# Appendix K Species and TEC Conservation Advices

# Approved Conservation Advice for *Egernia rugosa* (Yakka Skink)

(s266B of the *Environment Protection and Biodiversity Conservation Act 1999*)

This Conservation Advice has been developed based on the best available information at the time this Conservation Advice was approved; this includes existing plans, records or management prescriptions for this species.

## Description

*Egernia rugosa*, Family Scincidae, commonly known as the Yakka Skink is a robust bodied skink that grows up to 40 cm long. It has a broad dark brown to black stripe from nape to tail bordered on either side by a narrow, pale fawn back/side stripe. Dark brown to pale brown to reddish-brown scales on the flanks form a faintly variegated orange-brown pattern. The throat is cream-yellow, with blackish flecks/spots, and the chest and abdomen are yellow-orange (Cogger, 2000). This skink is often described as robust and is about the same size as a Blue Tongue Lizard (*Tiliqua scincoides*), making it one of the largest skinks in the region where it is found (TSN, 2008).

## Conservation Status

The Yakka Skink is listed as **vulnerable**. This species is eligible for listing as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) as, prior to the commencement of the EPBC Act, it was listed as vulnerable under Schedule 1 of the *Endangered Species Protection Act 1992* (Cwlth). The Yakka Skink is also listed as vulnerable under the *Nature Conservation Act 1992* (Queensland).

## Distribution and Habitat

The Yakka Skink is endemic to Queensland where its distribution is patchy. Isolated populations occur throughout subhumid areas in the interior of Queensland from St George in the south, to Coen and Cape York in the north. In the southern half of the Brigalow Belt it occurs near Rockhampton, south to St George and west to Chesterton Range National Park. The core habitat of this species is within the Mulga Lands and Brigalow Belt South Bioregions (TSN, 2008). Other populations have been recorded throughout the Brigalow Belt North and Einsaleigh Uplands Bioregions (TSN, 2008). Populations have been recorded across a range on land tenures including Thurshton National Park, Culgoa Floodplain National Park. Some populations (size not known) have been detected along the Queensland/NSW border (TSN, 2008).

The Yakka Skink is found in open dry sclerophyll forest or woodland (Wilson and Knowles, 1988; Cogger, 2000). This species will often take refuge among dense ground vegetation, large hollow logs, cavities in soil-bound root systems of fallen trees and beneath rocks (Wilson and Knowles, 1988; Cogger, 2000). They may also excavate burrow systems among low vegetation or below logs (Ehmann, 1992). In cleared habitat, Yakka Skinks may persist where shelter sites such as tunnel erosion, rabbit warrens and log piles exist (TSN, 2008). They are extremely secretive and seldom venture far from shelter sites, where they retreat to at the first sign of disturbance. Their presence is often indicated by a shared site where they deposit their droppings (Wilson, 2003).

This species occurs within the Border Rivers Maranoa-Balonne, Burdekin, Burnett Mary, Cape York, Condamine, Desert Channels, Fitzroy, Mackay Whitsunday and South West Natural Resource Management Regions.

The distribution of this species is associated with the "Brigalow (*Acacia harpophylla* dominant and co-dominant)" EPBC Act-listed threatened ecological community.

### Threats

The main identified threat to the Yakka Skink is a continued legacy of past braodscale land clearing and habitat degradation. The Brigalow Belt Bioregion is an area of high human impact (Covacevich et al., 1998) with much of the region modified through agricultural and urban development (McDonald et al., 1991; Cogger et al., 1993).

Other threats to the Yakka Skink include inappropriate roadside management, removal of wood debris and rock microhabitat features, ripping of rabbit warrens and predation by feral animals (TSN, 2008).

### Research Priorities

Research priorities that would inform future regional and local priority actions include:

- More precisely assess population size, distribution, ecological requirements and the relative impacts of threatening processes.
- Undertake survey work in suitable habitat and potential habitat to locate any additional populations/occurrences/remnants.
- Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.

### Regional and local Priority Actions

The following priority recovery and threat abatement actions can be done to support the recovery of the Yakka Skink.

<u>Habitat Loss, Disturbance and Modification</u>

- Monitor known populations to identify key threats.
- Identify populations of high conservation priority.
- Actively discourage the removal of fallen logs, leaf litter and rocks from known and potential habitat sites.
- Ensure that road widening and maintenance activities and ripping of rabbit warrens in areas where the Yakka Skink occurs do not adversely impact on known populations.
- Investigate formal conservation arrangements, management agreements and covenants on private land, and for crown and private land investigate inclusion in reserve tenure if possible.

<u>Animal Predation or Competition</u>

- Develop and implement a management plan for the control of foxes and feral cats in the region.

<u>Fire</u>

- Develop and implement a suitable fire management strategy for the habitat of the Yakka Skink.

<u>Conservation Information</u>

- Raise awareness of the Yakka Skink, and other reptiles, within the local community.
- Engage with private landholders and land managers responsible for the land on which populations occur and encourage these key stakeholders to contribute to the implementation of conservation management actions.

This list does not necessarily encompass all actions that may be of benefit to the Yakka Skink, but highlights those that are considered to be of highest priority at the time of preparing the Conservation Advice.

**Information Sources:**

Cogger HG (2000). Reptiles and Amphibians of Australia – 6th edition. Sydney: Reed New Holland.

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Ehmann H (1992). Reptiles. In: Strahan, R., ed. Encyclopedia of Australian Animals. Sydney: Angus and Robertson.

McDonald KR, Covacevich JA, Ingram GJ and Couper PJ (1991). The status of frogs and reptiles. In: Ingram, G.J. & R.J. Raven, eds. An Atlas of Queensland's Frogs, Reptiles, Birds and Mammals. Page(s) 338-345. Brisbane: Queensland Museum.

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Threatened Species Network (TSN) (2008). Yakka Skink: *Egernia rugosa*: *National* Threatened Species Day Information Sheet: Threatened Species Network; Department of the Environment, Water, Heritage and the Arts. Available on the Internet at: http://www.environment.gov.au/biodiversity/threatened/publications/tsday08-skink.html

Wilson SK and Knowles DG (1988). Australia's Reptiles: A Photographic Reference to the Terrestrial Reptiles of Australia: Collins Publishers.

Wilson S (2003). Reptiles of the Southern Brigalow Belt. WWF-Australia.

A statement for the purposes of approved conservation advice
(s266B of the *Environment Protection and Biodiversity Conservation Act 1999*)

# Approved Conservation Advice for *Anomalopus mackayi* (Five-clawed Worm-skink)

This Conservation Advice has been developed based on the best available information at the time this conservation advice was approved.

## Description

*Anomalopus mackayi,* Family Scincidae**,** also known as the Five-clawed Worm-skink, Long-legged Worm-skink and Mackays Burrowing Skink, is a medium-sized, up to 27 cm long, *Anomalopus* species bearing three fingers and two toes (Swan, 1990; Cogger, 2000; EPA, 2007). It is generally brown to dark-brown above and paler below. In the south of its range, individuals are unpatterned, while individuals from northern populations bear longitudinal rows of dark spots, one per scale, over the dorsal and lateral surfaces (Cogger et al., 1993; Cogger, 2000; EPA, 2007). For species in the north of its range, the ventral surface is occasionally marked with rows of dark spots (Cogger, 2000; EPA, 2007).

## Conservation Status

The Five-clawed Worm-skink is listed as **vulnerable**. This species is eligible for listing as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) as, prior to the commencement of the EPBC Act, it was listed as vulnerable under Schedule 1 of the *Endangered Species Protection Act 1992* (Cwlth). This species is also listed as endangered under the *Threatened Species Conservation Act 1995* (NSW) and the *Nature Conservation Act 1992* (Queensland).

## Distribution and Habitat

The Five-clawed Worm-skink is known from a relatively small area abutting the western edge of the Great Dividing Range, in north-eastern NSW and south-eastern Queensland (Sadlier & Pressy, 1994; DECC, 2005; DEWHA, 2007; EPA, 2007).

This species occurs within the Namoi and Border Rivers–Gwydir (NSW) and Condamine (Queensland) Natural Resource Management Regions. Records in the past 20 years have come only from the Oakey and Dalby regions of Queensland and the Wallangra, Mungindi and Wee Waa regions of NSW (Sadlier & Pressy, 1994; DECC, 2005).

The Five-clawed Worm-skink occurs on the lower slopes of slight rises in grassy White Box woodland, open woodland and River Red Gum–Coolibah-Bimble Box woodland. This type of woodland is generally supported by red-black to black clay-loam soils (Shea et al., 1987). The Five-clawed Worm-skink lives in permanent deep tunnel-like burrows and deep soil cracks, using fallen logs and timber as sheltering sites on the surface.

The distribution of this species is not known to overlap with any EPBC Act-listed threatened ecological communities.

## Threats

The main identified threats to the Five-clawed Worm-Skink include clearing and fragmentation of habitat for agriculture and development; habitat degradation from overgrazing; removal of refuge sites and ground litter; predation by foxes (*Vulpes vulpes*) and feral cats (*Felis catus*); and soil and water pollution.

## Research Priorities

Research priorities that would inform future regional and local priority actions include:

- Obtain sufficient information on the biology, ecology and distribution of the species to determine its current conservation status and formulate appropriate management strategies,
- Ensure that secure, viable populations of the species are maintained within a reserve system,
- Conduct ground surveys to determine full geographic range, habitat preferences and occurrence in existing reserves, and
- Research land management practices which promote the maintenance of secure, viable populations of the species outside reserves.

**Regional Priority Actions**

The following regional priority recovery and threat abatement actions can be done to support the recovery of the Five-clawed Worm-skink.

Habitat Loss, Disturbance and Modification
- Monitor known populations to identify key threats.
- Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.
- Identify populations of high conservation priority.
- Manage threats to areas of vegetation that contain populations of the Five-clawed Worm-skink.
- Investigate formal conservation arrangements, such as, the use of covenants, conservation agreements or inclusion in reserve tenure.

Trampling, Browsing or Grazing
- Develop and implement a stock management plan for roadside verges and travelling stock routes.

Animal Predation or Competition
- Develop and implement a management plan for the control and eradication of Foxes and Feral Cats in the local region.

Conservation Information
- Raise awareness of the Long-legged Worm-skink within the local community.

Enable Recovery of Additional Sites and/or Populations
- Investigate options for linking, enhancing or establishing additional populations.

**Local Priority Actions**

The following local priority recovery and threat abatement actions can be done to support the recovery of the Five-clawed Worm-skink.

Habitat Loss, Disturbance and Modification
- Undertake survey work in suitable habitat and potential habitat to locate any additional populations.
- Minimise adverse impacts from land use at known sites.
- Protect populations of the listed species through the development of conservation agreements and/or covenants

Trampling, Browsing or Grazing
- Prevent grazing pressure at known sites on private property through exclusion fencing or other barriers.
- Prevent grazing pressure at known sites on leased crown land through exclusion fencing or other barriers.

Animal Predation or Competition

- Manage known sites to control introduced pests, such as foxes and feral cats.

This list does not necessarily encompass all actions that may be of benefit to the Five-clawed Worm-skink, but highlights those that are considered to be of highest priority at the time of preparing the conservation advice.

## Existing Plans/Management Prescriptions that Could Affect the Species

- National Threat Abatement Plan for Predation by Feral Cats (EA, 1999), and
- National Threat Abatement Plan for Predation by the European Red Fox (EA, 1999).

## Information Sources:

Cogger, HG, Cameron, EE, Sadlier, RA & Eggler, P 1993, *The Action Plan for Australian Reptiles*, Australian Nature Conservation Agency (ANCA), Canberra, viewed 11 March 2008, <http://www.environment.gov.au/biodiversity/threatened/action/reptiles/index.html>

Cogger, H 2000, *Reptiles and Amphibians of Australia - 6th edition*, Reed New Holland, Sydney.

Department of Environment and Climate Change (DECC) 2005, *Threatened Species Profile Database,* Five-clawed Worm-skink, viewed 11 March 2008, <http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10055>.

Department of the Environment and Water Resources (DEWHA) 2007, *Anomalpus mackayi* in Species Profile and Threats Database, viewed 11 March 2008, <http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=25934>.

Environment Australia (EA) 1999, *Threat Abatement Plan for Predation by Feral Cats*, Biodiversity Group, Environment Australia, viewed 11 March 2008, <http://www.environment.gov.au/biodiversity/threatened/publications/tap/cats/index.html>.

Environment Australia (EA) 1999, *Threat Abatement Plan for Predation by European Red Fox*, Biodiversity Group, Environment Australia, viewed 11 March 2008, <http://www.environment.gov.au/biodiversity/threatened/publications/tap/foxes/index.html>.

Environmental Protection Agency (EPA) 2007, *Long-legged Work-skink*, viewed 11 March 2008, <http://www.epa.qld.gov.au/nature_conservation/wildlife/native_animals/longlegged_wormskink/?format=>.

Greer, AE & Cogger, HG 1985, 'Systematics of the reduced-limbed and limbless skinks currently assigned to the genus *Anomalopus* (Lacertilia: Scincidae)', *Records of the Australian Museum,* vol. 37, pp. 11-54.

Sadlier, RA & Pressey, RL 1994, 'Reptiles and amphibians of particular conservation concern in the western division of New South Wales: a preliminary review', *Biological Conservation,* vol. 69, pp. 41-54.

Shea, GM, Millgate, M & Peck, S, 1987, 'A range extension for the rare skink *Anomalopus mackayi*', *Herpetofauna*, vol. 17, pp. 16-19.

Swan, G 1990, *A Field Guide to the Snakes and Lizards of New South Wales*, Three Sisters Productions Pty Ltd, Winnmallee, NSW.

The Minister approved this conservation advice on 27/10/2015 and agreed that this species should retain its current listing status of vulnerable under the EPBC Act

# Conservation Advice

# *Geophaps scripta scripta*

squatter pigeon (southern)

## Taxonomy

Conventionally accepted as *Geophaps scripta scripta* (Temminck, 1821). The squatter pigeon (southern) is one of two subspecies, the other being *Geophaps scripta peninsulae* (squatter pigeon (northern)).

## Summary of assessment

### Conservation status

Vulnerable

The squatter pigeon (southern) was transferred from the *Endangered Species Protection Act 1992* (ESP Act) to the Vulnerable list of the *Environmental Protection and Biodiversity Conservation Act* (1999) (EPBC Act) when the latter came into force in July 2000. For a species to be considered as Vulnerable under the ESP Act, the Minister must have been satisfied that the species was likely to become endangered within the next 25 years.

Following a formal review of the listing status of the squatter pigeon (southern), the Threatened Species Scientific Committee (the Committee) has determined that there is no evidence that the species has undergone any demonstrable recovery since being listed; and that there is insufficient evidence to support a change of status under the EPBC Act. Therefore, the Committee concluded that the squatter pigeon (southern) should remain listed as Vulnerable under the EPBC Act.

Species can be listed as threatened under state and territory legislation. For information on the listing status of this species under relevant state or territory legislation, see http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

### Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of new information provided to the Committee to re-assess the listing status of *Geophaps scripta scripta,* for potential de-listing.

### Relevant part of the EPBC Act for amending the list of threatened native species

Section 186 of the EPBC Act states that:

"(2A) The Minister must not delete (whether as a result of a transfer or otherwise) a native species from a particular category unless satisfied that:

(a) the native species is no longer eligible to be included in that category; or

(b) the inclusion of the native species in that category is not contributing, or will not contribute, to the survival of the native species."

### Public Consultation

Notice of the proposed amendment and a consultation document was made available for public comment for greater than 30 business days between 17 November 2014 and 9 January 2015.

Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

## Species/Subspecies Information

### Description

The squatter pigeon (southern) is a medium-sized, ground-dwelling bird approximately 30 cm in length and weighing 190–250 g. Adults are predominantly grey-brown, with bold black and white stripes on the face and throat. The upperwings are dark-brown, the upperbreast light grey-brown grading to blue-grey on the lower breast and centre of the belly, and the rest of the belly and flanks are white. The underwings are white with a dark leading edge. It has a black bill and dull-purple legs and feet. The sexes are similar in appearance. Juveniles can be distinguished from adults by their duller colouring and less distinctive black and white facial stripes (Higgins & Davies, 1996).

The southern and northern subspecies of the squatter pigeon appear virtually identical, except that the southern subspecies is slightly larger, and the skin around the eyes is predominantly blue-grey compared to yellowy-orange to orange-red in the northern subspecies (Ford, 1986; Higgins & Davies, 1996).

### Distribution

The squatter pigeon (southern) occurs on the inland slopes of the Great Dividing Range. Its current distribution extends from the Burdekin-Lynd Divide in central Queensland, west to Longreach and Charleville, east to the coast between Port Curtis and Proserpine, and south to New South Wales (NSW) north of 29° S (Cooper et al., 2014). There is a broad zone of hybridisation with the northern subspecies along the Burdekin-Lynd Divide (Higgins & Davies, 1996; Garnett & Crowley, 2000).

The subspecies has disappeared from the southern half of its historical range. Formerly widespread and abundant in NSW, occurring south to West Wyalong at 34°S, its range has contracted markedly since the 1870s. There have been few sightings in NSW since 1975, with only three confirmed reports since 2000 (Higgins & Davies, 1996; Garnett & Crowley, 2000; Cooper et al., 2014).

### Relevant Biology/Ecology

The squatter pigeon (southern) inhabits the grassy understorey of open eucalypt woodland, and less often savannas. It is nearly always found near permanent water such as rivers, creeks and waterholes. Sandy areas dissected by gravel ridges, which have open and short grass cover allowing easier movement, are preferred. It is less commonly found on heavier soils with dense grass. It often occurs in burnt areas and is sometimes found on tracks and roadsides (Higgins & Davies, 1996; Garnett & Crowley, 2000).

