koala habitat that are long-unburnt and beyond recommended thresholds for biodiversity conservation. The long-term absence of fire can cause the decline of koala feed tree health through altered soil chemistry and ectomycorrhizal communities and can prevent feed tree recruitment, which is dependent on periodic fire to expose bare soil to sunlight. Feed tree health and recruitment can be further compromised by invading rainforest species that form a dense midstorey in the absence of fire.

When undertaking planned burns in koala habitat for hazard reduction or ecological restoration, use low intensity burns that avoid scorching the canopy to minimise impacts on koalas. Manual (e.g. raking) or mechanical (e.g. slashing) methods can be used in some situations to reduce fuel loads. Some areas have detailed koala fire management guidelines, for example [Tweed Shire Council](#).

Ideally, areas with extensive koala habitat revegetation should be identified in bushfire asset registers and recognised in fire management plans.

## 4.6 Spatial data and mapping

Spatial prioritisation and predictive modelling are powerful tools that inform where to revegetate koala habitat (Adams–Hosking et al. 2011). This can be time-consuming and costly, and relies on a very good understanding of local koala ecology, habitat mapping and threats.

Under the NSW Koala Strategy, the NSW Government funded a statewide [Koala Habitat Information Base](#). This database provides the best available state-wide spatial data on koala habitat, the likelihood of finding a koala at a location, koala preferred trees and koala sightings for NSW. It is publicly available on the [Sharing and Enabling Environmental Data \(SEED\) portal](#).

The database is helping to:

- protect koala habitat by supporting where to establish new koala reserves and private land conservation agreements
- ensure local actions are based on the best available information
- improve management of threats and disease.

## 5. How to revegetate koala habitat

Natural regeneration and direct planting of seeds and seedlings are three main techniques used to revegetate an area. The method you choose depends on the scale of revegetation, budget, soil type and condition of existing vegetation (native and introduced species).

Many fact sheets on revegetation techniques and materials exist, such as those published by Local Land Services, environmental organisations and Landcare groups. Contact local experts for the most relevant advice for your area. Not all techniques will work at all sites, so take the time to assess site conditions.

### 5.1 How to create good quality koala habitat

At least 30% of canopy trees in a habitat patch or corridor should be preferred koala use trees of a range of ages. Patches should also contain a range of other native trees and shrubs to provide shelter.

#### 5.1.1 What species to plant

When you revegetate:

- plant local eucalypt species
- plant other local native species consistent with existing vegetation types
- plant preferred koala use tree species for the area
- look at nearby forests with healthy koala populations and use these as a guide.

Make sure you select species that are suitable for the site. Plants grown in unsuitable locations may die or suffer nutrient and/or moisture stress, producing chemicals that discourage koalas from eating them.

If there is koala habitat nearby that supports koalas, use the tree species composition of this habitat to guide your plant selection.

Koalas can live in many different forest types. In some areas, forests are dominated by one or two preferred eucalyptus species and koala populations do well in such habitat. In other areas, forests are more diverse and local tree species may be less palatable, but koalas will survive by eating a varied diet and benefit from the diversity. Planting a range of different species can reduce the risk of dieback, plant toxicity and seedling death.

The best way to work out the ideal composition for revegetating in terms of diversity and type of tree species, is to look at nearby forests that occupy a similar geology and climate where there are healthy koala populations. Then use those examples to guide your selection of tree species and what proportion of species to use for revegetation.

In areas of high rainfall, avoid planting rainforest trees as they will compete with koala feed tree species for light, moisture and nutrients. Rainforest species can also smother plantings and encourage bell miner associated dieback. Rainforest shrubs may occur naturally in wet open forests and these should be allowed to migrate naturally into revegetation areas once koala feed trees have become well-established.



## 5.2 Natural regeneration

Natural regeneration is the germination of seedlings from seeds from existing or nearby vegetation, from the soil seedbank, or from seeds brought in by birds or animals. Natural regeneration can also occur from resprouting of existing vegetation. This technique requires less effort and money, plants tend to develop naturally strong root systems, and the site can end up looking more 'natural' compared to planted sites.

Natural regeneration needs:

- availability of seed or propagules
- a receptive seedbed
- appropriate water availability and temperatures
- minimal herbivory, for example, preventing cattle or kangaroos from eating seedlings before they establish.

The capacity of a site to regenerate naturally is the first thing to consider when you plan to revegetate an area.

Natural regeneration may not occur in the way it is needed. For example:

- there may not be enough local seeds or the existing seedbank is inadequate
- soil, water or light may be lacking
- species that regenerate may not be the one/s you want to establish
- trees may not establish exactly where they are needed
- the stand of trees may not be a desirable structure – natural regeneration is often dense and may require thinning.