The subspecies nests on the ground, usually laying two eggs among or under vegetation. It forages for seeds among sparse and low grass, in improved pastures, and beside railway lines and with domestic fowl around settlements. It roosts in low trees at night. Its movements are poorly known but it appears to be locally dispersive or resident, with no long-distance seasonal movements recorded (Higgins & Davies, 1996). The generation time is estimated at 5 years (Garnett & Crowley, 2000).

### Threats

The population declined rapidly during the late 19th and early 20th centuries, and continued to decline in NSW and southern Queensland where it is now very rare (Cooper et al., 2014). In NSW, the disappearance of the subspecies has been attributed to overgrazing at times of drought, followed by clearing of vegetation. Its original habitat in NSW is nearly all now grazed by sheep or is under cultivation. In Queensland, much of its original habitat has been replaced with improved pasture for cattle-grazing which, while decreasing the abundance of natural food plants, is not as destructive as grazing by sheep and may provide an important source of food (Higgins & Davies, 1996; Garnett & Crowley, 2000).

Current threats include ongoing vegetation clearance and fragmentation, overgrazing of habitat by livestock and feral herbivores such as rabbits (*Oryctolagus cuniculus*), introduction of weeds, inappropriate fire regimes, thickening of understorey vegetation, predation by feral cats (*Felis catus*) and foxes (*Vulpes vulpes*), trampling of nests by domestic stock and illegal shooting (Garnett & Crowley, 2000; Stewart, pers. comm. 2015).

## How judged by the Committee in relation to the EPBC Act Criteria and Regulations

**Criterion 1. Population size reduction (reduction in total numbers)**
Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

| | Critically Endangered<br>Very severe reduction | Endangered<br>Severe reduction | Vulnerable<br>Substantial reduction |
|---|---|---|---|
| **A1** | ≥ 90% | ≥ 70% | ≥ 50% |
| **A2, A3, A4** | ≥ 80% | ≥ 50% | ≥ 30% |

| | | | |
|---|---|---|---|
| A1 | Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased. | *based on any of the following:* | (a) direct observation [*except A3*] |
| A2 | Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible. | | (b) an index of abundance appropriate to the taxon |
| A3 | Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [*(a) cannot be used for A3*] | | (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat |
| A4 | An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible. | | (d) actual or potential levels of exploitation |
| | | | (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites |

**Evidence:**

**Insufficient data to determine eligibility**

The available information suggests that the squatter pigeon (southern) has continued to decline in southern Queensland and northern NSW. However, it is unclear how much of this decline occurred over the past three generations (15 years), as sub-populations in these regions are very low and there are insufficient data to determine trends. In Queensland, small colonies that once persisted in the south-eastern region are no longer found, with only one record in the Toowomba-Lockyer area and one record near Sundown National Park in the past few years (Stewart, pers. comm. 2015).

In NSW there were no confirmed reports between 1980 and 2000, and only three confirmed reports since 2000 (Cooper et al., 2014; Cooper, pers. comm. 2015). Breeding has not been recorded in NSW at any time during the past 50 years, suggesting that there is little or no remaining suitable breeding habitat (Cooper et al., 2014; Cooper, pers. comm. 2015). The NSW population is estimated to be extremely low at <100 individuals with an extent of occurrence estimated at <1000 $km^2$ (Cooper et al., 2014; Cooper, pers. comm. 2015).

The subspecies remains common north of the Carnarvon Ranges in central Queensland, where it is likely distributed as a single, continuous (i.e. inter-breeding) sub-population (Squatter

Pigeon Workshop, 2011). Numerous, recent records of the subspecies in the region between Injune and the Carnarvon Ranges (QLD DEHP, 2012) suggest that squatter pigeons (southern) found in this region are also part of the northern, continuous sub-population. However, no surveys have been undertaken in central Queensland to determine its status, and threatening processes such as fire, vegetation thickening, and coal and gas mining are likely to be affecting its habitat (Stewart, pers. comm. 2015).

Following assessment of the available information the Committee has determined that while there is evidence of ongoing population declines, the available evidence is insufficient to determine whether the rate of decline has changed during recent decades. Therefore, the Committee has determined there is insufficient data to judge whether the status of the squatter pigeon (southern) against this criterion should be changed from its current Vulnerable listing.

| **Criterion 2. Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy** | | | |
|---|---|---|---|
| | **Critically Endangered Very restricted** | **Endangered Restricted** | **Vulnerable Limited** |
| B1. Extent of occurrence (EOO) | **< 100 km²** | **< 5,000 km²** | **< 20,000 km²** |
| B2. Area of occupancy (AOO) | **< 10 km²** | **< 500 km²** | **< 2,000 km²** |
| AND at least 2 of the following 3 conditions: | | | |
| (a) Severely fragmented OR Number of locations | **= 1** | **≤ 5** | **≤ 10** |
| (b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals | | | |
| (c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals | | | |

**Evidence:**

**Not eligible**

Garnett & Crowley (2000) estimated the extent of occurrence to be 440 000 $km^2$ and the area of occupancy to be 10 000 $km^2$. These estimates were considered to be of medium and low reliability respectively. There are no other estimates available describing the species extent or area of occupancy.

The Queensland Resources Council (2015), which used GIS data (based on a 2 x 2 km grid) to examine the extent of squatter pigeon (southern) habitat overlapping resource industry sites, calculated the extent of occurrence to be 1 684 230 $km^2$ and the area of occupancy to be 2 888 $km^2$. Although it is unclear whether this entire habitat area is presently occupied, these data only covered a proportion of the subspecies' potential habitat, and support the conclusion that it does not meet the thresholds under Criterion B1 and B2.

Following assessment of the information the Committee has determined that the geographic distribution is not limited. Therefore, the subspecies has not been demonstrated to have met this required element of this criterion.

| Criterion 3. Population size and decline | | | |
|---|---|---|---|
| | **Critically Endangered Very low** | **Endangered Low** | **Vulnerable Limited** |
| Estimated number of mature individuals | **< 250** | **< 2,500** | **< 10,000** |
| AND either (C1) or (C2) is true | | | |
| C1 An observed, estimated or projected continuing decline of at least (up to a max. Of 100 years in future) | **Very high rate 25% in 3 years or 1 generation (whichever is longer)** | **High rate 20% in 5 years or 2 generations (whichever is longer)** | **Substantial rate 10% in 10 years or 3 generations (whichever is longer)** |
| C2 An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions: | | | |
| (a) (i) Number of mature individuals in each subpopulation | **≤ 50** | **≤ 250** | **≤ 1,000** |
| (a) (ii) % of mature individuals in one subpopulation = | **90 – 100%** | **95 – 100%** | **100%** |
| (b) Extreme fluctuations in the number of mature individuals | | | |

**Evidence:**

**Not eligible**

Garnett & Crowley (2000) estimated the number of mature individuals to be approximately 40 000, although this was considered to be of low reliability. Limited surveys have been undertaken and there are no reliable estimates of current population size or trends (Stewart, pers. comm. 2015); however, given the previous population estimate it is unlikely that the species meets the threshold for listing under this criterion.

The Committee considers that the subspecies is ineligible for listing under any category in this criterion as it is thought there are likely to be more than 10,000 mature individuals in the population.

| Criterion 4. Number of mature individuals | | | |
|---|---|---|---|
| | **Critically Endangered Extremely low** | **Endangered Very Low** | **Vulnerable Low** |
| Number of mature individuals | **< 50** | **< 250** | **< 1,000** |

**Evidence:**

**Not eligible**

Garnett & Crowley (2000) estimated the number of mature individuals to be approximately 40 000. Although this estimate was considered to be of low reliability and is out of date, it is highly unlikely that the current population is <1000 mature individuals.

The estimated number of mature individuals is approximately 40 000 which is not considered extremely low, very low or low. Therefore, the species has not been demonstrated to have met this required element of this criterion.

| Criterion 5. Quantitative Analysis | | | |
|---|---|---|---|
| | Critically Endangered<br>Immediate future | Endangered<br>Near future | Vulnerable<br>Medium-term future |
| Indicating the probability of extinction in the wild to be: | ≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.) | ≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.) | ≥ 10% in 100 years |

**Evidence:**

**Insufficient data to determine eligibility**

Population viability analysis has not been undertaken.

Consideration for delisting

The assessment indicates that there is insufficient evidence to judge whether the squatter pigeon (southern) is no longer eligible to be listed as Vulnerable under the EPBC Act. There is evidence that declines are continuing in the southern part of its range, and considerable uncertainty regarding population trends across its total range due to insufficient survey effort. It cannot be clearly demonstrated that the subspecies is ineligible for listing under Criterion 1.

The inclusion of the squatter pigeon (southern) in the Vulnerable category is contributing to the survival of the subspecies, as the EPBC Act requires project proponents to refer a proposal for assessment if it may have a significant impact on a threatened species. Where appropriate, the department has issued conditions requiring proponents to avoid, minimise or mitigate impacts on the subspecies.

## Conservation Actions

### Recovery Plan

The Committee recommends that there should not be a recovery plan for *Geophaps scripta scripta* (squatter pigeon (southern)) as the approved conservation advice for the subspecies provides sufficient direction to implement priority actions and mitigate against key threats.

Primary Conservation Action

### Conservation and Management Actions

- Identify sub-populations of high conservation priority, especially in the southern part of the squatter pigeon’s (southern) range.
- Protect and rehabilitate areas of vegetation that support important sub-populations.
- Protect sub-populations of the listed subspecies through the development of covenants, conservation agreements or inclusion in reserve tenure.
- Develop and implement a stock management plan for key sites.
- Develop and implement a management plan, or nominate an existing plan to be implemented, for the control and eradication of feral herbivores in areas inhabited by the squatter pigeon (southern).
- Raise awareness of the squatter pigeon (southern) within the local community, particularly among land managers.

### Survey and Monitoring priorities

- Monitor selected sub-populations throughout the distribution of the subspecies to identify rates of population change.

**Information and Research priorities**

- Identify preferred food plants, and the responses of these to fire and grazing regimes.
- Determine patterns of dispersal or residency, and the factors that may determine these.
- Assess reproductive success, and the factors that affect this.
- Assess the species' status, and the impacts of mining, in central Queensland.

## Recommendations

(i) The Committee recommends that *Geophaps scripta scripta* should retain its current listing status of Vulnerable under the EPBC Act as there is insufficient evidence to support transferring it to a different category.

(ii) The Committee recommends that there should not be a recovery plan for this subspecies.

Threatened Species Scientific Committee

02/09/2015

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Australian Government
Department of the Environment

The Minister approved this conservation advice on 25/06/2015 and transferred this species from the Endangered to the Critically Endangered category, effective from 08/07/2015

# Conservation Advice

# *Anthochaera phrygia*

regent honeyeater

## Taxonomy

The species is conventionally accepted as *Anthochaera phrygia* (regent honeyeater) Shaw, 1794. It was previously referred to as *Xanthomyza phrygia*; the change to the genus *Anthochaera phrygia* is based on molecular evidence (Christidis and Boles, 2008).

## Summary of assessment

### Conservation status

Critically endangered: Criterion 1 A2(a)

*Anthochaera phrygia* has been found to be eligible for listing under the following listing categories:
Criterion 1 A2(a): Critically Endangered
Criterion 3 C2a(ii): Endangered
Criterion 4: Vulnerable

The highest category for which *Anthochaera phrygia* is eligible to be listed is Critically Endangered.

Species/subspecies can be listed as threatened under state and territory legislation. For information on the listing status of this species under relevant state or territory legislation, see http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

### Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of new information provided to the Committee to list *Anthochaera Phrygia.*

### Public Consultation

Notice of the proposed amendment and a consultation document was made available for public comment for > 30 business days between 30 October 2014 and 21 December 2014. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

## Species Information

### Description

The regent honeyeater is a striking, predominantly black and yellow bird. Its head and neck are black, with warty pink or yellow skin around the eyes. The upperparts of its body are black and heavily scalloped with pale yellow. The breast and upper belly are black with a pale yellow to white v-shaped pattern, and the lower belly is a pure pale yellow. The wing and tail feathers have broad yellow edges.

## Distribution

The Regent honeyeater is endemic to mainland south-eastern Australia. It has a patchy distribution which extends from south-east Queensland, through New South Wales (NSW) and the Australian Capital Territory (ACT), to central Victoria. Records are widely distributed across its range, but it is only found regularly at a few localities in NSW and Victoria where most of the sightings have been recorded. There are four known key breeding areas: three in NSW and one in Victoria (Garnett et al., 2011; Higgins et al., 2001; Ingwersen et al., 2013; Webster and Menkhorst, 1992).

The species range and numbers have contracted greatly since about the 1940s. It previously ranged from near Rockhampton in Queensland, to Wilmington in South Australia. It was last recorded in South Australia in 1977 and is now probably extinct in that state. There were reports of 'immense' numbers and 'very large flocks' in the early 20$^{th}$ century, but flocks of more than 30 birds are now uncommon (Higgins et al., 2001).

## Relevant Biology/Ecology

The species mostly inhabits inland slopes of the Great Dividing Range, in areas of low to moderate relief with moist, fertile soils. It is most commonly associated with box-ironbark eucalypt woodland and dry sclerophyll forest, but also inhabits riparian vegetation such as sheoak (*Casuarina spp*) where it feeds on needle-leaved mistletoe and sometimes breeds (Franklin et al., 1989; Higgins et al., 2001; Oliver et al., 1998; Webster and Menkhorst, 1992). It sometimes utilises lowland coastal forest, which may act as a refuge when its usual habitat is affected by drought (Menkorst et al., 1999). It also uses a range of other habitats including remnant patches in farmland and urban areas, roadside reserves and travelling stock routes (Franklin et al., 1989; Higgins et al., 2001; Oliver and Lollback, 2010).

The Regent honeyeater's diet primarily consists of nectar, but also includes invertebrates (mostly insects) and their exudates (e.g. lerps and honeydew), and occasionally fruit. Its time spent foraging for nectar ranges from 10% to 90% depending on availability. It obtains nectar chiefly from eucalypts and mistletoe, and appears reliant on select species which provide reliable nectar flows. It prefers taller and larger diameter trees for foraging, as these typically produce more nectar (Franklin et al., 1989; Menkhorst et al., 1999; Oliver, 2000; Webster and Menkhorst, 1992).

The species' movement patterns are thought to be governed by the flowering of select eucalypt species. It is nomadic and partly migratory, with some predictable seasonal movements observed. The species is highly mobile and capable of travelling large distances, however the regularity and extent of long-distance movements are unknown (Higgins et al., 2001; Ingwersen et al., 2013; Oliver and Lollback, 2010; Webster and Menkhorst, 1992). Aggregations historically occurred at nectar sources, mostly during autumn and winter (Franklin et al., 1989; Webster and Menkhorst, 1992), but these events are now rare. The species roosts communally in small groups or large flocks, in trees with dense foliage. Foraging trees are rarely used as roosting sites (Higgins et al., 2001).

The timing of breeding varies between regions, and appears to correspond with the flowering of key eucalypt and mistletoe species (Franklin et al., 1989; Geering and French, 1998). Breeding mostly occurs during spring and summer, from August to January (Franklin et al., 1989). While there is some fidelity to nesting sites, pairs may nest 85 km from a nest site used the previous year, and some pairs change breeding sites between seasons. Re-nesting may occur after nest failure, but not necessarily in the same location (Geering and French, 1998; Ingwersen et al., 2013; Oliver et al., 1998). Breeding territories usually consists of the nest-tree and surrounding feeding areas, and may extend 5–40 m or more from the nest-tree (Higgins et al., 2001).

Regent honeyeater nests are usually placed in the canopy of mature trees with rough bark. A cup-shaped nest is constructed in which two to three eggs are laid. Nests may be near or far from food resources; one nest has been recorded 700 m from a resource tree (Geering and French, 1998). Most pairs nest solitarily, but sometimes nest in loose congregations where distances between nests can range from 40 m to 110 m depending on location and habitat (Higgins et al., 2001). Generation time is estimated at 8.0 years (Garnett et al., 2011).

### Threats

The decline of the Regent honeyeater is thought to be mainly due to the clearing, fragmentation and degradation of its habitat (Garnett et al., 2011). The species relies on a range of different food resources, and is particularly vulnerable to the removal of large mature trees which are important feeding and breeding habitat (Franklin et al., 1989; Oliver, 2000).

Woodlands have been widely cleared for agriculture and development, or replaced by silviculture, resulting in a fragmented landscape. Fragmentation exposes woodlands to increased degradation. Many remnant areas are in poor health and are continuing to be degraded by the removal of trees for timber and firewood, invasive weeds, inappropriate fire regimes, and grazing by livestock and rabbits which prevent regeneration. Eucalypt dieback (loss of eucalypts in pastoral areas caused by factors such as nutrient overload and salinity) has also resulted in habitat degradation and loss (Garnett et al., 2011; Higgins et al., 2001).

The Regent honeyeater competes with a range of nectarivorous and non-nectarivorous birds for resources, and actively defends feeding and breeding territories (Franklin et al., 1989; Geering and French, 1998; Higgins et al., 2001; Webster and Menkhorst, 1992). Competition for resources with more aggressive honeyeaters, particularly the noisy miner (*Manorina melanocephala*) and noisy friarbird (*Philemon corniculatus*) may be a factor in its decline (Ingwersen et al., 2013; Menkhorst et al., 1999). Increased predation by native nest predators, such as pied currawongs (*Strepera graculina*), may also be a threat (Fulton and Ford, 2002; Remes et al., 2012).

The rapid decline of the once large population also means that a severe loss of genetic variability is also a threat (Garnett et al., 2011).