Natural regeneration may be an option wherever remnant native vegetation exists, even isolated paddock trees. Focus your efforts where there is a greater chance of success. For example, plant species known to be good regenerators such as red gums (*Eucalyptus camaldulensis*, *E. blakelyi*, *E. tereticornis*, *E. parramattensis*, *E. amplifolia*, *E. chloroclada*) or manna gum (*E. viminalis*), and plant them in areas of native pasture rather than exotic grasses.

Wildlife friendly fencing to exclude animals that eat grasses and new seedlings may be all that is needed to promote natural regeneration in a site.

Consider these tips to encourage natural regeneration:

- reduce competition from groundcover by spraying (see Table 1) or allowing short-duration grazing
- lightly cultivate soil around trees to promote suckering (the growth of new shoots)
- clear the soil of weeds and debris to create a bare seedbed
- conduct ecological burning to promote seedfall and germination.

See Corr (2003) for more details about revegetation techniques for native Australian plants.

## 5.3 Planting seedlings

Planting seedlings is usually more expensive than natural regeneration or direct seeding because it involves more labour, time and money. Planting may be the preferred method of revegetation because it:

- gives greater control over the species mix, density and placement
- gives a more immediate impression of success
- is more efficient if seed is scarce
- can involve the community, which has important associated social and educational benefits.

There are many factors to consider when planting and establishing new seedlings to ensure they have the best chance of survival (Table 1). For example, site preparation is a critical part of establishing new seedlings. A well-prepared site will:

- reduce competition from grasses and weeds
- help build soil moisture
- provide the best opportunity for moisture and rain to infiltrate the soil
- allow for rapid and healthy root development.

Site preparation will be even more important given the anticipated impacts of climate change.

**Table 1 Steps to consider when planting and establishing new seedlings**

Planting process			
Step	Method	Why	When
1. Weed control	<ul style="list-style-type: none"> <li>• varies depending on weed type</li> <li>• there are several options including chemical, mechanical, manual and biological methods</li> <li>• consult the <a href="#">NSW Weed Control Handbook</a> for more information on weed control methods, chemical use and withholding periods</li> </ul>	<ul style="list-style-type: none"> <li>• weeds compete for light, moisture and nutrients and can smother plantings</li> </ul>	<ul style="list-style-type: none"> <li>• up to 1 year before planting in drier areas, with 1–3 treatments depending on weeds</li> <li>• wetter/more productive areas will require weed control closer to the time of planting</li> </ul>
2. Animal control	<ul style="list-style-type: none"> <li>• Control or eradicate feral animals, e.g. rabbits</li> <li>• exclude livestock by using wildlife friendly fencing</li> <li>• deter native browsing animals by using wildlife friendly fencing or tree guards</li> </ul>	<ul style="list-style-type: none"> <li>• animals can eat and destroy seedlings</li> </ul>	<ul style="list-style-type: none"> <li>• before planting</li> </ul>

Planting process			
Step	Method	Why	When
3. Soil preparation	<ul style="list-style-type: none"> <li>ripping/deep tillage of soil (30–60 centimetres deep)</li> <li>augering/drilling holes</li> </ul>	<ul style="list-style-type: none"> <li>breaks up hard or compacted soil</li> <li>increases soil moisture and rainfall penetration, which facilitates faster root development in seedlings</li> </ul>	<ul style="list-style-type: none"> <li>rip soil preferably 4–6 months, minimum 1–2 months, before planting</li> <li>augering should be done closer to planting time to reduce moisture loss</li> </ul>
4. Source seedlings	<ul style="list-style-type: none"> <li>start with local species but also investigate a mix of different provenances of these species (see section 4.5)</li> <li>ensure good quality stock</li> <li>commonly used pot sizes are Hiko cells and forestry tubes, established trees are also an option</li> </ul>	<ul style="list-style-type: none"> <li>to ensure climate-resilient plantings</li> <li>choice of pot size depends on budget and likelihood of plant survival</li> </ul>	<ul style="list-style-type: none"> <li>source plants several months before planting</li> <li>large orders may need to be placed a year in advance</li> </ul>
5. Planting	<ul style="list-style-type: none"> <li>by hand (mattock, spade), or using tree planting tools, or tree planting machines</li> <li>water plants well on the day of planting</li> <li>tubes can be soaked in water and holes watered before seedlings are planted to minimise follow-up watering</li> <li>plant spacing is variable (see koala management area revegetation fact sheets, section 3.1)</li> <li>delay planting if too dry</li> </ul>	<ul style="list-style-type: none"> <li>method depends on budget and resources available</li> <li>watering removes air pockets around roots and minimises transplanting shock</li> </ul>	<ul style="list-style-type: none"> <li>varies with region, but usually autumn, winter and spring (not summer unless well-watered)</li> </ul>
6. Tree protection	<ul style="list-style-type: none"> <li>the whole site or area being planted can be fenced, but this can be expensive</li> <li>a variety of tree guards are available, with varying costs, for</li> </ul>	<ul style="list-style-type: none"> <li>select type of protection depending on browsing pressure, budget available to install and remove, biodegradability and position in the landscape</li> </ul>	<ul style="list-style-type: none"> <li>during planting</li> </ul>

Planting process			
Step	Method	Why	When
	example, carton/cardboard, corflute and wire/plastic mesh guards. <ul style="list-style-type: none"> <li>• browse deterrent may be an effective and cheap alternative</li> </ul>		
7. Extras (optional)	<ul style="list-style-type: none"> <li>• mulch</li> <li>• weed mat</li> <li>• fertiliser/liquid seaweed</li> <li>• water crystals</li> </ul>	can improve the success of planting, but depend on cost, time and effort it takes to install/apply them	during and after planting
8. Maintenance	<ul style="list-style-type: none"> <li>• weed and animal control</li> <li>• remove tree guards once plants are tall enough</li> <li>• water plants if needed in summer of the first year</li> <li>• remove and replace dead plants if you have extra stock</li> </ul>	<ul style="list-style-type: none"> <li>• will enable the highest success of plantings</li> </ul>	after planting (for a minimum of 1 year)
9. Monitoring	<ul style="list-style-type: none"> <li>• monitor plant survival</li> </ul>	<ul style="list-style-type: none"> <li>• ensure plant survival meets desired targets</li> <li>• to inform ongoing maintenance such as weed and animal control and additional planting</li> </ul>	<ul style="list-style-type: none"> <li>• after planting (for a minimum of 2 years)</li> </ul>

## 5.4 Direct seeding

Direct seeding is a cost-effective and efficient technique, particularly for large-scale projects. Direct seeding is less suitable for some sites. Areas with heavy clay soils may have low germination rates and very rocky sites may prevent use of machinery. Sites with highly competitive, dense grasses may also be unsuitable for this method. Direct seeding has been widely used in some regions and has not been trialled in others. Check with your local natural resource managers about the use of this method in your region.

As with planting, site preparation is a critical part of direct seeding to reduce weeds that compete with germinating seedlings for moisture, light and nutrients. Site preparation will be even more important given the anticipated impacts of climate change.



**Table 2 Steps to consider when planting seeds directly into soil**

Direct seeding			
Stage	Method	Why	When
1. Weed control and site preparation	<ul style="list-style-type: none"> <li>varies depending on weed type</li> <li>there are several options including chemical, mechanical, manual and biological methods</li> <li>consult the <a href="#">NSW Weed Control Handbook</a> for more information on weed control methods, chemical use and withholding periods</li> <li>spray weeds or scrape soil in lines 1–1.5 metres wide and 4–5 metres apart</li> <li>good site preparation is important</li> </ul>	<ul style="list-style-type: none"> <li>weeds compete for light, moisture and nutrients and can smother plantings</li> </ul>	<ul style="list-style-type: none"> <li>for best results spray twice, once in autumn (6 months in advance) and once in spring just before seeding</li> </ul>
2. Animal control	<ul style="list-style-type: none"> <li>control or eradicate feral animals (e.g. rabbits)</li> <li>exclude livestock by using fencing</li> <li>deter native browsing animals by using wildlife friendly fencing</li> </ul>	<ul style="list-style-type: none"> <li>animals can eat and destroy new seedlings, for example rabbits can be very destructive and eat all traces of germinated seedlings</li> </ul>	<ul style="list-style-type: none"> <li>before planting</li> </ul>
3. Seed	<ul style="list-style-type: none"> <li>select local koala tree and shrub species suitable for the site</li> <li>try a mix of different provenances (local seeds, plus others from hotter/drier areas)</li> </ul>	<ul style="list-style-type: none"> <li>climate-proof revegetation</li> </ul>	<ul style="list-style-type: none"> <li>source seed and secure a seeding operator 2–12 months in advance</li> </ul>
4. Direct seeding	<ul style="list-style-type: none"> <li>technique varies depending on site condition and type of seeder machine used</li> <li>ask your local experts</li> <li>create seeding lines along contours or across</li> </ul>	<ul style="list-style-type: none"> <li>direct seeding operators and resource managers will know the best seed rates and species ratios to use for your area</li> <li>they also know how to calibrate seeder machines</li> </ul>	<ul style="list-style-type: none"> <li>areas with high-moderate rainfall and/or frost: spring</li> <li>semi-arid areas: autumn–winter</li> </ul>