## How judged by the Committee in relation to the EPBC Act Criteria and Regulations

**Criterion 1. Population size reduction (reduction in total numbers)**
Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

| | Critically Endangered<br>Very severe reduction | Endangered<br>Severe reduction | Vulnerable<br>Substantial reduction |
|---|---|---|---|
| **A1** | **≥ 90%** | **≥ 70%** | **≥ 50%** |
| **A2, A3, A4** | **≥ 80%** | **≥ 50%** | **≥ 30%** |

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [*(a) cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

*based on any of the following:*

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

**Evidence:**

**Eligible under Criterion 1 A2(a) for listing as Critically Endangered**

The population size is difficult to assess. The species is mobile and unpredictable in its movements, and numbers recorded fluctuate greatly between years at a given site. Expert opinion suggests that there are currently 350–400 mature individuals (Ingwersen & Menkhorst, cited in Garnett et al., 2011). The population in NSW was estimated at maximum of 1000 birds in 1997, but there have been many fewer seen subsequently, with a maximum count of just 40 in 2009 (a decline of almost 95%). In north-eastern Victoria there are probably fewer than 20 mature individuals, and probably about 20-30 mature individuals in the Bundarra-Barraba region, NSW (NSW Scientific Committee, 2010). In the 19th century, the species was recorded in 'great' or 'immense' numbers, occasionally in 'thousands' or 'very large flocks' during influxes (Higgins et al., 2001). They are now usually seen singly, in twos, or in small groups, (DSEWPaC, n.d.). Based on the above and inferred from monitoring (Garnett et al., 2011), the species is thought to have undergone a past population decline of >80% over three generations (24 years). The main cause of the decline is thought to be clearance of the species' habitat.

The Committee considers that the species has undergone a very severe reduction in numbers over three generation lengths (24 years for this assessment), equivalent to at least 80 percent, and the reduction and cause of the decline have not ceased. Therefore, the species has been demonstrated to have met the relevant elements of Criterion 1 to make it eligible for listing as Critically Endangered.

| **Criterion 2. Geographic distribution is precarious for either extent of occurrence AND/OR area of occupancy** | | | |
|---|---|---|---|
| | **Critically Endangered Very restricted** | **Endangered Restricted** | **Vulnerable Limited** |
| B1. Extent of occurrence (EOO) | **< 100 km$^2$** | **< 5,000 km$^2$** | **< 20,000 km$^2$** |
| B2. Area of occupancy (AOO) | **< 10 km$^2$** | **< 500 km$^2$** | **< 2,000 km$^2$** |
| AND at least 2 of the following 3 conditions: | | | |
| (a) Severely fragmented OR Number of locations | **= 1** | **≤ 5** | **≤ 10** |
| (b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals | | | |
| (c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals | | | |

**Evidence:**

**Not eligible**

The extent of occurrence is estimated at 600 000 km$^2$ and the area of occupancy at 300 km$^2$. Both are considered to be decreasing, and the number of mature individuals is continuing to decline. However, the population is not severely fragmented and the species occurs at >10 locations. No extreme fluctuations in the population, extent of occurrence or area of occupancy have been recorded (Garnett et al., 2011).

Following assessment of the data the Committee has determined that the geographic distribution is restricted, however there are insufficient data available to judge whether there are threats operating that would make the species' geographic distribution precarious for its survival. Therefore, the species has not been demonstrated to have met this required element of this criterion.

| Criterion 3. Small population size and decline | | | |
|---|---|---|---|
| | Critically Endangered Very low | Endangered Low | Vulnerable Limited |
| Estimated number of mature individuals | < 250 | < 2,500 | < 10,000 |
| AND either (C1) or (C2) is true | | | |
| C1 An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future | Very high rate 25% in 3 years or 1 generation (whichever is longer) | High rate 20% in 5 years or 2 generation (whichever is longer) | Substantial rate 10% in 10 years or 3 generations (whichever is longer) |
| C2 An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions: | | | |
| (a) (i) Number of mature individuals in each subpopulation | ≤ 50 | ≤ 250 | ≤ 1,000 |
| (a) (ii) % of mature individuals in one subpopulation = | 90 – 100% | 95 – 100% | 100% |
| (b) Extreme fluctuations in the number of mature individuals | | | |

**Evidence:**

**Eligible under Criterion 3 C2(a)ii for listing as Endangered**

The number of mature individuals is estimated at 350-400 (Ingwersen & Menkhorst, cited in Garnett et al., 2011) and there is an inferred continuing decline (Garnett et al., 2011), although there is no estimate as to the ongoing rate of decline. More than 95% of mature individuals occur in a single subpopulation (Garnett et al., 2011).

The Committee considers that the estimated total number of mature individuals of this species is low, and the geographic distribution is precarious for the survival of the species because more than 95% of mature individuals occur in a single subpopulation. Therefore, the species has been demonstrated to have met the relevant elements of Criterion 3 to make it eligible for listing as Endangered.

| Criterion 4. Very small population | | | |
|---|---|---|---|
| | Critically Endangered Extremely low | Endangered Very Low | Vulnerable Low |
| Number of mature individuals | < 50 | < 250 | < 1,000 |

**Evidence:**

**Eligible under Criterion 4 for listing as Vulnerable**

The number of mature individuals is estimated at 350-400 (Ingwersen & Menkhorst, cited in Garnett et al., 2011).

The Committee considers that the total number of mature individuals is 350-400 which is low. Therefore, the species has been demonstrated to have met the relevant elements of Criterion 4 to make it eligible for listing as Vulnerable.

| Criterion 5. Quantitative Analysis | | | |
|---|---|---|---|
| | **Critically Endangered Immediate future** | **Endangered Near future** | **Vulnerable Medium-term future** |
| Indicating the probability of extinction in the wild to be: | **≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)** | **≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)** | **≥ 10% in 100 years** |

**Evidence:**

**Not eligible**

Population viability analysis has not been undertaken.

## Conservation Actions

### Recovery Plan

The regent honeyeater *(Anthochaera Phrygia)* was listed under the *Environment Protection and Biodiversity Conservation Act (1999)* in July 2000. At the time of listing, all species were required to have a recovery plan. The decision to have a recovery plan for the regent honeyeater should remain.

### Primary Conservation Objectives

1. Reverse the long-term population trend of decline and increase the numbers of regent honeyeaters to a level where there is a viable, wild breeding population, even in poor breeding years
2. Maintain key regent honeyeater habitat in a condition that maximises survival and reproductive success, and provides refugia during periods of extreme environmental fluctuation.

### Conservation and Management Actions

1. Improve the extent and quality of regent honeyeater habitat.
2. Bolster the wild population with captive-bred birds until the wild population becomes self sustaining.
3. Maintain and increase community awareness, understanding and involvement in the recovery program

### Monitoring priorities

1. Determine trends in the number and location of breeding birds

### Information and research priorities

1. Increase understanding of the size, structure and population trend of the wild population of the regent honeyeater.
2. Increase understanding of movement patterns, particularly after breeding, and environmental correlates of sightings and absences
3. Quantify the impacts of noisy miners on the wild population
4. Develop silvicultural techniques that accelerate maturity in key food species
5. Determine genetic variability, particularly the extent to which the captive population is representative of the wild variability

## Recommendations

(i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **transferring** from the Endangered category to the Critically Endangered category of the list:

*Anthochaera phrygia*

(ii) The Committee recommends that the current decision to have a recovery plan should be upheld.

Threatened Species Scientific Committee

04/03/2015

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The Minister approved this conservation advice on 25/06/2015 and included this species in the Vulnerable category, effective from 08/07/2015

# Conservation Advice

# *Grantiella picta*

painted honeyeater

## Taxonomy

Generally accepted as *Grantiella picta* (painted honeyeater), Gould, 1838. The species is endemic to mainland Australia. Taxonomic uniqueness is high; the species is the only one in its genus and there are no subspecies.

## Summary of assessment

### Conservation status

Vulnerable: Criterion 3 C2a(ii)

*Grantiella picta* has been found to be eligible for listing under criterion 3 only.

Species/subspecies can be listed as threatened under state and territory legislation. For information on the listing status of this species under relevant state or territory legislation, see http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

### Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of new information provided to the Committee to list *Grantiella picta*.

### Public Consultation

Notice of the proposed amendment and a consultation document was made available for public comment for > 30 business days between 30 October 2014 and 21 December 2014. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

## Species Information

### Description

The painted honeyeater has black upperparts, white underparts, black spots on its flanks and yellow edges to the flight and tail feathers. The bill is a deep pink and the eye red. The females are smaller and browner on the back than the male, frequently with fewer streaks or spots on their breast and flanks (Higgins et al., 2001).

The painted honeyeater is the only small to medium honeyeater with a wholly or mostly pink bill, and the only yellow-winged honeyeater with almost wholly white underparts (marked only with sparse, fine and short black streaks) (Higgins et al., 2001).

### Distribution

The species is sparsely distributed from south-eastern Australia to north-western Queensland and eastern Northern Territory. The greatest concentrations and almost all records of breeding come from south of 26ºS, on inland slopes of the Great Dividing Range between the Grampians, Victoria and Roma, Queensland (Higgins et al., 2001).

The species exhibits seasonal north-south movements governed principally by the fruiting of mistletoe, with which its breeding season is closely matched (Barea and Watson, 2007). Many birds move after breeding to semi-arid regions such as north-eastern South Australia, central and western Queensland, and central Northern Territory. Considering its dispersive habits, the species is considered to have a single population (Garnett et al., 2011).

### Cultural Significance

Mistletoe fruit was consumed as a food source by many Aboriginal nations. The spreading of mistletoe by the painted honeyeater may have contributed to the availability of mistletoe fruit for indigenous peoples throughout the painted honeyeater's distribution (Lindsay, pers. comm., 2014).

### Relevant Biology/Ecology

The painted honeyeater is the most specialised of Australia's honeyeaters. Its diet mainly consists of mistletoe fruits, but also includes nectar (from flowering mistletoe, eucalypts and possibly banksias) and arthropods, especially in the non-breeding season (Garnett et al., 2011; Higgins et al., 2001; BirdLife International, n.d.). Arthropods are an important dietary item provided to nestlings (Barea, 2008a) and for adults during the breeding season (Barea and Herrera, 2009).

The species inhabits mistletoes in eucalypt forests/woodlands, riparian woodlands of black box and river red gum, box-ironbark-yellow gum woodlands, acacia-dominated woodlands, paperbarks, casuarinas, callitris, and trees on farmland or gardens. The species prefers woodlands which contain a higher number of mature trees, as these host more mistletoes. It is more common in wider blocks of remnant woodland than in narrower strips (Garnett et al., 2011), although it breeds in quite narrow roadside strips if ample mistletoe fruit is available (BirdLife International, n.d.).

The species often occurs singly or in pairs, and less often in small flocks. Breeding occurs from October to March when mistletoe fruits are most available. The species builds a flimsy cup nest made of plant-fibre, spiders' webs and rootlets in the outer foliage of trees anywhere from 3 m to 20 m above the ground. Usually 2-3 eggs are laid and both parents incubate the nest, brood and feed young (Barea, 2008b; Higgins et al., 2001; Garnett et al., 2011, Barea, 2012).

The species appears to prefer mistletoe as a nest substrate and selects nest sites in habitats where mistletoe prevalence and parasitism rates are high (Barea, 2008b). Nesting success is relatively low; in the foliage of trees it is approximately 43% and within mistletoe clumps it is only 17%, with 83% of nest failures caused by predation (Barea and Watson, 2013). Generation time is estimated at 5.8 years, with a maximum longevity in the wild estimated at 10.1 years (Garnett et al., 2011).

### Threats

Habitat loss is a key threat to this species. Much of its breeding habitat has been cleared or has been reduced to ageing, widely-spaced trees, particularly in box-ironbark and boree woodlands. Its non-breeding habitat is also still being cleared for agriculture (Barea, 2008a). Some acacia and casuarina woodlands (e.g. brigalow and buloke), in which the species occurs, have been heavily cleared and degraded to the extent that they are now nationally endangered ecological communities (DotE, 2015; Garnett et al., 2011). In the breeding strongholds of south-eastern Australia, woodlands are being cleared at a greater rate than they are being restored. In particular, regrowth woodland, which contains similar or higher densities of mistletoe than remnant woodland, is viewed as having little conservation value and is being cleared at an unsustainable rate (Lindsay, pers. comm., 2014).

Most of the painted honeyeater's remaining habitat is on private land which continues to be degraded by grazing by livestock, native macropods and rabbits (*Oryctolagus cuniculus*) (Garnett et al., 2011). Grazing inhibits tree recruitment through the consumption of seedlings and suckers, and as mature trees die there is insufficient recruitment to replace them (Lindsay, pers. comm., 2014). Grazing results in an uneven age structure of mistletoe host trees and promotion of future collapse of mistletoe resources. Grazing thresholds supporting non-significant effects to mistletoe resources are unknown, but may be very low (Barea, pers. comm., 2014). Additionally, many landholders remove mistletoes from trees as they view it as a pest. Mistletoe becomes more abundant on trees that have become isolated as a result of land disturbance or clearing (Lindsay, pers. comm., 2014).

Even with no further loss or degradation of habitat, the species is likely to continue to decline at some of the edges of its distribution (Ford et al., 2009). It is likely that numbers of painted honeyeaters breeding in southern and central Queensland are already extremely low, and the use of habitat by painted honeyeaters in north-west Queensland is becoming increasingly uncommon. Under current trends, the painted honeyeater may become extinct or absent from the extremes of its northern distribution (Lindsay, pers. comm., 2014).

Other threats to the painted honeyeater include: competition with the aggressive noisy miner (*Manorina melanocephala*); predation by invasive species (e.g. black rats *Rattus rattus*); deliberate destruction of mistletoe in production forests; exacerbation of tree decline through pasture improvement activities; collision with road vehicles; and nest predation by over-abundant pied currawongs (*Strepera graculina*), pied and grey butcherbirds (*Cracticus nigrogularis* and *Cracticus torquatus*), and crows and ravens (Corvidae) (Lindsay, pers. comm. 2014; DEPI, 2014).

## How judged by the Committee in relation to the EPBC Act Criteria and Regulations

**Criterion 1. Population size reduction (reduction in total numbers)**
Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

| | Critically Endangered<br>Very severe reduction | Endangered<br>Severe reduction | Vulnerable<br>Substantial reduction |
|---|---|---|---|
| **A1** | **≥ 90%** | **≥ 70%** | **≥ 50%** |
| **A2, A3, A4** | **≥ 80%** | **≥ 50%** | **≥ 30%** |

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(*a*) *cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

*based on any of the following:*

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

**Evidence:**

**Not eligible**

It is thought that the population has undergone long-term decline, likely to have been accelerated by clearance of trees for agriculture, and lack of regeneration resulting from grazing by introduced herbivores. Much of its breeding habitat has become degraded, although it may have benefited from an increase in abundance of mistletoe in some degraded woodlands (Higgins et al., 2001). The population decline is suspected to be 20-29% over the last three generations (17 years), based on monitoring, a reduced area of occupancy and deteriorating habitat quality (Garnett et al., 2011).

Following assessment of the data the Committee has determined that the species is not eligible for listing in any category under this criterion as the past, current or future population declines are thought unlikely to exceed 30% in any three-generation period.

| **Criterion 2. Geographic distribution is precarious for either extent of occurrence AND/OR area of occupancy** | | | |
|---|---|---|---|
| | **Critically Endangered Very restricted** | **Endangered Restricted** | **Vulnerable Limited** |
| B1. Extent of occurrence (EOO) | **< 100 km$^2$** | **< 5,000 km$^2$** | **< 20,000 km$^2$** |
| B2. Area of occupancy (AOO) | **< 10 km$^2$** | **< 500 km$^2$** | **< 2,000 km$^2$** |
| AND at least 2 of the following 3 conditions: | | | |
| (a) Severely fragmented OR Number of locations | **= 1** | **≤ 5** | **≤ 10** |
| (b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals | | | |
| (c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (number of mature individuals | | | |

**Evidence:**

**Not eligible**

The extent of occurrence is estimated to be 2 800 000 km$^2$ and the area of occupancy estimated to be 1000 km$^2$ (Garnett et al., 2011). Its distribution may have contracted, with the species likely to be disappearing or have already disappeared from most of its north-west Queensland and Northern Territory range (Lindsay, pers. comm., 2014). Its abundance has declined in western New South Wales and Victoria, and there is an inferred continuing decline in the number of mature individuals and area of occupancy. However, the species distribution is not severely fragmented and population fluctuations have not been extreme (Garnett et al., 2011).

Following assessment of the data the Committee has determined that the geographic distribution is limited, however there are insufficient data available to judge whether there are threats operating that would make the species' geographic distribution precarious for its survival. Therefore, the species has not been demonstrated to have met this required element of this criterion.

| **Criterion 3. Small population size and decline** | | | |
|---|---|---|---|
| | **Critically Endangered Very low** | **Endangered Low** | **Vulnerable Limited** |
| Estimated number of mature individuals | **< 250** | **< 2,500** | **< 10,000** |
| AND either (C1) or (C2) is true | | | |
| C1 An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future | **Very high rate 25% in 3 years or 1 generation (whichever is longer)** | **High rate 20% in 5 years or 2 generation (whichever is longer)** | **Substantial rate 10% in 10 years or 3 generations (whichever is longer)** |

| | | | |
|---|---|---|---|
| C2 An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions: | | | |
| (a) (i) Number of mature individuals in each subpopulation | **≤ 50** | **≤ 250** | **≤ 1,000** |
| (a) (ii) % of mature individuals in one subpopulation = | **90 – 100%** | **95 – 100%** | **100%** |
| (b) Extreme fluctuations in the number of mature individuals | | | |

**Evidence:**

**Eligible under Criterion 3C2a(ii) for listing as Vulnerable**

Garnett et al. (2011) estimate the total number of individuals at <10 000, based on an extrapolation of counts undertaken in areas of NSW and Victoria. The population is suspected to have declined by 20-29% over the last three generations based on monitoring, a reduced area of occupancy and deteriorating habitat quality (Garnett et al., 2011). Threats to the species' already fragmented habitat are ongoing, with habitat continuing to be cleared for agriculture and degraded by over-grazing (BirdLife International, n.d.). This suggests that the population is likely to continue to decline at a substantial rate. Its geographic distribution is precarious for its survival as 100% of mature individuals exist in one subpopulation (Garnett et al., 2011).