Direct seeding			
Stage	Method	Why	When
	the slope of land to reduce soil erosion		
5. Maintenance	<ul style="list-style-type: none"> <li>weed and animal control</li> </ul>	<ul style="list-style-type: none"> <li>enable high rates of seedling establishment</li> <li>thinning may be necessary</li> </ul>	<ul style="list-style-type: none"> <li>after planting (minimum 3 years)</li> </ul>
6. Monitoring	<ul style="list-style-type: none"> <li>monitor germination and seedling establishment rates over a few years</li> <li>most seedlings come up within 2–3 years</li> </ul>	<ul style="list-style-type: none"> <li>ensure plant germination rates meet desired targets and assess which species germinate well at the site</li> <li>direct seed a second time or do infill planting if seeding is unsuccessful</li> </ul>	<ul style="list-style-type: none"> <li>after planting (minimum 3 years)</li> </ul>

## 6. Monitoring revegetated koala habitat

There are three stages of koala habitat revegetation monitoring:

1. plant survival
2. detecting koala presence/absence
3. monitoring koala activity and/or breeding.

### 6.1 Plant survival

Plant survival (for seedlings) and establishment (direct seeding) should be monitored in a systematic and unbiased way. Ideally, you should monitor your site for 10 years after planting or seeding to assess whether further maintenance or replacement plantings are required. Unless there is significant plant mortality, replacement plantings may not be needed as natural gaps in the canopy can benefit other plants and animals.

To monitor plant survival:

- for plantings, count the number of plants of each species that have survived (by counting all plants or sampling several randomly selected plots spread across the site)
- for direct seeding, count the number of seedlings of each species located along a standard transect length (e.g. the number of seedlings along five 20-metre transects).

You can also record an index of plant health and/or plant height when evaluating plant survival in the revegetated area. The Australian Network for Plant Conservation's [Guidelines for the Translocation of Threatened Plants in Australia](#) provides more guidance on evaluation of plants.

Photopoint monitoring or taking snapshots to record and monitor changes in plants over time are effective ways of monitoring and communicating the success of revegetation works. This is particularly useful for long-term monitoring of plots and quadrats. It is important that enough photopoints are included to enable an area to be seen as plants grow taller.

### 6.2 Koala monitoring

There are many ways to monitor koala presence/absence and whether they are occupying remnant and revegetated habitat. These include:

- **Faecal pellet surveys** search an area for koala scats to infer the presence/absence of koalas and koala activity. There are many scat survey methods, the most commonly used are:
  - Spot Assessment Technique (SAT) consists of a variable radius plot in which the litter within 1 metre of the trunks of the nearest 30 live trees is searched for koala faecal pellets (Phillips & Callaghan 2011).
  - Regularised Grid-Based Spot Assessment Technique (RGB-SAT) involves survey sites located at grid-line intersections at defined intervals (350 metres, 500 metres or 1 kilometre). The presence/absence of koala faecal pellets are assessed using the SAT method. This method is powerful when repeated at the same survey sites and the same trees over several years (Phillips & Hopkins 2008).
  - Rapid Spot Assessment Technique (Rapid-SAT) is designed to optimise detection rates by focusing on preferred koala use tree species (Phillips & Wallis 2016). This method must be performed by trained personnel with knowledge of local tree species most likely to support koalas.

- **Dog surveys** involve detection dogs trained to detect the scent of koalas and/or koala scats (Cristescu et al. 2015). Although dogs can be more effective than humans at detecting koala scats, their ability to detect koalas can be limited.
- **Radio- or GPS-tracking** follow the movement of koalas using radio- or GPS-tracking devices. Radio or GPS devices are attached to individual animals and used to understand home ranges, habitat use and connectivity (Crowther et al. 2014; Davies et al. 2013; Goldingay & Dobner 2014). These methods are undertaken by licensed wildlife researchers.
- **Systematic nocturnal spotlighting** involves walking a specified path at night using a bright torch or spotlight to look for koala eyeshine (Smith 2004; Wilmott et al. 2018). Limitations to this method include missing koalas when they are not facing the spotlight, when they have conjunctivitis, or in areas with dense canopy.
- **Acoustic recordings** involve setting up a small recording device in the field for extended periods to record koala calls or bellows. It is most effective in the peak of the koala breeding season (September to December) and to detect males at a regional/landscape level (Law et al. 2018). Recordings indicate koala presence and provide good supporting evidence for carrying out more systematic surveys.
- **Sightings reported by landholders or members of the community** can be a valuable source of information. Download the 'I Spy Koala' app to your phone or tablet to record sightings of koalas in the wild. Sightings are uploaded to the [BioNet Atlas](#). Alternatively, koala sightings can be sent to [BioNet directly](#). There are also many koala citizen science projects registered with BioNet. Some local councils record koala sightings on their websites.
- **Sightings of mothers with joeys** are a good indicator of long-term habitat revegetation success because the habitat is able to support a breeding population.