The Committee considers that the estimated total number of mature individuals of this species is limited, the geographic distribution is precarious for the survival of the species because 100% of mature individuals exist in one subpopulation, and a decline in extent of occurrence, area of occupancy, habitat, number of individuals and number of locations may be inferred or projected.

| **Criterion 4. Very small population** | | | |
|---|---|---|---|
| | **Critically Endangered Extremely low** | **Endangered Very Low** | **Vulnerable Low** |
| Number of mature individuals | **< 50** | **< 250** | **< 1,000** |

**Evidence:**

**Not eligible**

Estimating population size is difficult given the species' rarity in most of its range. However, the total number of mature individuals is likely to be <10 000 (Garnett et al., 2011).

The total number of mature individuals is not considered extremely low, very low or low. Therefore, the species has not been demonstrated to have met this required element of this criterion.

| **Criterion 5. Quantitative Analysis** | | | |
|---|---|---|---|
| | **Critically Endangered Immediate future** | **Endangered Near future** | **Vulnerable Medium-term future** |
| Indicating the probability of extinction in the wild to be: | **≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)** | **≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)** | **≥ 10% in 100 years** |

**Evidence:**

**Insufficient data to determine eligibility**

Population viability analysis has not been undertaken for this species, therefore there is insufficient information to assess against this criterion

## Conservation Actions

### Recovery Plan

There should be a recovery plan for *Grantiella picta* (painted honeyeater) as existing mechanisms are not adequate to stop its decline and support recovery. The species has a widespread scattered distribution that spans five states and occurs on public and private land held across multiple land holders and land tenures. Threats to the species are ongoing, particularly to its woodland habitat which continues to be cleared and degraded across its range. Only two state governments, Victoria and New South Wales, have identified management actions for the species. All of these factors make planning recovery for this species complicated, and best managed through a nationally coordinated recovery plan.

### Primary Conservation Objectives

1. Stable population at key sites
2. No further clearance of suitable habitat
3. Adequate numbers of mature trees and mistletoe populations across its distribution

### Conservation and Management Actions

1. Protect all woodland from clearing in which painted honeyeaters have been regularly sighted, including remnant roadside vegetation and regrowth
2. Place all areas of public land that contain the species under secure conservation management, particularly those in timber reserves, transport corridors and areas owned by local government
3. Promote ecological management of woodland remnants and regrowth on public or private land, including maintaining adequate populations of mature trees and trees that host the species' preferred mistletoe species
4. Promote revegetation and land reclamation that recreates woodland habitat with a full complement of biodiversity, including the painted honeyeater
5. Control firewood collection from areas occupied by painted honeyeaters, and reduce grazing densities to a level where mistletoe host population dynamics are secured over the long term

### Monitoring priorities

1. Population trends at key sites
2. Health of key sites, particularly where there are management interventions

### Information and research priorities

1. Ecology and locations during the non-breeding season, including foraging resources in the northern parts of the species' distribution
2. Improved understanding of reproductive success and causes of nest failure across a range of habitats, and influence on the species' population viability
3. Improved estimates of population size and distribution

## Recommendations

(i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **including** in the list in the Vulnerable category:

*Grantiella picta*

(ii) The Committee recommends that there should be a recovery plan for this species.

Threatened Species Scientific Committee

04/03/2015

## References cited in the advice


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The Minister approved this conservation advice and included this species in the vulnerable category, effective from 04/07/2019.

# Conservation Advice

# *Hirundapus caudacutus*

White-throated Needletail

## Taxonomy

Conventionally accepted as *Hirundapus caudacutus* Latham, 1801.

Other names: Needle-tailed, Spine-tailed or White-throated Swift, Needletail or Northern Needletail, Needle-tailed, Pin-tailed or Prickly Swallow, Prickly Tail or Prickly Swift, Storm Bird (Higgins 1999).

There are two recognised subspecies:

- subspecies *caudacutus* occurs in central and eastern Siberia, northern Mongolia, northern China and the Korean Peninsula, Sakhalin and Japan, and migrates to spend the non-breeding season in Australasia.
- subspecies *nudipes*, which breeds in the Himalayas from northern Pakistan to Assam and south-western China, and is largely resident and does not occur in Australasia (Chantler 1999; Higgins 1999).

## Summary of assessment

### Conservation status

Vulnerable: Criterion 1 A2(b)

The highest category for which *Hirundapus caudacutus* is eligible to be listed is Vulnerable.

*Hirundapus caudacutus* has been found to be eligible for listing under the following categories:
Criterion 1: A2(b): Vulnerable
Criterion 2: Not eligible
Criterion 3: Not eligible
Criterion 4: Not eligible
Criterion 5: Not eligible

The Victorian Scientific Advisory Committee undertook an assessment in 2016 and found White-throated Needletail eligible for listing. The White-throated Needletail is listed as threatened in Victoria under the *Flora and Fauna Guarantee Act 1988*.

For information on the listing status of this species under relevant state or territory legislation, see http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

### Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of information provided by a nomination from the public to list the White-throated Needletail.

### Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 37 business days between 31 October and 21 December 2018. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

## Species/sub-species information

### Description

The White-throated Needletail is a large swift with a thickset, cigar-shaped body, stubby tail and long pointed wings (20 cm in length and approximately 115–120 g in weight). Sexes are alike, with no seasonal variation in plumage. The adults have a dark-olive head and neck, with an iridescent gloss on the crown; the mantle and the back are paler, greyish; and the upperwings are blackish, sometimes with a greenish gloss, with a contrasting white patch at the base of the trailing edge; the uppertail is black with a greenish gloss. The face is dark-olive with a narrow, white band across the forehead and lores and a white patch on the chin and throat. The underparts are generally dark-olive except for a U-shaped band across the rear flanks, the vent and the undertail coverts, and the undertail is black with a greenish gloss. The underwing is black brown with glossy grey-brown flight feathers. The bill is black, the eyes black-brown and the legs and feet are dark grey, sometimes with a pinkish tinge.

Juveniles have a similar appearance to the adults, but can be separated by duller plumage, with little gloss. The pale saddle is duller, contrasting less with the head, neck and uppertail; and the white band across the forehead and white patches on the upperwings and the vent and undertail coverts are all less prominent and duller (Higgins 1999).

The White-throated Needletail is generally gregarious when in Australia, sometimes occurring in large flocks, though they are occasionally seen singly. Occasionally the species occurs in mixed flocks with other aerial insectivores, including Fork-tailed Swifts (*Apus pacificus*) and Fairy Martins (*Hirundo ariel*) (Learmonth 1950, 1951; McMicking 1925; Wheeler 1959).

### Distribution

The White-throated Needletail is widespread in eastern and south-eastern Australia (Barrett et al. 2003; Blakers et al. 1984; Higgins 1999). In eastern Australia, the species is recorded in all coastal regions of Queensland and NSW, extending inland to the western slopes of the Great Dividing Range and occasionally onto the adjacent inland plains. Further south on the mainland, it is widespread in Victoria, though more so on and south of the Great Dividing Range, and there are few records in western Victoria. The species occurs in adjacent areas of south-eastern South Australia, where it extends west to the Yorke Peninsula and the Mount Lofty Ranges. It is widespread in Tasmania (Barrett et al. 2003; Blakers et al. 1984; Higgins 1999).

White-throated Needletails only occur as vagrants in the Northern Territory (recorded in the Top End, including around Darwin, Katherine and Mataranka and Tennant Creek; and further south around Alice Springs) and in Western Australia (at disparate sites from the Mitchell Plateau in the Kimberley, south to the Nullarbor Plain and Augusta in the South West, and west to Barrow Island, the Houtman Abrolhos Islands and the Swan River Plain) (Barrett et al. 2003; Blakers et al. 1984; Brooker et al. 1979; Sedgwick 1978; Slater 1964; Storr 1987; Storr et al. 1986; Wheeler 1959). The species is also a vagrant to various outlying islands, including Norfolk, Lord Howe, Macquarie, Christmas and Cocos-Keeling Islands (Barrand 2005; Green 1989; McAllan et al. 2004; Schodde et al. 1983; Stokes et al. 1984; Warham 1961).

The breeding distribution of the White-throated Needletail is fragmented, with two subspecies occurring in different parts of Asia. The nominate subspecies *H. c. caudacutus* breeds from northern Japan west to central and eastern Siberia, while subspecies *H. c. nudipes* breeds from south-western China to northern Pakistan, and is largely resident (Chantler 1999).

## Relevant biology/ecology

### *General habitat*

In Australia, the White-throated Needletail is mostly aerial, from heights of less than 1 m up to more than 1000 m above the ground (Coventry 1989; Tarburton 1993). Although they occur over most types of habitat, they are recorded most often above wooded areas, including open forest and rainforest, and may also fly below the canopy between trees or in clearings (Higgins 1999). When flying above farmland, they are more often recorded above partly cleared pasture, plantations or remnant vegetation at the edge of paddocks (Emison & Porter 1978; Friend 1982; Tarburton 1993). In coastal areas, they have been observed flying over sandy beaches or mudflats (Cooper 1971; Crompton 1936; Davis 1965), and often around coastal cliffs and other areas with prominent updraughts, such as ridges and sand-dunes (Cooper 1971; Dawson et al. 1991; Loyn 1980; Mitchell et al. 1996; Schulz & Kristensen 1994).

### *Roosting habitat*

The species roosts in trees amongst dense foliage in the canopy or in hollows (Corben et al. 1982; Day 1993; Quested 1982; Tarburton 1993, 2015).

### *Feeding*

During the non-breeding season in Australia, the White-throated Needletail has been recorded eating a wide variety of insects, including beetles, cicadas, flying ants, bees, wasps, flies, termites, moths, locusts and grasshoppers (Cameron 1968; Madden 1982; Rose 1997; Tarburton 1993).

### *Life history*

The species does not breed in Australia (Higgins 1999). The White-throated Needletail lays eggs from late May to early June in their breeding grounds in the Northern Hemisphere (Chantler 1999). The nest is placed in a vertical hollow in a tall coniferous tree or on a vertical rock-face, either comprising a small bracket or half-cup of thin twigs and straw cemented together by the bird's saliva and glued to the side of the hollow or rock (Roberts 1991), or a shallow scrape among debris accumulated at the bottom of a tree hollow (Chantler 1999). Clutches usually comprise two eggs (Dement'ev & Gladkov 1951; Yamashina 1962) but some may be as large as seven eggs (Chantler 1999), and these are incubated by both sexes for 40 days (Chantler 1999). The chicks fledge after 40–42 days (Chantler 1999; Dement'ev & Gladkov 1951; Yamashina 1962).

There are no published details of the ages of sexual maturity or life expectancy of the White-throated Needletail, however, the estimated generation time is 8.5 years (BirdLife International 2018).

### *Movement patterns*

The nominate subspecies *caudacutus* is a trans-equatorial migrant, breeding in the Northern Hemisphere and flying south for the boreal winter (Higgins 1999).

### *Departure from breeding grounds*

The species breeds in wooded lowlands and sparsely vegetated hills, as well as mountains covered with coniferous forests in eastern Siberia, north-eastern China, the Korean Peninsula and Japan. The species leaves the breeding grounds between late August and October, flying singly or in scattered flocks (Chantler 1999; Dement'ev & Gladkov 1951).

The southern passage from the breeding grounds takes needletails through eastern China and Japan between August and November (Dement'ev & Gladkov 1951), and the Korean Peninsula mainly between September and October (Gore & Won 1971). Between late September and late November, most birds apparently migrate through Borneo and along the Malay Peninsula (Higgins 1999; M. Tarburton pers. Comm.). Passage may be extremely rapid and thus poorly detected (White & Bruce 1986). In Papua New Guinea, most records, presumably of birds on southern passage, occur between September and November (Bell 1970; Coates 1985; Hicks 1990; Rand & Gilliard 1967).

*Non-breeding season in Australia*

White-throated Needletails mainly enter Australia via the Torres Strait, usually during September and October, and sometimes in early November (Draffan et al. 1983; Warham 1962), and less often via the Arafura Sea (Warham 1962). The mean date of the first sighting in Australia is 22 October ± 27.62 days (range of 1 September and 27 December (Higgins 1999)). After reaching Australia, they move south along both sides of the Great Dividing Range in Queensland and NSW in October and November, usually arriving in southern parts of their range (Victoria and Tasmania) in November, with increasing numbers recorded from December and peaking in March (Emison et al. 1987; Higgins 1999).

*Northern passage*

Northward migration from Australia begins between mid-March and April (Higgins 1999). A few birds occasionally remain in Australia during the breeding season (Higgins 1999).

When undertaking northern migration to return to their breeding grounds in the Northern Hemisphere, the majority of the White-throated Needletail population pass through New Guinea in March and April (Eastwood & Gregory 1995; Hicks 1990) and are thought to mostly travel east of Borneo (Smythies 1957, 1981). There are records of birds on northward passage through Indonesia in March and April (Coates & Bishop 1997; Smythies 1957, 1981; White & Bruce 1986), and there are records from the Malay Peninsula, between March and mid-May (Medway & Wells 1976; Wells 1999). They are also recorded passing through Hong Kong between mid-March and mid-May (Chalmers 1986; Chantler & Driessens 1995), and eastern China in May.

White-throated Needletails arrive back at their breeding grounds in the Northern Hemisphere in mid-May (Chantler 1999; Chantler & Driessens 1995; Dement'ev & Gladkov 1951).

## Threats

In Australia there is evidence of collision with wind turbines (Hull 2013), overhead wires (Cameron & Hinchey 1981; Campbell 1930; Wheeler 1965), windows (Slater 1964) and lighthouses (Draffan et al. 1983; Stokes 1983) but the scale of impact at the population level requires further investigation.

Tarburton (2014) identified the use of insecticides, particularly organochlorines, as another possible cause of decline of White-throated Needletails, either through a decrease in the abundance of invertebrates from wide use of insecticides or from secondary poisoning by insecticides accumulated as sublethal doses in the prey.

As noted in Tarburton (2014), the loss of roosting sites in Australia may also be contributing to the decline of the species. Loss of forest and woodland habitats may have also resulted in the reduction of invertebrate prey.

It is thought that logging of taiga forests in Siberia, where most of the population breeds, poses the greatest risk by removing old trees and stumps that contain hollows which this species uses to breed (Newell et al. 2000; Crowley 2005; Smirnov et al. 2013).

On the species' breeding grounds it was formerly hunted with nets placed near their breeding sites.

**Table 1**: Threats impacting the White-throated Needletail in approximate order of severity of risk, based on available evidence

| Number | Threat factor | Threat type and status | Evidence base |
|---|---|---|---|
| 1.0 | Habitat loss and fragmentation | | |
| 1.1 | Logging of breeding habitat | suspected current | The loss of old, hollow bearing trees in the breeding range in the northern hemisphere is suspected be impacting breeding success (Tarburton 2014). |
| 1.2 | Loss of habitat in the non-breeding range | suspected current | The loss of roosting sites in Australia may be contributing to the decline of the species. Loss of forest and woodland habitats may have also resulted in the reduction of invertebrate prey (Tarburton 2014). |
| 2.0 | Direct mortality | | |
| 2.1 | Wind turbines and overhead wires | known current | Impacts from wind farms can be categorised as direct (collisions with wind turbines) and indirect (barrier and alienation, with the potential to reduce access to habitat).<br><br>Collision with wind turbines and overhead wires is of low severity and affects a small number of birds (Hull 2013) |
| 3.0 | Poisoning | | |
| 3.1 | Organochlorines | potential | Tarburton (2014) identified the use of insecticides, particularly organochlorines, as a possible cause of decline of White-throated Needletail, either through a decrease in the abundance of invertebrates from wide use of insecticides or from secondary poisoning by insecticides accumulated as sublethal doses in the prey. |

## How judged by the Committee in relation to the EPBC Act criteria and regulations

| **Criterion 1. Population size reduction (reduction in total numbers)**<br>Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4 | | | |
|---|---|---|---|
| | **Critically Endangered**<br>**Very severe reduction** | **Endangered**<br>**Severe reduction** | **Vulnerable**<br>**Substantial reduction** |
| **A1** | **≥ 90%** | **≥ 70%** | **≥ 50%** |
| **A2, A3, A4** | **≥ 80%** | **≥ 50%** | **≥ 30%** |

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(*a*) *cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

*based on any of the following:*

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

**Evidence:**

**Eligible under Criterion 1 A2(b) for listing as Vulnerable**

Tarburton (2014) reported that based on data collected between 1998 and 2002, the *New Atlas of Australian Birds* (Barrett et al. 2003) indicated a 49 per cent decline in reporting rates (number of records as a proportion of number of surveys, adjusted for the survey method, season and size of area searched) of needletails compared with those of the first *Atlas of Australian Birds* conducted between 1977 and 1981 (Blakers et al. 1984).