## 7. Case studies

These case studies provide examples of koala habitat being successfully created, revegetated and/or enhanced across some of the koala management areas (KMAs) identified in NSW (see section 3.1).

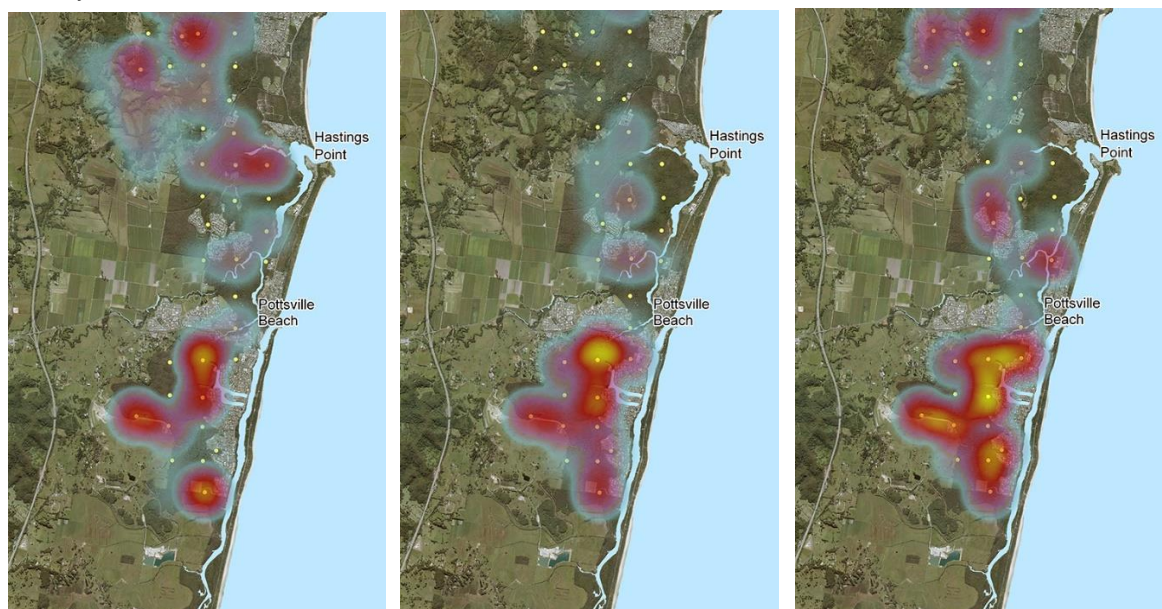
### Case study 1: Monitoring Koalas on the Tweed Coast (KMA 1)

**Context:** Remaining koala habitat on the Tweed Coast in north-eastern NSW is extremely fragmented. Patches of eucalypt forest or woodland large enough to sustain a viable koala population are restricted to areas between Kingscliff and Pottsville. The koala population in this area is listed as endangered. Tweed Shire Council has been implementing programs to protect koalas and improve their habitat for many years. The Tweed Coast Koala Plan of Management (KPoM) was adopted in 2015. Since then, Council has partnered with community organisations to plant 34,460 trees, providing 23.25 hectares of new koala habitat. They have also implemented other recovery actions such as purchasing land to protect koala habitat and creating koala zones to reduce vehicle strike. To assess whether the Tweed Coast KPoM was having an impact, Council implemented a rigorous monitoring program.

**Aim:** To understand changes in koala distribution, activity and occupancy within the Tweed Shire Council area between 2010 and 2018.

**How:** Koala scat surveys used the Regularised Grid-Based Spot Assessment Technique (see section 6.2). Permanent monitoring sites were established in a regular pattern of about 600-metre spacings. Survey sites were marked to ensure consistency through time. Surveys were conducted in 2010, 2015 and 2018; before, during and after the introduction of the Tweed Coast KPoM.

**Results:** Koala activity and distribution on the Tweed Coast declined substantially between 2010 and 2015, and increased in 2018 in some of the areas that were vacant in 2015. This suggests that some recovery and reconnection of populations has occurred. In the southern portion of the Tweed Coast, a large and stable resident population continues to persist in good quality habitat in the Pottsville Wetland (Figure 4). In the adjacent northern portion, the distribution and intensity of koala activity fluctuates over time.



**Figure 4** Heat map showing changes in the intensity and the distribution of koala activity in the southern portion of the Tweed Coast between 2010 (left), 2015 (middle) and 2018 (right). Lower koala activity is indicated by blue shading, grading through red with yellow representing areas of highest koala activity. Yellow dots represent the locations of 56 sites that were surveyed in all three years. Source: Tweed Coast Koala Study 2018

Encouragingly, two-thirds of monitored koala habitat planting sites have been used by koalas. Many sites were used within 2.5 years of planting.



The koala population on the Tweed Coast remains unstable, small, fragmented, and at an occupancy rate that is well below sustainable. Continued monitoring (every 3 years) is vital to understand long-term koala population trends in the area.

**Key messages:**

- Following a rigorous, repeatable survey method across a region is a powerful way to understand changes in distribution and activity of a koala population.
- Through the implementation of threat abatement, recovery actions and development controls in the Tweed Coast KPOM the Tweed Council and local community are working towards the long-term protection of the Tweed Coast koala population. Continued population monitoring is essential.

More information: [Tweed Shire Council](#)

**References:**

Scott Hetherington (Senior Program Leader for Biodiversity, Tweed Shire Council), 2019, pers comm.

Tweed Shire Council 2015, Tweed Coast Comprehensive Koala Plan of Management 2015. Tweed Shire Council, Murwillumbah, NSW.

Tweed Shire Council 2019, Tweed Coast Koala Study 2018, Tweed Shire Council, Murwillumbah, NSW, [www.tweed.nsw.gov.au/koalas](http://www.tweed.nsw.gov.au/koalas).

## Case study 2: Tree Parents Project, Bongil Bongil National Park (KMA 1)

**Context:** Bongil Bongil National Park is a 4300-hectare conservation reserve located 20 kilometres south of Coffs Harbour on the NSW north coast. The national park is renowned for its large koala population and provides high-quality habitat for an estimated 400 koalas. However, a significant proportion (around 660 hectares) of the park is occupied by even-aged stands of native eucalypt plantation species, such as blackbutt (*Eucalyptus pilularis*) and flooded gum (*Eucalyptus grandis*), that were planted in the early 1970s. These plantation species, although endemic to the NSW north coast, are not preferred koala use trees. The understorey of many of these plantations is now dominated by the weed species lantana (*Lantana camara*) and broad-leaved paspalum (*Paspalum mandiocanum*).

**Aim:** To convert 20 hectares of degraded eucalypt plantation within Bongil Bongil National Park to primary koala habitat using 10 teams of volunteers planting and nurturing 600 koala food trees for 3–4 years.

**How:** The NSW National Parks and Wildlife Service (NPWS) received funding through the Office of Environment and Heritage (OEH) Volunteer Grants Program. The project gathered 10 teams of volunteers from the local community. Each team was allocated two hectares and 60 preferred koala use trees to plant and manage. Tree species planted included *Eucalyptus microcorys*, *E. propinqua*, *E. robusta* and *Allocasuarina torulosa*. Each team was given tools, water and personal protective equipment to use when planting and maintaining their block. Plants were protected with wallaby-proof wire cages. Several years before planting, lantana was removed systematically by NPWS staff using splatter gun, hand pulling, cut, and paint- and spot-spray techniques.

NPWS trained the volunteers and supported them over 3–4 years to be good ‘tree parents’ by encouraging accountability, teamwork, experiential learning and competitiveness. Trophies were presented to teams with the tallest trees and highest plant survival.

**Results:** After 12 months, 96% of plants had survived. Dead plants were replaced and this increased the survival rate to 100%.

The plants grew quickly. The tallest tree (*E. robusta*) reached almost 3 metres in 12 months (Figure 5).

Within less than a year, a koala and joey were frequently sighted in remnant trees inside a planting block. Other koalas were seen in other blocks shortly after.

The program was so successful it was repeated in 2017 and another 600 koala trees were planted by volunteer tree parents. The survivorship of plants after 18 months replicated the 2015 results of 96%.



**Figure 5** The winning swamp mahogany, grown by the 'Roos' in Block 7, almost 3 metres high at 12 months of age. Photo: Martin Smith/NPWS Coffs Coast Area

**Key messages:**

- Competitiveness of volunteers, supportive management and recognition of their dedication through awards can lead to high plant survival and growth rates.
- Good site preparation, weed control, protection from browsing animals, and follow-up maintenance can lead to excellent results.

More information: NPWS, Coffs Coast Area

Phone: 02 6652 0900 or email: [info@environment.nsw.gov.au](mailto:info@environment.nsw.gov.au)

**References:**

Martin Smith (NPWS senior ranger), pers comm. 2019

Martin Smith 2016, The Tree Parents Project, Bongil Bongil National Park. Project Review: The First Year 2015–16. NPWS, Coffs Coast Area.