Tarburton (2014) showed that with each decade after 1950 a progressive decline in the mean number of needletails counted per flock has occurred. Australia-wide trends in mean number of White-throated Needletails counted per flock have fallen from 164 ± 37.3 in 1951-1960 to 42 ± 1.7 in 2001-2010 (Tarburton 2014). These declines are continuing with more recent data indicating that the mean number of White-throated Needletails counted per flock between 2011-2017 has fallen to 36 ± 0.9.

Tarburton (2014) demonstrated that from three sites in Victoria, at the level of each eastern state and at the national scale, a 30-50 per cent decline in White-throated Needletail flock size has occurred over three generations (25.5 years).

The Committee considers that the species has undergone a substantial reduction in numbers over three generation lengths (25.5 years for this assessment), equivalent to at least 30 – 50 percent and the reduction has not ceased, the cause has not ceased and is not understood. Therefore, the species has met the relevant elements of Criterion 1 to make it eligible for listing as Vulnerable.

| Criterion 2. Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy | | | | |
|---|---|---|---|---|
| | | Critically Endangered Very restricted | Endangered Restricted | Vulnerable Limited |
| B1. | Extent of occurrence (EOO) | < 100 km$^2$ | < 5,000 km$^2$ | < 20,000 km$^2$ |
| B2. | Area of occupancy (AOO) | < 10 km$^2$ | < 500 km$^2$ | < 2,000 km$^2$ |
| AND at least 2 of the following 3 conditions: | | | | |
| (a) | Severely fragmented OR Number of locations | = 1 | ≤ 5 | ≤ 10 |
| (b) | Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals | | | |
| (c) | Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals | | | |

**Evidence:**

**Not eligible**

Within Australia, the extent of occurrence is estimated at >20,000 sq km, and the area of occupancy estimated at >18,000 sq km. These figures are based on the mapping of point records from post 1997 species observations, obtained from state governments, museums, CSIRO, and Birdlife Australia. The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014 (DotE 2015). Therefore, the species has not met a required element of this criterion.

| Criterion 3. Population size and decline | | | | |
|---|---|---|---|---|
| | | Critically Endangered Very low | Endangered Low | Vulnerable Limited |
| Estimated number of mature individuals | | < 250 | < 2,500 | < 10,000 |
| AND either (C1) or (C2) is true | | | | |
| C1 | An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future) | Very high rate 25% in 3 years or 1 generation (whichever is longer) | High rate 20% in 5 years or 2 generation (whichever is longer) | Substantial rate 10% in 10 years or 3 generations (whichever is longer) |
| C2 | An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions: | | | |
| (a) | (i) Number of mature individuals in each subpopulation | ≤ 50 | ≤ 250 | ≤ 1,000 |
| | (ii) % of mature individuals in one subpopulation = | 90 – 100% | 95 – 100% | 100% |
| (b) | Extreme fluctuations in the number of mature individuals | | | |

**Evidence:**

**Not eligible**

Within Australia, the population size has not been quantified, but it is not believed to approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10 per cent in ten years or three generations, or with a specified population structure) (BirdLife International 2018). Therefore, the species has not met this required element of this criterion.

| Criterion 4. Number of mature individuals | | | |
|---|---|---|---|
| | **Critically Endangered Extremely low** | **Endangered Very Low** | **Vulnerable Low** |
| Number of mature individuals | **< 50** | **< 250** | **< 1,000** |

**Evidence:**

**Not eligible**

The global population size has not been quantified, but the species is reported to be local and uncommon throughout much of its range (del Hoyo *et al*. 1999). Within Australia, the population size has not been quantified (BirdLife International 2018), but it is not believed to approach the thresholds for Vulnerable under the population size criterion. Therefore, the species has not met this required element of this criterion.

| Criterion 5. Quantitative Analysis | | | |
|---|---|---|---|
| | **Critically Endangered Immediate future** | **Endangered Near future** | **Vulnerable Medium-term future** |
| Indicating the probability of extinction in the wild to be: | **≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)** | **≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)** | **≥ 10% in 100 years** |

**Evidence:**

**Not eligible**

Population viability analysis has not been undertaken.

## Conservation actions

### Recovery plan

A Recovery Plan is not required; an approved Conservation Advice for the species provides sufficient direction to implement priority actions, mitigate against key threats and enable recovery. Management and research activities are being undertaken at international, national, state and local levels.

### Primary conservation actions

Work with governments in East Asia to minimise destruction of key breeding habitats.

Important habitats in Australia are identified and protected.

**Conservation and Management priorities**

- Habitat loss and modifications
  - Seek the support of governments in East Asia to protect remaining old growth forests within the breeding range of the species.
  - Identify requirements of important habitat in Australia.
  - Support initiatives to improve habitat management at key sites in Australia.

**Stakeholder Engagement**

- Through the bilateral migratory bird consultative meetings with the Governments of Japan, China and the Republic of Korea, raise awareness of the conservation of White-throated Needletail.
- Promote the conservation, and raise the profile, of White-throated Needletail through strategic programs and educational products.
- Promote the exchange of information between governments, NGOs and communities through use of networks, publications and websites.

**Survey and Monitoring priorities**

- Enhance existing White-throated Needletail monitoring programs, such as BirdLife Australia's *Swift Monitoring Sites*, particularly to improve coverage in under surveyed parts of Australia.

**Information and Research priorities**

- Use remote sensing to assess the extent of habitat loss at the breeding grounds.
- Undertake work to more precisely assess White-throated Needletail life history, population size, distribution and ecological requirements in Australia.
- Improve knowledge about potential threatening processes including the impacts of infrastructure (i.e. wind turbines and overhead wires).
- Quantify levels of organochlorines in individuals and prey species.

## Recommendations

(i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **including** in the list in the Vulnerable category:

*Hirundapus caudacutus*

(ii) The Committee recommends that there not be a recovery plan for this species.

Threatened Species Scientific Committee

27/02/2019

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Australian Government
Department of Climate Change, Energy, the Environment and Water

# Conservation Advice for *Petauroides volans* (greater glider (southern and central))

**In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 5 July 2022.**

This document combines the approved conservation advice and listing assessment for the species. It provides a foundation for conservation action and further planning.

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# Conservation status

*Petauroides volans* (greater glider) is listed in the Vulnerable category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) effective from 5 May 2016.

This assessment recognises that *P. volans*, as understood in 2016 is now considered to be at least two separate species: *P. volans* (greater glider (southern and central)) and *P. minor* (greater glider (northern)) (McGregor et al. 2020).

*Petauroides volans* (southern and central) was assessed by the Threatened Species Scientific Committee to be eligible for listing as Endangered under Criterion 1. The Committee's assessment is at Attachment A. The Committee assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: A2abc+4bc: Endangered
- Criterion 2: Not eligible
- Criterion 3: Not eligible
- Criterion 4: Not eligible
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing in the Endangered category are an overall rate of population decline exceeding 50 percent over a 21-year (three generation) period, including population reduction and habitat destruction following the 2019–20 bushfires.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this subspecies under relevant state or territory legislation, see the Species Profile and Threat Database.

The current listing status of this species under relevant state or territory legislation is:

- Victoria (Vic): Vulnerable under the *Flora and Fauna Guarantee Act 1988* since June 2017,
- Australian Capital Territory (ACT): Vulnerable under the *Nature Conservation Act 2014* since May 2019,
- New South Wales (NSW): Three subpopulations listed as Endangered Populations under the *Biodiversity Conservation Act 2016* (Euroballa Local Government Area since 2007, Mount Gibraltar Reserve since 2015 and Seven Mile Beach National Park since 2016), and
- Queensland (Qld): Vulnerable under the *Nature Conservation Act 1992* (includes both the greater glider (southern and central) and greater glider (northern)) since October 2014.

# Species information

## Taxonomy

Conventionally accepted as *Petauroides volans* Kerr (1792).

This was formerly the only species in the genus. Two subspecies were recognised: *P. v. minor* (in north-eastern Qld) and *P. v. volans* (in south-eastern Australia) (van Dyck & Strahan 2008).

Jackson & Groves (2015) split the species into three separate species: *P. minor* (Atherton Tablelands and coastal central and northern Qld), *P. armillatus* (inland central Qld), and *P. volans* (from south-east Qld to Vic). McGregor et al. (2020) agreed with this taxonomic arrangement within *Petauroides* on the basis of genomic-scale nuclear markers and external morphological data.

A new dataset that combined the genetic resources of McGregor et al. (2020) and that of B Arbogast & K Armstrong et al. (manuscript in prep.), which included more extensive sampling throughout the range of *Petauroides* for genomic-scale markers, a mitochondrial marker dataset and cranial measurements, has supported the separate recognition of *P. minor* (KN Armstrong pers comm 24 June 2021). The dataset also provides evidence that all *Petauroides* south of the Burdekin gap (from around Proserpine) should be considered as two separate taxa, at least at the level of subspecies, with a point of contact between them in the vicinity of Coffs Harbour (KN Armstrong pers comm 24 June 2021). These two taxa need redescription, and might be elevated to the species level in the future. Until this ambiguity is resolved and the taxonomic split of *P. volans* is formally recognised by the Australian Faunal Directory, the listed entity in this Conservation Advice will be referred to as *Petauroides volans* (greater glider (southern and central)). The common name greater glider will refer to the genus *Petauroides.*

## Description

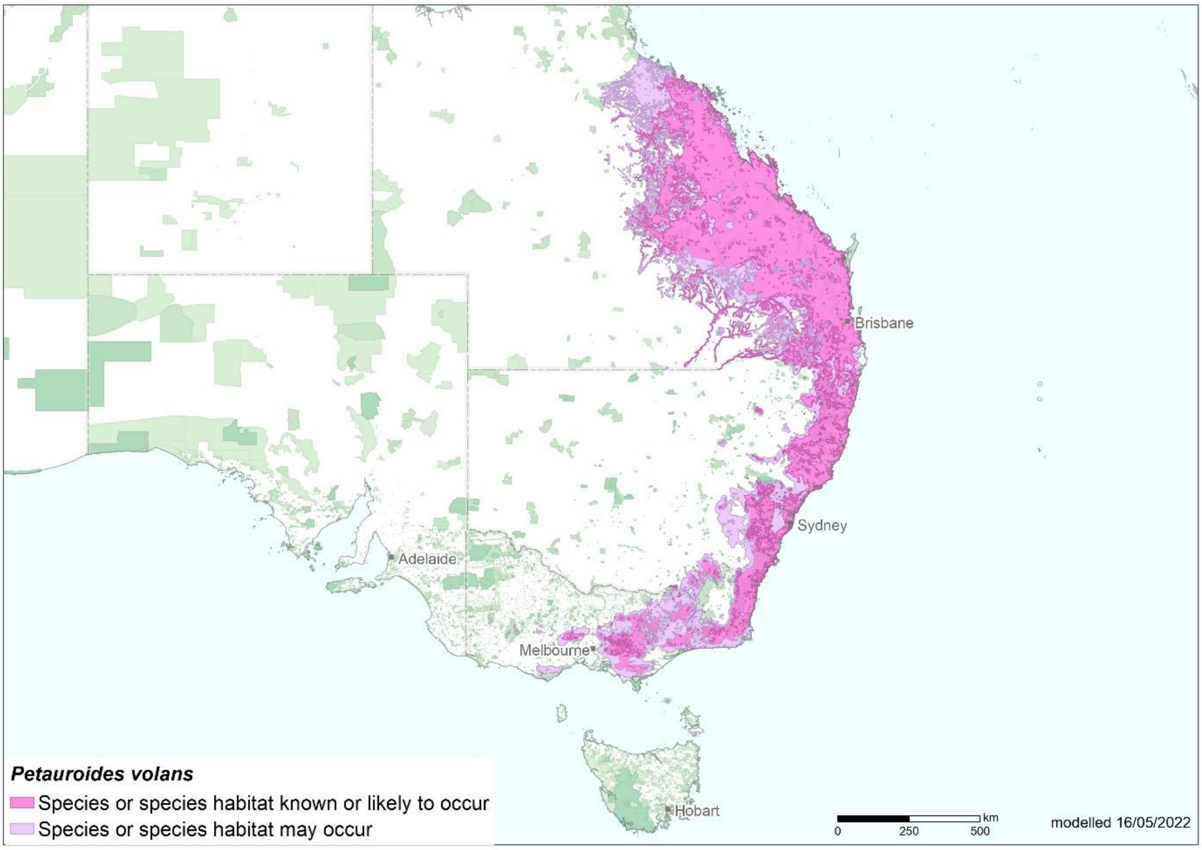
The greater glider (southern and central) is the largest gliding possum in eastern Australia. It has a head and body length of 35−46 cm, tail length of 45−60 cm, and a weight range of 900−1700 g, with females being larger than males (McKay 1989, 2008; McGregor et al. 2020). The greater glider (southern and central) has thick fur that increases its apparent size. Its fur colour is white or cream below and varies from dark grey, dusky brown through to light mottled grey and cream above. It has a long furry tail, large furry ears and a short snout. Its tail is not prehensile, and the gliding membrane extends from the forearm to the tibia (Mckay 1989, 2008).

## Distribution

The greater glider (southern and central) occurs in eastern Australia, where it has a broad distribution from around Proserpine in Qld, south through NSW and the ACT, to Wombat State Forest in central Vic (McGregor et al. 2020; B Arbogast & KN Armstrong et al. unpublished data; OZCAM records: Atlas of Living Australia 2021). It occurs across an elevational range of 0−1200 m above sea level (a.s.l) (Kavanagh 2004). The distribution appears to be restricted in the ACT, where the species is only known from the Lower Cotter Catchment and Namadgi National Park (Canberra Nature Map 2019). The species formerly occurred in Booderee National Park but appears to have been extirpated from that location in the mid-late 2000s.

The species' distribution overlaps with some World Heritage Areas, including the Gondwana Rainforests of Australia and the Blue Mountains. It also occurs on some Commonwealth lands, including the Shoalwater Bay Training Area (managed by the Department of Defence) near Rockhampton (Queensland Herbarium 2018).

The extent of occurrence (EOO) is unlikely to have changed appreciably since European settlement (Eyre 2004; Kavanagh 2004; van der Ree et al. 2004). However, the area of occupancy (AOO) has decreased substantially, mostly due to land clearing. This area is probably continuing to decline due to further clearing, fragmentation impacts, edge effects, bushfire, climate change and some forestry activities (Eyre 2005; Lindenmayer et al. 2011; Youngentob et al. 2012; Berry et al. 2015; McLean et al. 2018; Wagner et al. 2020). In addition, some subpopulations in undisturbed, intact habitat have disappeared or undergone rapid decline (Lindenmayer et al. 2011, 2018b; Smith & Smith 2018). The species appears to have been extirpated from Booderee National Park, where it has not been recorded since 2006, for reasons that are unclear (Lindenmayer 2018b). The steep decline of subpopulations in the Blue Mountains World Heritage Area is likely to be due to increased temperatures as a result of climate change (Smith & Smith 2018; Wagner et al. 2020). The existence of these recent declines suggests that many unmonitored subpopulations of the greater glider (southern and central) are likely similarly declining.




Source: Base map Geoscience Australia; species distribution data [Species of National Environmental Significance] database.
**Caveat**: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.
**Species distribution mapping**: The species distribution mapping categories are indicative only and aim to capture (a) the specific habitat type or geographic feature that represents to recent observed locations of the species (known to occur) or preferred habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence

categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

## Cultural and community significance

The cultural significance of the greater glider (southern and central) is poorly known. However, the habitats and area in which it is found have a long and profound history of management by Indigenous Australians. Stacie Nicho Piper, Wurundjeri Traditional Owner, states that: "All native animals on Country are our totems, spirit protectors, including the greater glider. They hold significant roles in the balance of country and our spiritual connections/values. When they are affected, country is affected, we as people are affected."

## Relevant biology and ecology

*General habitat*

The greater glider (southern and central) is an arboreal nocturnal marsupial, predominantly solitary and largely restricted to eucalypt forests and woodlands of eastern Australia. It is typically found in highest abundance in taller, montane, moist eucalypt forests on fertile soils, with relatively old trees and abundant hollows – e.g. north-eastern NSW (Andrews et al. 1994; Smith et al. 1994a,b), south-eastern NSW (Kavanagh 2000), eastern Vic (van der Ree et al. 2004) – but also occurs in drier habitats in south-eastern Qld (Eyre 2004). The distribution may be patchy even in continuous areas of habitat, such as Tantawangalo State Forest in NSW (Kavanagh 2000). It is likely that only a proportion of forest in potential habitat areas is suitable for the species, as the structural attributes of the forest overstorey and forage quality it relies on vary considerably across the landscape (Eyre 2002; Youngentob et al. 2011).

*Den trees*

During the day the greater glider (southern and central) shelters in tree hollows, with a particular preference for large hollows (diameter >10 cm) in large, old trees (Henry 1984; Kehl & Borsboom 1984; Lindenmayer et al. 1991; Smith et al. 2007; Goldingay 2012). Both live and standing dead trees are used for denning (Goldingay 2012), however the species prefers to use live hollow-bearing trees when adequate numbers are available (Kehl & Borsboom 1984; Kavanagh & Wheeler 2004; Lindenmayer et al. 2004). Multiple dens are used by an individual. Near Tumut in NSW, individuals used a few den trees frequently, located near core home-range areas, and numerous others infrequently (Lindenmayer et al. 2004). In south-eastern Queensland, 4−20 different den trees were used by individuals (Smith et al. 2007).