OEH 2017, Volunteers invited to compete in local tree planting project to save koalas. Media release: [www.environment.nsw.gov.au/news/volunteers-invited-to-compete-in-local-tree-planting-project-to-save-koalas](http://www.environment.nsw.gov.au/news/volunteers-invited-to-compete-in-local-tree-planting-project-to-save-koalas)

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### Case study 3: Koala connectivity corridor in the Cumberland Plain (KMA 2)

**Context:** The Cumberland Plain woodlands once covered 107,000 hectares of the western Sydney Basin. Only 6500 hectares, less than 6%, of the woodlands remain in small fragments surrounded by agriculture, housing and industry. Key koala habitat in the southern section of the Cumberland Plain has been significantly degraded, especially the mid- and ground-storey. Connection between koala habitat areas has also been impacted and remaining fragments are under intense pressure from urban development and weeds. Despite this, there is some evidence that koala numbers are slowly recovering in the woodlands.

**Aim:** To restore 0.8 hectares of degraded koala habitat at Cook Park in Ruse using native trees, shrubs and grasses. To strengthen a key koala corridor between the Georges River wildlife corridor and Smiths Creek, Campbelltown's largest urban bushland reserve. This will allow safer koala movement within the landscape.

**How:** Greening Australia received funding from WWF-Australia for this habitat restoration project. Three-thousand seedlings were planted in 2019 in three separate events, including a large community planting on Wild Koala Day when over 100 volunteers planted 1500 plants (Figure 6). The remaining seedlings were planted during events with a local school, Bushcare volunteers and Greening Australia staff. A thick layer of mulch was also added to cover the site and reduce weed competition. Most plants were groundcover species or shrubs (50 koala food trees were planted), because the existing canopy layer was relatively intact. Koala-friendly species were identified through consultation with experts from Campbelltown City Council.

**Result:** Koalas were sighted in remnant trees on the site within one year of revegetation actions. At the time of writing, the plantings were in good condition.

**Key messages:**

- It is possible to restore and connect koala habitat by enhancing degraded remnants, even when land availability is limited.
- Working with local stakeholders, such as the local council who have knowledge and expertise is important. Campbelltown City Council identified this site as an important koala corridor.
- Engaging the community in revegetation events is an effective way of getting a large amount of plants in the ground in a short amount of time.
- Raising awareness about local koalas is important.
- It is important to make use of local knowledge, as local experts will know what tree species koalas prefer in each area.



**Figure 6 Community planting event at Cook Park in Ruse. Photo: Greening Australia**

More information: [Greening Australia](#), Western Sydney Office

**Reference:** Courtney Sullivan, Greening Australia Restoration Ecologist, 2019, pers comm



#### Case study 4: Koala use of young Eucalyptus plantations on the Liverpool Plains (KMA 6)

**Context:** The Liverpool Plains are among some of Australia's most productive and fertile agricultural lands. This region has been substantially cleared for intensive cropping, grazing and most recently mining, resulting in a reduction of woodland cover by more than 90%. Rising soil salinity from land clearing triggered a revegetation program between 2001 and 2004, which resulted in 400 hectares of eucalypt plantations being established on private land. These plantings had the added benefit of providing potential habitat for native animals. Gunnedah and the Liverpool Plains are a well-known hotspot for koalas, but it was unknown whether koalas would use the new plantings.

**Aim:** To understand whether koalas (and other animals) would use young eucalypt plantations on the Liverpool Plains, and what factors influenced their use.

**How:** Researchers from the NSW Department of Primary Industries recorded koala presence and absence at 43 study sites: 27 eucalypt plantations, 11 remnant patches of forest and woodland, and 5 paddocks. Surveys included daylight searches, spotlight surveys, camera trap records and scat surveys. Two koalas were fitted with GPS collars and tracked for 5–7 months.

**Results:** Koalas were more likely to be found in remnant patches than young eucalypt plantations. Koalas were recorded at 64% of remnant patch sites compared to 26% of plantation sites. No koalas were recorded in paddock sites. Koala presence or absence was strongly linked to the amount of remnant vegetation within 5 kilometres. Sites surrounded by large areas of remnant vegetation were more likely to be used by koalas.

Koalas used trees as young as 2 years old for foraging, particularly river red gum (*Eucalyptus camaldulensis*), and trees 4–7 years old for foraging and shelter (Figure 7).

The two tracked koalas often used eucalypt plantations, woodland patches and isolated paddock trees, and showed a slight preference for eucalypt plantations.



**Figure 7** Koalas commonly used young trees in eucalypt plantations – this tree was about 2 years old. Photo: Helen Engel

**Key messages:**

- Young eucalypt plantations of preferred koala tree species can provide valuable koala habitat, provided they are located close to large areas of remnant forest and woodland.

- A combination of remnant patches, plantations and scattered trees within the landscape provides a variety of complementary resources that koalas will use.
- Uptake and use of eucalypt plantations by koalas can be remarkably quick and extensive.
- Revegetation can help sustain a koala population and mitigate the impacts of habitat loss and fragmentation in the short term.

More information: Rod Kavanagh, NSW Senior Ecologist at Australian Wildlife Conservancy

#### References:

Kavanagh RP and Stanton MA 2012, Koalas use young Eucalyptus plantations in an agricultural landscape on the Liverpool Plains. *Ecological Management & Restoration*, 13: 3.

Stanton MA 2016, Rehabilitation: to what state and for which purpose? Poster presented at the 6th Annual Best Practice Ecological Rehabilitation of Mined Lands Conference.

### Case study 5: Revegetation of high-quality koala habitat in the Wingecarribee Shire (KMA 2)

**Context:** Surveys conducted in the Wingecarribee Shire in 2017 by NSW Government staff estimated that over 3000 koalas reside in the region, making it the largest known population in southern NSW. Koala density is influenced by vegetation community type and condition. Within the region, higher koala densities correlate with higher soil fertility. A koala habitat restoration project in the Southern Highlands focused on two critically endangered ecological or vegetation communities: Robertson basalt tall open-forest and Southern Highlands shale forest and woodland. These two vegetation communities support a relatively high density of koalas and are considered the highest quality koala habitat in the region.

**Aim:** To engage local stakeholders to restore 42 hectares of high-quality koala habitat and endangered ecological communities by planting 2500 trees, including koala feed trees.

**How:** Three sites within the Upper Nepean State Conservation Area had been high-quality koala habitat but were later cleared for timber. The sites were in varying condition before planting, but typically had good natural regeneration of the ground cover and understorey. There was little regeneration of canopy species.

Revegetation species were selected based on official listing advice for the two endangered ecological communities and knowledge of experts including government staff. Only canopy species were planted. Due to dry conditions in spring 2018, planting was held over until autumn 2019.

Seedlings were sourced from local nurseries. Minimal spot-spraying of weeds was required due to the largely native groundcover. A hazard reduction burn at one site helped the planting process. Holes for seedlings were dug about eight metres apart, water crystals added, and seedlings were protected with 800-millimetre-tall galvanised mesh tree guards. The seedlings were watered at planting and then monthly.

**Results:** Preliminary results at the time of writing indicate a greater than 90% survival of seedlings. Monitoring at each site will include plant diversity surveys within fixed plots to understand the condition of the endangered ecological communities, recording seedling survival counts, as well as evidence of koala use (scats, scratches, tops of plants snapped).

#### Key messages:

- Good planning involves targeting areas of high-quality habitat for restoration and/or areas that have high connectivity value.
- Good site preparation, protection of seedlings from browsers and follow-up maintenance achieves good results.
- Targeting areas with potential high habitat value, such as good quality soils, will result in greater benefits to koalas.

More information: Department of Planning, Industry and Environment (DPIE) Illawarra

#### Reference:

Lachlan Wilmott, Threatened Species Officer, DPIE Illawarra Region, 2019, pers comm



## 8. Glossary

**Browse deterrent:** A compound applied to leaves of plants to make them non-palatable to herbivores such as cows or kangaroos and protect newly planted trees and shrubs from being eaten.

**Direct seeding:** Sowing seeds directly onto a site by machine or hand.

**Natural regeneration:** Recovery or recruitment of species from a germination or resprouting event.

**Local provenance species:** Plant species or populations that contain local genetic variation. Local provenance plants are grown from seed collected from healthy plants growing near to and in similar conditions as the planting site. This gives the plants a better chance of surviving.

**Patch:** An area of vegetation or habitat that differs from its surroundings.

**Planting:** Planting nursery-grown seedlings by machine or hand.

**Preferred koala use tree species:** Trees that koalas use for food, shelter and social activities. Koalas often shelter in rainforest trees and non-native trees for shade, but do not feed in these trees. For details see the [Koala Habitat Information Base Technical Guide](#) and our koala management area fact sheets (section 3.1).

**Propagule:** A vegetative structure such as a bud, sucker, or spore, that can detach from a plant and give rise to a new plant.

**Restoration:** The process of helping the recovery to a healthier condition of a species, population or ecosystem that has been degraded, damaged or destroyed.

**Revegetation:** Establishment, by any means, of plants on a site.

**Riparian:** A riparian area or riparian zone is the interface between land and a river or stream, such as a riverbank.

## 9. References

- Adams–Hosking C, Grantham HS, Rhodes JR, McAlpine C and Moss PT 2011, Modelling climate-change-induced shifts in the distribution of the koala, *Wildlife Research* 38 (2) 122–130, <https://doi.org/10.1071/WR10156>.
- Ashton DH and Chinner JH 1999, Problems of regeneration of the mature *Eucalyptus regnans* F. Muell, (The Big Ash) forest, in the absence of fire at Wallaby Creek, Victoria, Australia. *Australian Forestry* 62, 265–280.
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