The probability of occurrence of the species is positively correlated with the availability of tree hollows (Andrews et al. 1994; Smith et al. 1994a,b; Lindenmayer et al. 2020), which is a key limiting resource. Greater gliders (southern and central) can be found in regrowth forest provided sufficient hollows are present (Macfarlane 1988; Lindenmayer et al. 1990a), and conversely are absent when there are insufficient hollows. In the Grafton/Casino region of NSW, the species was not recorded from surveyed sites containing fewer than six tree hollows per hectare (Smith et al. 1994). In southern Qld, the species appears to require at least 2–4 live den trees for every 2 ha of suitable forest habitat (Eyre 2002). Most hollow-bearing trees used for denning by arboreal and scansorial mammals are at least 100 years of age (Mackowski 1984; Wormington & Lamb 1999; Gibbons & Lindenmayer 2002; Goldingay 2012). However, the size and age at which suitable hollows develop depends on tree species and climate.

Some tree species form hollows more readily than others (Gibbons & Lindenmayer 2002), and the greater glider appears to select these for denning. Near Tumut in NSW, the greater glider used *Eucalypts viminalis* (manna gum) and *E. dalrympleana* (mountain gum) more frequently than other species, and these species supported the highest numbers of hollows in this region (Lindenmayer et al. 2004). In south-eastern Qld the species showed a strong preference for three den-tree species (*E. acmenoides* (broad-leaved white mahogany), *E. fibrosa* (red ironbark) and *E. tereticornis* (forest red gum)) due to their availability as hollow-bearing trees (Kehl & Borsboom 1984; Smith et al. 2007). In five studies across its geographic range, the greater glider was found to utilise 25 different tree species for denning (Goldingay 2012).

*Diet*

The greater glider (southern and central) is primarily folivorous, with a diet mostly comprising eucalypt leaves supplemented by buds and flowers (Kehl & Borsboom 1984; Kavanagh & Lambert 1990; van der Ree et al. 2004). It feeds from a restricted range of eucalypt species, such as *E. radiata* (narrow-leaved peppermint) in Vic (Henry 1995), manna gum in south-eastern NSW (Kavanagh & Lambert 1990), and *E. moluccana* (grey box) in south-eastern Qld (Smith et al. 2007). The tree species favoured by greater gliders varies regionally. It favours forests with a diversity of eucalypt species, due to seasonal variation in growth and nutrient content of its preferred tree species (Kavanagh 1984). Approximately 85 percent of the greater glider's water requirements are provided by consumed leaves (Foley et al. 1990). Free water is presumably obtained from dew condensation on leaf surfaces (Rübsamen et al. 1984).

*Life history*

Females give birth to a single young from March to June (Tyndale-Biscoe & Smith 1969b; McKay 2008). Sexual maturity is reached in the second year (Tyndale-Biscoe & Smith 1969b). Longevity has been estimated at 15 years (Jones et al. 2009), and generation length is estimated to be six to eight years (Pacifici et al. 2013; Woinarski et al. 2014). The relatively low reproductive rate (Henry 1984) may render small populations in isolated remnants prone to extinction (van der Ree 2004; Pope et al. 2004).

*Home ranges and densities*

Home ranges are typically relatively small (1–4 ha: Henry 1984; Kehl & Borsboom 1984; Gibbons & Lindenmayer 2002; Pope et al. 2004), but are larger (up to 19 ha) in forests on less fertile sites and in more open woodlands (Smith et al. 2007). Males tend to have larger home ranges than females in the same region (Kavanagh & Wheeler 2004; Pope et al. 2004), and male home ranges tend not to overlap (Henry 1984; Kavanagh & Wheeler 2004; Pope et al. 2004).

Densities vary significantly across the greater glider's range. Average densities have been found to range from 0.6 to 2.8 individuals per hectare in Vic (Henry 1984; van der Ree et al. 2004; Lindenmayer et al. 2011; Nelson et al. 2018), 0.2 to 3.0 individuals per hectare in NSW (Tyndale-Biscoe & Smith 1969b; Kavanagh 1984, 1995; Pope et al. 2004; Lindenmayer et al. 2011; Smith & Smith 2018; Vinson et al. 2020), and 0.2 to 2.3 individuals per hectare in south-eastern Qld (Kehl & Borsboom 1984; Smith et al. 2007; Ferguson et al. 2018).

*Disturbance ecology*

The greater glider is particularly sensitive to forest clearance (Tyndale-Biscoe & Smith 1969a) and to intensive timber harvesting (Kavanagh & Bamkin 1995; Kavanagh & Webb 1998; Kavanagh & Wheeler 2004; Mclean et al. 2018), although responses vary according to landscape context and the extent of tree removal and retention (Kavanagh 2000; Taylor et al. 2007).

Large hollow-bearing trees are in rapid decline in some landscapes (Lindenmayer et al. 2017a,b) primarily due to timber production practices and bushfires that prevent trees growing to an age when they might produce hollows (Lunney 1987; Lindenmayer et al. 2018b). Site-level, tree-level (e.g. size, extent of decay) and landscape factors all appear to influence the rate of collapse of hollow-bearing trees. Lindenmayer et al. (2018a) found that the probability of collapse of hollow-bearing trees in remnant 1 ha patches increased with an increasing amount of logged or burned areas in the surrounding landscape (within a 2 km radius), most likely due to altered wind patterns from a reduction in forest cover. The decline in hollow-bearing trees is a concern for recovery as the greater glider is dependent on this habitat feature, and the development of hollows in suitable tree species can take over a century (Mackowski 1984). Additionally, the abundance of hollow-bearing trees may be an overestimate of the actual number that are suitable for occupation by wildlife, as only one in every 3–5 hollow-bearing trees within montane ash forests is occupied by arboreal marsupials (Lindenmayer et al. 1990b, 1993). A decline or loss of hollow-bearing trees reduces the numbers of greater gliders in the landscape (Mclean et al. 2018).

Greater gliders are sensitive to fragmentation (McCarthy & Lindenmayer 1999a,b; Lindenmayer et al. 2000; Eyre 2006; Taylor & Goldingay 2009). Although greater gliders have small home ranges, their low reproductive rate and sensitivity to disturbance means they tend to become locally extinct in small and fragmented habitat patches. Greater gliders disperse poorly across vegetation that is not native forest, and so do not readily recolonise isolated sites from which they have been lost (Pope et al. 2004). In a study of remnant patches <1 ha to >50 ha in size, Youngentob et al. (2013) found that the probability of occurrence of greater gliders increased as the area of remnant habitat increased. It is difficult to identify the smallest patch size used, as this likely varies across the range depending on vegetation type, quality, connectivity and other environmental factors. Greater gliders have been found in habitat patches <10 ha in some fragmented and remnant forest patches in the southern part of their geographic range (Pope et al. 2004; Lindenmayer 2002), but may require larger habitat patches in Queensland (Eyre 2006).

The greater glider is sensitive to bushfire (Lunney 1987; Andrews et al. 1994; Lindenmayer et al. 2011; Mclean et al. 2018) and is slow to recover following major fires (Kavanagh 2004). Substantial losses or declines of greater glider populations have been documented after fires (see Table 1), through direct mortality and indirect impacts on habitat (McLean et al. 2018).

Over the longer term, repeated disturbance such as intense or too-frequent fires degrades greater glider habitat by changing the composition, structure and nutrient profile of forests. Fire can increase or decrease the amount of tree hollows depending on the fire regime, age and species of the dominant trees, and disturbance history. Fire can destroy live and dead hollow-bearing trees, particularly in young forests because smaller diameter trees have a lower capacity to survive burning (Gibbons & Lindenmayer 2002). Fire can also result in extensive losses of dead hollow-bearing trees (Lindenmayer et al. 2012), though these are less preferred by greater gliders. Eyre et al. (2010) found that the density of such trees was substantially reduced by both low-frequency and high-intensity fires (wildfire), and by high-frequency and low-intensity burns associated with stock grazing management. Too-frequent fires can change the floristic composition and nutritional profile of glider habitat if a fire returns before the dominant trees preferred by gliders can mature and reproduce (Lindenmayer et al. 2013, Au et al. 2019). A positive feedback loop may also occur as dense regrowth is at higher risk of burning at high severity (Taylor et al. 2014).

Greater glider populations are slow to recover and recolonise burnt sites following fire and may take decades to return (Andrew et al. 2014; Lumsden et al. 2013; Vic SAC 2015; Lindenmayer et al. 2021), due to the low reproductive rate of the species and its limited dispersal capabilities. Habitat fragmentation can compound the impact of fires by hampering the recolonisation ability of greater gliders. Recovery depends on there being no further major fires in the interim (Vic SAC 2015). Major bushfires in 2003, 2006−2007 and 2009 burnt much of the species' range in Victoria, and further fragmented its distribution as evidenced by surveys and species records (Lumsden et al. 2013; Vic SAC 2015). Since the 2009 fires, spotlighting records of greater gliders (southern and central) in the Kinglake East Bushland Reserve and nearby areas have significantly declined and not yet recovered (C Cobern 2015. pers comm 9 November). Unburnt areas provide critical refuges for greater gliders in regions heavily impacted by fires, as they may be the only areas with the requisite habitat attributes within extensive landscapes for many years (Lumsden et al. 2013; Chia et al. 2015).

## Habitat critical to the survival

Within the same forest type (with similar habitat structure and tree species composition), the species' occurrence is positively correlated with levels of foliar nutrients (Braithwaite et al. 1983), amount of foliage (Davey 1984), canopy productivity (Youngentob et al. 2015), stand age (Lindenmayer et al. 1990a), overstorey basal area (Kavanagh 1987; Incoll et al. 2001), tree hollow abundance (Lindenmayer et al. 1990b; Lindenmayer et al. 2013), patch size (Incoll et al. 2001; Youngentob et al. 2015) and connectivity (Youngentob et al. 2013).

Habitat critical to survival for the greater glider (southern and central) may be broadly defined as (noting that geographic areas containing habitat critical to survival needs to be defined by forest type on a regional basis):

- large contiguous areas of eucalypt forest, which contain mature hollow-bearing trees[1] and a diverse range of the species' preferred food species in a particular region; and
- smaller or fragmented habitat patches connected to larger patches of habitat, that can facilitate dispersal of the species and/or that enable recolonization; and
- cool microclimate forest/woodland areas (e.g. protected gullies, sheltered high elevation areas, coastal lowland areas, southern slopes); and
- areas identified as refuges under future climate changes scenarios; and
- short-term or long-term post-fire refuges (i.e. unburnt habitat within or adjacent to recently burnt landscapes) that allow the species to persist, recover and recolonise burnt areas.

[1] Tree hollows can be difficult to detect in ground-based surveys. The presence of trees with basal diameter > 30 cm can be used as a proxy measure for tree hollows used by greater gliders in Queensland (Eyre et al. 2021).

Habitat meeting any one of the criteria above is considered habitat critical to the survival of greater glider (southern and central), irrespective of the current abundance or density of greater gliders or the perceived quality of the site. Forest areas currently unoccupied by the greater glider (southern and central) may still represent habitat critical to survival, if the recruitment of hollow-bearing trees as the forest ages could allow the species to colonise these areas and ensure persistence of a subpopulation.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

## Important populations

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

Given its Endangered status, all populations of the greater glider (southern and central) are important for the conservation of the species across its range. Due to the species' low fecundity and limited dispersal capabilities, areas where the species has become locally extinct are not readily recolonised. Coastal populations may be important for maintaining genetic diversity, as they are geographically distinct from inland populations (DoEE 2016b).

## Threats

Key threats to the greater glider (southern and central) are frequent and intense bushfires, inappropriate prescribed burning, climate change, land clearing and timber harvesting (Table 1). There are synergies between these threats, and their combined impact needs to be considered in the recovery of the species. Loss and fragmentation of habitat has already occurred in many areas of the species' range (Lindenmayer et al. 2011; Youngentob et al. 2013), and the unprecedented 2019-20 bushfires have increased pressure on its remaining habitat.

**Table 1 Threats impacting the greater glider (southern and central)**

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| Habitat loss, disturbance and modification | | |
| Inappropriate fire regimes | • Timing: current and future<br>• Confidence: observed<br>• Consequence: catastrophic<br>• Trend: increasing<br>• Extent: across the entire range | <u>Extensive severe bushfires</u><br>Substantial population losses or declines have been documented in and after high severity bushfires (Lindenmayer et al. 2013; Berry et al. 2015; McLean et al. 2018). Losses can occur as a result of direct mortality due to lethal heating or suffocation from smoke, or indirect mortality due to the loss of key habitat features and resources (McLean et al. 2018).<br>A single fire in a ten-year period is capable of reducing the abundance of greater gliders (southern and central) by more than half (McLean et al. 2018). Declines can occur even in small fire refuges; Berry et al. (2015) found that the species was significantly less abundant in wet unburnt forest gullies within the extent of a major fire compared to similar sites outside.<br>Occurrence at burnt sites is influenced by landscape context. Lindenmayer et al. (2020) found that the probability of occurrence of greater gliders (southern and central) is negatively associated with increasing extent of fire in the surrounding landscape. Chia et al. (2015) found that Glider abundance was lower in areas affected by high-intensity fires than in areas where fires |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| | | burnt only the understorey, and that abundance increased with increasing amount of unburnt and understorey-only burnt forest within a 1 km radius. These results suggest that unburnt areas, e.g. gullies, can serve as post-fire refuges and assist recolonization of severely burned forest. Remaining unburnt areas provide critical refuges for species heavily impacted by fires, as they will be the only areas with mature habitat within extensive landscapes for many years (Dickman et al. 2020).<br><br>In 2019-20, following years of drought (DPI 2020) and Australia's hottest and driest year on record in 2019, catastrophic wildfire conditions culminated in fires that covered an unusually large area of eastern and southern Australia and burnt with high severity in many places (Boer et al. 2020). The full impact of the 2019-20 bushfires has yet to be determined. However, an estimated 40% of the distribution of the greater glider (southern and central) overlapped with the areas affected by the bushfires (Legge et al. 2021). A population decline analysis for the greater glider (southern and central) that incorporates spatial variation in fire severity plus estimated declines for differing fire severity classes, provided an estimate of overall decline for the taxon of 24% (range 17-31%) one year after the fire, assuming current management conditions (Legge et al. 2021).<br><br><u>High frequency fires</u><br><br>Frequent fire can decrease the availability of hollow-bearing trees in the landscape, and change the floristic composition and nutritional profile of glider habitat (Lindenmayer et al. 2013, Au et al. 2019). High frequency fire has reduced the density and stature of Mountain ash forests, posing threats to a range of tree-dependent fauna (Burns et al. 2015). In the Urbenville FMA of northern NSW, the species' abundance on survey sites was found to be significantly greater in forests that were infrequently burnt (Andrews et al. 1994).<br><br>Too intense or frequent planned burning may contribute to population losses or declines in the southern part of the greater glider's range. Bluff (2016) reported that hollow-bearing trees (HBTs) affected by fire during planned burns were 28 times more likely to collapse than HBTs that were not burnt. Parnaby et al. (2010) found that following low intensity prescription burns in the Pilliga forests (NSW), mean collapse rates for burnt HBTs were 14-26%. This was consistent with the collapse rate of 25.6% found by Bluff (2016). A survey following a planned burn at Tallarook Range in the Central Highlands (Vic) in 2021 found that a large number of potential greater glider habitat trees were burnt, with "many destroyed" (N. Stimson 2021, pers. comm. 26 June).<br><br>There is increased pressure from some parts of the community to undertake more hazard reduction burning, follow the severe bushfires of 2019-20.<br><br><u>Interactions with habitat clearing</u><br><br>Habitat fragmentation, due to clearing, can compound the impact of fires by hampering the ability of species to recolonise burnt areas (Dickman et al. 2020). Populations of greater gliders (southern and central) |

| Threat | Status and severity [a] | Evidence |
| --- | --- | --- |
| | | have disappeared after major bushfires; for example, no individuals were recorded for 19 years after a 1994 fire in the isolated Royal National Park (NSW) (Andrews et al. 2014).<br>The impacts of fire on greater glider habitat are higher in landscapes that have been subject to previous timber harvesting, and at sites where post-fire salvage operations take place (Bowd EJ et al. 2021; Lindenmayer et al. 2021). Following the 2009 Victorian bushfires, 79% of large living trees with cavities died in the *Eucalyptus regnans* (Mountain Ash) forests, with no recruitment of new large cavity-bearing trees by 2011 (Lindenmayer et al. 2012). This was attributed to repeated past fires, and widespread timber harvesting which had resulted in the landscape being dominated by young stands. In the Dorrigo, Guy Fawkes and Chaelundi plateaux of north-eastern NSW, the combined effects of high fire frequency and high timber harvesting intensity resulted in greater declines of greater gliders (southern and central) than each threat alone (McLean et al. 2018).<br>Physical disturbances associated with firefighting operations and post-fire 'mop up' include construction of roads and fire control lines, earthworks, tree removal and expansion of burnt areas through backburning (Driscoll et al. 2010). After fires, hazardous trees with large hollows are often felled for safety reasons (along roads, fire trails and walking trails) within greater glider habitat (DECCW 2011). Andrew (2001) reported that 120 HBTs were felled after the 1994 bushfires in Royal National Park by NPWS due to concerns about public safety.<br>In Vic, loss of HBTs due to mechanical site preparation works associated with prescribed burning (which primarily occurs in foothill forests close to settled areas) may reduce suitable habitat for the greater glider (southern and central). Trees that are assessed as potentially hazardous (if they were to catch fire) are routinely removed from the perimeter of planned burns on public land in Vic. They are also removed from bushfire control lines during and after bushfire suppression activities (DELWP n.d). Although not all hazardous trees are hollow bearing, many are, or are likely to be trees that form hollows more quickly (J Nelson 2021. pers comm 16 April).<br><u>Interactions with climate change</u><br>Fire poses an increasing risk to the species. Indicators of forest fire danger in south-eastern Australia have emerged outside of the range of historical experience. More than 23% of the temperate forests in south-eastern Australia were burnt in the 2019-20 fire season, making the scale of the fires unprecedented both for Australia and globally (Boer et al. 2020). The radiative power of the 2019-20 fires, and the number of fires that developed into pyroconvective storms, were also unmatched in Australia's historical record (Boer et al. 2020). The multiple climate change contributors to fire risk in southeast Australia, as well as the observed non-linear escalation of fire extent and intensity, increase the likelihood that fire events will rapidly intensify in the future (Boer et al. 2020). |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| Habitat clearing and fragmentation | • Timing: current and future<br>• Confidence: observed<br>• Consequence: catastrophic<br>• Trend: decreasing<br>• Extent: across parts of the range | The greater glider is absent from cleared areas and has little dispersal ability to move through cleared areas between fragments (Tyndale-Biscoe & Smith 1969b; McCarthy & Lindenmayer 1999a,b; Lindenmayer et al. 2000; Eyre 2006; Taylor & Goldingay 2009). Population viability in small remnants is low due to the species' low reproductive output, susceptibility to disturbance and edge effects.<br>Extensive land clearing for development and agriculture has led to fragmentation of habitat in some areas, e.g. the Tumut area of NSW (Pope et al. 2004) where small subpopulations exist in a pine matrix. About 30 years after clearing in the Tumut area, Lindenmayer et al. (1999) found that the occupancy rate of greater gliders (southern and central) in remnant patches was 21% compared to 38% in the surrounding native forest, indicating that recolonization does not occur readily. The probability of occurrence was significantly greater in large remnants, sites on flat terrain, and sites dominated by particular eucalypt forest types. Genetic analysis in the Tumut population by Taylor et al. (2007) indicated that some immigration into patches was occurring, with dispersal through distances of up to 7 km recorded, but there were lower levels of immigration and genetic mixing in patches further (> 1 km) from continuous forest.<br>Artificial wildlife crossing structures to aid gliders to cross gaps such as highways and powerline easements have now been built within greater glider habitat throughout eastern Australia (Dalton 2018; Goldingay et al. 2018, 2020). Greater gliders have been recorded using these structures at only one location. At this site, the Sugarloaf Pipeline in Victoria, greater gliders were occasionally recorded on glide poles, although it is unclear whether they were using them to cross gaps or to move parallel to gaps (GHD 2017; Dalton 2018). The absence of records of greater gliders crossing highways or railways, despite glide poles being installed and monitored in multiple projects, suggest that they may be reluctant to cross near traffic.<br>Gliders have rarely been recorded using nest boxes. In a 3-year study of 120 nest boxes in Victoria, one was used on two occasions by a greater glider, 640 days after placement (Menkhorst 1984). No greater glider use was seen in a 4-year study on 96 nest boxes (Lindenmayer et al. 2003). In a study of 206 glider-suitable nest boxes intended to mitigate loss of tree hollows from construction of 16 roads projects in NSW, 3 boxes in 2 projects were used by greater gliders (Goldingay et al. 2020). Nest boxes have been utilised in a 2-year program at Mirboo North (Gippsland, Vic) to increase habitat connectivity, with greater gliders (southern and central) filmed using the boxes as maternal dens (D Liepa 2020. pers comm 10 September). Alterations to improve the thermal properties of nest boxes may improve their use by greater gliders (e.g. Griffiths et al. 2018). Fragmentation effects are likely exacerbated by inappropriate fire regimes. |

| | | |
|---|---|---|
| Timber harvesting | • Timing: current and future<br>• Confidence: observed<br>• Consequence: major<br>• Trend: decreasing<br>• Extent: across parts of the range | The sensitivity of greater gliders (southern and central) to timber harvesting has been well documented. Although some habitat across the species' range is found in conservation reserves (Smith & Smith 2018, Wagner et al. 2020), where timber harvesting is excluded and the removal of HBTs is subject to constraints, prime habitat coincides largely with areas suitable for timber harvesting (Braithwaite 1984). There is a progressive decline in numbers of HBTs in some production forests, as harvesting rotations become shorter and dead stags collapse, and HBTs are not being replaced due to lack of recruitment (Ross 1999; Ball et al. 1999; Lindenmayer et al. 2011, 2012).<br><br>The degree of impact depends on forest type and timber harvesting intensity, with larger declines in more heavily logged sites (Tyndale-Biscoe & Smith 1969b; Lunney 1987; Kavanagh et al. 1995; Kavanagh & Webb 1998; Kavanagh 2000; McLean et al. 2018). In the Central Highlands of Vic, where clearfelling is undertaken, Lindenmayer et al. (2017b) found that the rate of loss of HBTs greatly exceeded the rate of recruitment. The area of clearfelled forest adjacent to wildlife corridors was also found to increase the chance of collapse of HBTs, possibly due to the greater exposure of stems to elevated wind speeds at corridor edges. However, models investigating the impacts of forest disturbance on the greater glider (southern and central) in the same area found that timber harvesting in the surrounding landscape was not a significant covariate influencing the probability of occurrence of the species (Lindenmayer et al. 2020).<br><br>Recovery of subpopulations following timber harvesting is slow. Subpopulations in south-east NSW had not recovered 8 years after timber harvesting in sites retaining 62%, 52% and 21% of the original tree basal area (Kavanagh & Webb 1998). In the regrowth Mountain Ash forests (Central Highlands) of Vic, greater gliders (southern and central) were absent post-timber harvesting until the forests were >38 years old (Macfarlane 1988).<br><br>Greater Gliders can persist, albeit likely in lower numbers, following harvesting. Kavanagh (2000) found that, in production forests in south-east NSW, subpopulations could persist post-timber harvesting if 40% of the original tree basal area was retained, provided (adjoining) riparian vegetation was also protected. An analysis overlaying all detections (from the Victorian Biodiversity Atlas and VicForests Species Observations layer) made post-harvest in timber harvesting areas in Vic since 1980, found that the species can persist in timber harvesting regrowth areas of very young age (VicForests 2021).<br><br>The impacts of timber harvesting on greater gliders can be mitigated by landscape-level management strategies that retain habitat corridors and HBTs (Eyre 2006; Woinarski et al. 2014). In 2019, VicForests began moving away from clearfelling towards variable retention systems, which aim to retain more habitat trees and reduce the use of controlled burns for regeneration post-harvest. Protections for the species in East Gippsland and the Midlands (where Special Management Zones were required) were also revised to retain 40% of the basal area of eucalypts across each coupe where ≥5 greater gliders per $km^2$ are identified. |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| | | Under the new Victorian Forestry Plan, harvest rates will reduce from 2024, leading up to a cessation of all native forest timber harvesting by 2030 (VicForests 2021).<br>However, cumulative impacts of the 2019-20 bushfires, ongoing prescribed burning, timber harvesting and climate change will continue to put pressure on remaining greater glider habitat. Fire-logging interactions likely increase risks to greater glider populations. |
| Barbed wire fencing (entanglement) | • Timing: current and future<br>• Confidence: observed<br>• Consequence: minor<br>• Trend: unknown<br>• Extent: across the entire range | There are occasional losses of individuals due to entanglement in barbed wire fences across the greater glider's range (van der Ree 1999). |
| Climate Change | | |
| Increased temperatures and changes to rainfall patterns | • Timing: current and future<br>• Confidence: observed<br>• Consequence: major<br>• Trend: increasing<br>• Extent: across the entire range | Mean temperatures across the distribution of greater glider have risen by 1.4 degrees and heat waves have become longer and more frequent over the past century (BOM & CSIRO 2020). In the southern part of the range, winter rainfall has declined by 12% since the 1990's, but summer rainfall remains unchanged. These trends are projected to continue over the coming decades under moderate and high emissions scenarios (CSIRO & BOM 2021).<br>A unique physiology and a strict eucalypt diet make the greater glider vulnerable to high temperatures and low water availability (Rübsamen et al. 1984). Prolonged exposure to temperatures over 40°C is likely to lead to high mortality (Rübsamen et al. 1984). Moore et al. (2004) suggested that the preference of greater gliders for higher elevations is because they are sensitive to heat and must expend energy and considerable water to cool themselves when the ambient temperature is over 20°C.<br>The increase of night-time temperatures has been implicated in the decline of greater glider (southern and central) numbers in Vic subpopulations (Wagner et al. 2020). At lower altitude (<500 m) surveyed sites in the Blue Mountains, increasing mean annual temperatures were attributed to be the cause of declines of greater gliders (southern and central), suggesting that night-time as well as day-time temperatures may be impacting the species, especially during heatwaves (Smith & Smith 2018, 2020).<br>During extreme hot days over the 2019-2020 summer in the Blue Mountains and Lithgow LGA, two individuals were found on the ground and died soon after rescue. An autopsy concluded that they died as a result of drought and extreme heat (P Ridgeway 2021. pers comm 6 January). This further suggests that daytime temperatures are impacting the species.<br>Water stress affects growth in forest eucalypts (Matusick at al. 2013) and reduces the availability of young, more palatable foliage. Combined with higher temperatures and extreme heat events this may cause heat stress, drought stress and mortality (Vic SAC |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| | | 2015). Elevated $CO_2$ may change the nutritional and water content of eucalypt leaves (Duan et al. 2019), though effects are difficult to predict and may have only a small impact on greater glider survival (Hovenden & Williams 2010).<br><br>A warmer climate also reduces the nutritional and water content of eucalypt leaves (Foley et al. 1990; Lawler et al. 1997; Gleadow et al. 1998; McKiernan et al. 2014), and could be expected to reduce reproduction rates and population size (DeGabriel et al. 2009; Kearney et al. 2010). Above temperatures of 35°C, greater gliders need to dissipate >100% of metabolic heat production by evaporative means (Rübasamen 1984). At the same time, they reduce their food intake due to thermogenesis, leading to their energy and water stores being rapidly expended (Beale et al. 2018; Youngentob et al. 2021). This can lead to death of both young and adult gliders, or if less severe, can reduce growth in milk-fed young and reduce the health and fitness of adult gliders (Youngentob et al. 2021).<br><br>Altered weather conditions are leading to higher frequency and intensity of bushfires (BOM & CSIRO 2020), further compounding the impacts of climate change on greater gliders. Large storms, particularly following fire or timber harvesting, may also result in the further loss of old hollow-bearing trees (Lindenmayer et al. 2018a).<br><br>The age and dominant species of trees in the forests of east coast Australia are likely to continue to alter over the coming century, due to the compounding impacts of climate change, fire, clearing and timber harvesting. Some eucalypt species preferred by greater gliders may be lost from sites where they currently occur as conditions become climatically unsuitable for these trees (Butt et al. 2013; González-Orozco et al. 2016; Booth 2017). It difficult to robustly predict how and where forests will change, as local genetics, disturbance history, soil, topography, and hydrology can all influence how native forest respond to climate change (Booth et al. 2015; Booth 2018). |
| Over-abundant native species | | |
| Hyper-predation by owls | • Timing: current and future<br>• Confidence: observed<br>• Consequence: moderate<br>• Trend: static<br>• Extent: across parts of the range | The greater glider forms a significant part of the diet of *Ninox strenua* (powerful owl) (Bilney et al. 2006), and has become a significant part of the diet of *Tyto tenebricosa* (sooty owl) since European settlement due to the widespread decline of terrestrial prey species for these owls (Bilney et al. 2010).<br><br>The greater glider has significantly declined or become locally extinct in some intact forest areas, possibly due to owl predation (Lindenmayer et al. 2011, 2018b; P. Rickards pers. comm. 2015). At one site over a three-year period, two powerful owls were suspected to have reduced a greater glider (southern and central) population from 80 to 7 individuals (Kavanagh 1988). Hyper-predation by large forest owls may possibly be due to increased abundance of owls following release from competition with the European red fox for prey, caused in turn by suppression of red fox populations by baiting activities (Lindenmayer et al. 2011).<br><br>However, the presence of large forest owls does not necessarily indicate a population-level impact on |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| | | greater gliders. Numbers of powerful and sooty owls have increased greatly in the Blue Mountains since the 1980s and these species have been recorded at many sites with greater gliders, but no significant relationship between greater glider abundance and the presence of either owl species was found (Smith & Smith 2018). Effects may be exacerbated by fire-predator interactions. |
| Competition from *Cacatua galerita* (Sulphur-crested Cockatoos) | • Timing: current and future<br>• Confidence: suspected<br>• Consequence: minor<br>• Trend: increasing<br>• Extent: across parts of the range | Numbers of Sulphur-crested Cockatoos in the Blue Mountains have increased significantly since 1990 and may be competing with greater gliders for hollows. They have been observed taking over nesting hollows of powerful owls and have been roosting in increasing numbers at several greater glider sites since 2007 (Smith & Smith 2018). However, no significant relationship was found between greater glider (southern and central) abundance and the number of roosting cockatoos (Smith & Smith 2018). Further research is required to determine the impact of inter-species competition for hollows on greater gliders. |
| Introduced species | | |
| Predation by feral cats (*Felis catus*) | • Timing: current and future<br>• Confidence: observed<br>• Consequence: minor<br>• Trend: unknown<br>• Extent: across the entire range | Remains of greater gliders have been found in the stomachs of feral cats, however they formed a tiny proportion of the overall animals consumed (Jones & Coman 1981). It is unclear whether they were killed by cats (if so, most likely when gliders come to the ground) or consumed as carrion. After wildfires, greater gliders are displaced and have been observed on the ground where they are more susceptible to predation (Fleay 1947), suggesting that fire-predator interactions amplify threats to the species. |
| Predation by European red foxes (*Vulpes vulpes*) | • Timing: current and future<br>• Confidence: observed<br>• Consequence: minor<br>• Trend: unknown<br>• Extent: across the entire range | Remains of greater gliders have been found in the stomachs and scats of European red foxes (Coman 1973; Brunner et al. 1975; Wallis & Brunner 1986; Lunney et al. 1990). However, they formed a tiny proportion of the overall animals consumed, and it is unclear whether they were killed by foxes (if so, most likely when gliders come to the ground) or consumed as carrion. After wildfires, greater gliders are displaced and have been observed on the ground where they are more susceptible to predation (Fleay 1947), suggesting that fire-predator interactions amplify threats to the species. |

Timing—identify the temporal nature of the threat;

Confidence—identify the extent to which we have confidence about the impact of the threat on the species;

Consequence—identify the severity of the threat;

Trend—identify the extent to which it will continue to operate on the species;

Extent—identify its spatial content in terms of the range of the species.

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with in-house expertise using available literature.

## Table 2 Greater glider (southern and central) risk matrix

| Likelihood | Consequences | | | | |
|---|---|---|---|---|---|
| | **Not significant** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| **Almost certain** | Low risk | Moderate risk | Very high risk | Very high risk<br>**Timber harvesting**<br>**Increased temperatures and changes to rainfall patterns** | Very high risk<br>**Inappropriate fire regimes**<br>**Habitat clearing and fragmentation** |
| **Likely** | Low risk | Moderate risk<br>**Competition from Sulphur-crested Cockatoos** | High risk | Very high | Very high risk |
| **Possible** | Low risk | Moderate risk | High risk<br>**Hyper-predation by owls** | Very high risk | Very high risk |
| **Unlikely** | Low risk | Low risk<br>**Predation by foxes**<br>**Predation by feral cats**<br>**Barbed wire fencing (entanglement)** | Moderate risk | High risk | Very high risk |
| **Unknown** | Low risk | Low risk | Moderate risk | High risk | Very high risk |

**Categories for likelihood are defined as follows:**
Almost certain – expected to occur every year
Likely – expected to occur at least once every five years
Possible – might occur at some time
Unlikely – such events are known to have occurred on a worldwide bases but only a few times
Unknown – currently unknown how often the incident will occur
**Categories for consequences are defined as follows:**
Not significant – no long-term effect on individuals or populations
Minor – individuals are adversely affected but no effect at population level
Moderate – population recovery stalls or reduces
Major – population decreases
Catastrophic – population extirpation/extinction

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be 'very high' or 'high'. For those threats with an unknown or low risk outcome it may be more appropriate to identify further research or maintain a watching brief.

# Conservation and recovery actions

## Primary conservation objective

Within the next three generations, the population size as well as the extent, quality and connectivity of habitat required to maintain the population will have increased.

## Conservation and management priorities

### Habitat loss, disturbance and modification (including fire)

- In the aftermath of bushfires, protect any unburnt habitat (within or adjacent to recently burnt landscapes) in order to support population recovery. This includes, but is not limited to:
    - Areas identified to be important post-fire refuges.
    - Protecting hollow-bearing trees from post-fire salvage timber harvesting and clean-up operations.
    - Avoiding hazard reduction burns in these areas.
- Re-assess and revise current prescriptions used for prescribed burning to ensure that the frequency and severity of fires in greater glider habitat are minimised, in order to mitigate the risk of further population declines and loss of hollow-bearing trees. Measures to reduce risk from future bushfires should be strategic, incorporate adaptive management, and include a risk assessment that considers trade-offs between fire control efficiency and environmental damage.
- Implement and enforce measures to reduce direct mortality and loss of hollow-bearing trees during site preparation and execution of prescribed burns, including rake hoeing around the base of trees.
- Ensure that eucalypt forests and the impacts of disturbance (including fire) are managed to prevent them transitioning to less nutritious, hotter, and/or more fire-prone plant communities, and to ensure that food tree species preferred by the greater glider (southern and central) continue to be the dominant canopy trees.
- Protect and maintain sufficient areas of suitable habitat, including denning and foraging resources and habitat connectivity, to sustain viable subpopulations throughout the species' range.
- Protect hollow-bearing trees on private property, roadside reserves, and along the edges of roads/tracks. Prior to removing trees identified to be a 'hazard', undertake a risk assessment by a suitably qualified person to determine whether their removal is necessary, including a consideration of the potential impacts of tree removal on the greater glider. Incorporate measures to ensure ongoing recruitment of hollow-bearing trees into planning processes.
- Avoid fragmentation and loss of habitat due to development of new transport corridors. Include consideration of the species in planning processes, and where possible re-locate recreational activities and roads away from habitat.
- Establish, maintain and enforce effective prescriptions in production forests to support populations of the greater glider (southern and central). This includes, but is not limited to: appropriate levels of habitat retention, timber harvesting exclusion and timber harvesting

rotation cycles; maintenance of wildlife corridors between harvested patches; maintenance of vegetation buffers around habitat patches excluded from harvesting; protection of existing hollow-bearing trees with appropriate buffers; adequate recruitment of hollow-bearing trees; maintaining preferred food tree species as dominant canopy trees; and minimal use and adequate containment of regeneration burns. Clearfelling should be avoided, as well as timber harvesting in climate or post-fire refuges.

- As a last resort, where hollows are limiting, consider the use of nest boxes and artificial hollows that are suitable for the species. Monitor use of these structures to ensure they are being utilised, and revise designs or placement as required.
- Restore habitat and connectivity:
  - where habitat has been substantially fragmented, disturbed or modified,
  - between small habitat patches and larger areas of contiguous forest,
  - at a landscape scale through projects such as the Great Eastern Ranges Initiative, to facilitate movement and recolonisation of areas impacted by fires, droughts or other factors, and to provide opportunities for the species to adapt to the changing climate,
  - following climate-ready restoration guidelines (e.g. Hancock et al. 2018), and
  - following the National Restoration Standards (Standards Reference Group SERA 2021).
- Revise mitigation and offset guidelines for development and linear infrastructure (e.g. pipelines, transport corridors) to reflect the limited effectiveness of artificial structures (nest boxes, glide poles) as mitigation actions for loss, degradation or fragmentation of greater glider habitat.
- Avoid the use of barbed wire, and replace the top strands of existing barbed wire with single-strand wire in habitat known to be occupied by greater gliders.

### Climate change

- Protect all habitat likely to be climate change refuges, including sites buffered against desiccating conditions (e.g. sheltered and/or on south-facing aspects), under future climate change scenarios. Where possible, maintain or establish connectivity with other habitat in order to facilitate movement.
- Undertake habitat restoration to improve micro-climate conditions in areas at high risk of extreme temperatures and drought.

### Invasive species (including threats from predation, grazing, trampling)

- Where threats from introduced predators (including the European red fox and feral cat) are locally significant:
  - Implement appropriate control measures, particularly in areas burnt by bushfires.
  - Develop and implement longer-term strategies to control predation by the European red fox and feral cat, as detailed in the relevant Threat Abatement Plans.

### Ex-situ recovery actions

- Investigate the feasibility of reintroductions to areas from which the species has recently been extirpated, where natural recolonisation is unlikely.

- If feasible, undertake translocations to these areas, ensuring that habitats are managed for future suitability including adaptive management of threats that may have led to the species' extirpation.
- Ensure that any proposals for translocations are developed collaboratively and focused on the best conservation outcomes for the species.

## Stakeholder engagement/community engagement

- Seek stakeholder input into assessment and planning processes that include protections for the greater glider (southern and central) and its habitat. This may include environmental impact assessments, park management plans, water resource plans, fire management plans and transport development plans.
- Develop and implement a communication strategy around the need to balance hazard reduction burning with the need to conserve and protect species and habitats.
- Liaise with private landholders, Traditional Owners, and conservation and land management groups to co-create guidelines for on-ground management of the greater glider (southern and central).
- Support volunteer involvement in surveying and monitoring, in particular gathering data on the species' occurrence and foraging habitat, and in the implementation of conservation actions.
- Pursue opportunities with landholders to enter land management agreements, particularly in-perpetuity covenants, that promote the protection and maintenance of habitat on private lands with high value for the species.
- Engage and involve Traditional Owners in conservation actions, including survey, monitoring and management actions.
- Foster public interest in the species and its ongoing conservation, to increase support for the implementation of conservation actions.

## Survey and monitoring priorities

- Implement an integrated long-term monitoring program across the species' range to:
  - determine trends in abundance and distribution,
  - ascertain the status and viability of subpopulations,
  - assess the impacts of compounding threats, and
  - evaluate the relative benefits and effectiveness of management actions.
- Conduct on-ground surveys to establish habitat and population impacts as a result of the 2019–20 bushfires and to provide a baseline for future population monitoring. Leverage post-fire monitoring at sites where surveys were undertaken prior to 2019–20, to assess population trends across the fire cycle. Undertake these actions for any future large-scale events such as bushfires, heatwaves or drought.
- Monitor the incidence and impacts of fire and timber harvesting in the species' range, particularly in areas adjacent to those burnt in the 2019–20 bushfires.

- Monitor the abundance, age and size structure of hollow-bearing trees and their responses to management measures. This includes before and after prescribed burns, and before and after timber harvesting.
- Continue to undertake surveys on high priority timber harvesting coupes as part of DELWP's Forest Protection Survey Program (begun in 2018), and other pre-harvest surveys, to inform adaptive management in timber harvesting areas.

## Information and research priorities

- Undertake genetic sampling to resolve taxonomy, especially in areas where there is contact between the two greater glider species and subspecies.
- Improve understanding of actions that can be undertaken to improve rates of survival and recovery following major bushfires (including characteristics of refuges, role of patchiness in fire severity, and interactions with habitat quality and disturbance history).
- Support the development of guidelines for fire management by assessing the impacts of fire management and different fire regimes (including frequency and intensity) on habitat, subpopulation size and hollow availability.
- Define appropriate levels of timber harvesting exclusion, and hollow-bearing tree retention and recruitment, to maintain subpopulation sizes and persistence across the species' distribution. Assess and monitor the species' response to current timber harvesting prescriptions and revise as required, noting that the effectiveness of prescriptions may differ on a regional basis depending on forest type.
- To support protection and restoration activities, improve understanding of the species' behaviours, and landscape and habitat features, that promote or constrain genetic and functional connectivity between greater glider habitat patches.
- Investigate ways to improve the effectiveness of artificial structures for mitigation of impacts on greater gliders. Research should aim to evaluate effectiveness at a scale likely to be significant for subpopulation-level recovery rather than isolated instances of use (e.g. genetic connectivity provided by glide poles over transport routes, feasibility of artificial hollows and nest boxes to sustain populations).
- Investigate the impact of inter-species competition for hollows on the greater glider, and the extent to which this may be inhibiting subpopulation recovery.
- Investigate changes in subpopulations or dietary preferences of large owls, factors which may contribute to these changes, and the extent to which they may affect greater glider subpopulations.
- Improve understanding of actions that can be undertaken to improve rates of survival and recovery in climate-affected subpopulations.
- Identify areas likely to be climate refuges for the species under robust scenarios of climate change.
- Improve understanding of the species' diet and life history, especially in areas where subpopulations have declined. Determine the likely effects of increased temperatures and drought on food supply, behaviour and survival.

### Recovery plan

The Committee recommends that there should be a recovery plan for *Petauroides volans* (greater glider (southern and central)). Stopping decline and supporting recovery is complex, due to a need to fully identify all the threats, the requirement for a high level of planning to abate the threats, a high level of support by key stakeholders, a high level of prioritisation and a highly adaptive management process. Existing mechanisms are not adequate to address these needs.

## Links to relevant implementation documents

NSW Saving Our Species Strategy: Greater Glider Population in the Eurobadalla local government area (*Petauroides volans*) – Endangered Population)

NSW Saving Our Species Strategy: Greater Glider Population at Seven Mile Beach National Park (*Petauroides volans* – Endangered Population)

NSW Saving Our Species Strategy: Greater Glider Population at Mount Gibraltar Reserve area (*Petauroides volans* – Endangered Population)

Threat abatement plan for predation by feral cats 2015

Threat abatement plan for predation by the European red fox 2008

Threat abatement plan for predation by the European red fox 2008 - background document

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The Threatened Species Scientific Committee finalised this assessment on 9 September 2021.

# Attachment A: Listing Assessment for *Petauroides volans* (greater glider (southern and central))

## Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC.

## Assessment of eligibility for listing

This assessment uses the criteria set out in the EPBC Regulations. The thresholds used correspond with those in the IUCN Red List criteria except where noted in criterion 4, sub-criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

## Key assessment parameters

Table 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

### Table 3 Key assessment parameters

| Metric | Estimate used in the assessment | Minimum plausible value | Maximum plausible value | Justification |
|---|---|---|---|---|
| **Number of mature individuals** | >100 000 | 100 000 | Unknown | There is no robust estimate of the population size of the greater glider (southern and central). Woinarski et al. (2014) estimated over 100 000 mature individuals, and Nelson et al. (2018) estimated a subpopulation size of 69 000 in the Strathbogie ranges in Vic. |
| **Trend** | declining | | | Declines in occupancy of the greater glider (southern and central) have been recorded for over two decades in the Central Highlands (Lumsden et al. 2013; Lindenmayer 2020) and East Gippsland (L Bluff 2020. pers comm 15 October) regions of Vic. There have been losses of subpopulations in NSW within the Jervis Bay and Blue Mountains areas (Lindenmayer et al. 2011; Smith & Smith 2018). These declines were recorded pre-2019–20 bushfires and overall show a ≥30% decline. Post-fire surveys have indicated that in areas of high fire severity there is zero to very low occupancy (J Smith 2020. pers comm 10 December).<br>Following the 2019–20 bushfires, an overall population decline of >20%, with local subpopulation extirpations, is estimated one year after the fires. This is expected to increase to >30% within three generations after the fires (Legge et al. 2021). |

| Metric | Estimate used in the assessment | Minimum plausible value | Maximum plausible value | Justification |
|---|---|---|---|---|
| **Generation time (years)** | 7 | 6 | 8 | The greater glider can live for 15 years (Jones et al. 2009) and reaches sexual maturity at two years of age (Tyndale-Biscoe & Smith 1969b), suggesting a generation length of six to eight years (Pacifici et al. 2013; Woinarski et al. 2014). |
| **Extent of occurrence** | 752 962 $km^2$ | 752 962 $km^2$ | 1 066 146 $km^2$ | Woinarski et al. (2014) estimated the extent of occurrence (EOO) of the greater glider (southern and central) as 752 962 $km^2$, calculated using records from 1993 to 2012.<br>The 1 066 146 $km^2$ figure was based on the mapping of point records from 2000 to 2020, obtained from state governments, museums and CSIRO (DAWE 2021). The EOO was calculated using a minimum convex hull, based on the IUCN Red List Guidelines 2019. |
| **Trend** | contracting | | | The EOO has contracted since European settlement, with loss of habitat from land clearing, fragmentation, timber harvesting, inappropriate fire regimes, and climate change.<br>Local extinctions of subpopulations have occurred recently (Lindenmayer et al. 2018b), and the EOO is likely to continue contracting due to loss of habitat from the 2019–20 bushfires and climate change. |
| **Area of Occupancy** | 15 316 $km^2$ | 15 316 $km^2$ | >20 000 $km^2$ | The 15 316 $km^2$ figure is based on the mapping of point records from 2000 to 2020, obtained from state governments, museums and CSIRO (DAWE 2021). The AOO was calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2019.<br>The AOO is likely to be significantly under-estimated due to limited sampling across the species' range. |
| **Trend** | contracting | | | The AOO has contracted since European settlement, with loss of habitat from land clearing, fragmentation, timber harvesting, inappropriate fire regimes, and climate change.<br>Local extinctions of subpopulations have occurred recently (Lindenmayer et al. 2018b, Smith & Smith 2020), and the AOO is likely to continue contracting due to loss of habitat from the 2019-20 bushfires and climate change. |
| **Number of subpopulations** | Unknown | Unknown | Unknown | The species has a broad distribution. The number of subpopulations is not able to be estimated due to insufficient sampling across its range. |
| **Trend** | declining | | | The number of greater gliders (southern and central) have been declining across its range, and together with the contracting AOO and EOO, the number of subpopulations is likely to be declining. |

| **Metric** | **Estimate used in the assessment** | **Minimum plausible value** | **Maximum plausible value** | **Justification** |
|---|---|---|---|---|
| **Basis of assessment of subpopulation number** | The greater glider (southern and central) number of subpopulations is unknown, as there is limited sampling across its broad range. | | | |
| **No. locations** | unknown | unknown | >10 | The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present (IUCN Standards and Petitions Committee 2019).<br>There is no robust estimate of the number of locations. The 2019–20 bushfires burnt a large area of south-eastern Australia, overlapping c. 40% of the greater glider (southern and central) distribution.<br>However, the fire intensity was highly spatially variable, with greater gliders (southern and central) persisting in at least some areas burnt at low or moderate intensity (J Smith 2020. pers comm 10 December; J Nelson 2021. pers comm 16 April). Impacts were also spatially variable, with some individuals persisting in areas burnt at high intensity, possibly due to the proximity of unburnt or low intensity burnt areas (Kavanagh et al. 2021). Thus, the number of locations may be significantly greater than 10. |
| **Trend** | declining | | | Climate change is likely to increase the extent, intensity and frequency of bushfires, and thus the number of locations is likely to decrease. |
| **Basis of assessment of location number** | Although the 2019-20 bushfires were extensive the habitat and landscape topography, along with the stochastic variation in fire spread, leaves numerous unburnt habitat fragments from which subpopulations may recover. | | | |
| **Fragmentation** | Not severely fragmented – less than 50% of the AOO are in habitat patches that cannot support minimum viable subpopulations. | | | |
| **Fluctuations** | Not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals. | | | |

### Criterion 1 Population size reduction

| Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4 | | | |
|---|---|---|---|
| | **Critically Endangered**<br>**Very severe reduction** | **Endangered**<br>**Severe reduction** | **Vulnerable**<br>**Substantial reduction** |
| **A1** | ≥ 90% | ≥ 70% | ≥ 50% |
| **A2, A3, A4** | ≥ 80% | ≥ 50% | ≥ 30% |

**A1** Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

**A2** Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

**A3** Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [*(a) cannot be used for A3*]

**A4** An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

Based on any of the following

(a) direct observation [except A3]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

## Criterion 1 evidence

**Eligible under Criterion 1 A2abc+4bc for listing as Endangered**

The greater glider (southern and central) has a generation length of six to eight years (see Table 3). In this assessment a generation length of seven years is used, which gives a timeframe of 21 years for this criterion.

There are no robust estimates of population size or population trends of the greater glider (southern and central) across its distribution. However, declines in numbers, occupancy rates and extent of habitat have been recorded at many sites (see below). Although there are a few sites where subpopulations appear to be stable or increasing, the overall trend is one of decline.

## Prior to 2019-20 bushfires

### *Victoria*

The most comprehensive long-term monitoring program for the greater glider (southern and central) is in the *Eucalyptus regnans* (Mountain Ash) forests of the Central Highlands in Vic, where 160 permanent 1 ha sites across a 1,800 km$^2$ study area (in both conservation reserves and production forests, and spanning a broad range of forest ages and environmental settings) (Lindenmayer 2009) have been monitored annually since 1997. Over the period 1997−2010, the greater glider (southern and central) declined by an average of 8.8 percent per year (Lindenmayer et al. 2011) − a rate that if extrapolated over the 21-year period relevant to this assessment is 85 percent. The trend could in part be explained by lower-than-average rainfall and major bushfires, with the species not detected in any of the sites burned in 2009. However, the probability of observing the species was also significantly higher on sites located in the Yarra Ranges National Park than in forests broadly designated for pulp and timber production, and there was a significant positive relationship between the species' abundance and both the age of the forest and number of trees with hollows on a site (Lindenmayer 2009). Populations of large hollow-bearing trees in the Central Highlands are in rapid decline, with the rate of loss greatly exceeding the rate of recruitment (Lindenmayer et al. 2017a,b).

Other surveys undertaken in the Central Highlands, in both Mountain Ash and mixed species forests, indicate a significant decline in occupancy rates of the greater glider (southern and central) over the past two decades (Lindenmayer et al. 2011; Lindenmayer & Sato 2018; Lumsden et al. 2013).

In 2018, a broad-scale survey of 80 sites (500 m off-track transects) spread across central and north-eastern Vic found low numbers of greater gliders (southern and central) at the majority of sites. Despite many of the sites supporting seemingly suitable habitat, the species was detected on fewer than half (41 percent) of the transects. On average, 0.93 gliders (range 0−6) were detected per 500 m transect (DELWP unpublished data). Surveys in 2019 conducted at 63 sites within eastern Vic also found low numbers of the species, with individuals detected on only 19 percent of sites (0.21 gliders/500 m transect, range 0−2). Based on records held in the Victorian Biodiversity Atlas and anecdotally, these results suggest the species has declined across this area (DELWP 2019. pers comm 15 October).

In contrast, surveys using the same broad-scale survey methodology in the Strathbogie Ranges in north-eastern Vic found relatively high densities of gliders, with 4.92 gliders detected on average per transect (range 0−14; Nelson et al. 2018). Analyses of the survey data estimated the number of greater gliders (southern and central) within the Strathbogie Ranges to be 69 000, although with relatively broad confidence intervals (95 percent confidence interval 3000−121 000 individuals). A comparison of data from three surveys conducted in the Strathbogie Ranges in 1983 (Land Conservation Council 1984), 1997 (Downes et al. 1997) and 2017 (Nelson et al. 2018), suggests that the subpopulation in the Strathbogie Ranges has not declined over a 34 year period to the extent that has been observed elsewhere in Vic (Nelson et al. 2018).

Major bushfires in 2003, 2006–2007 and 2009 burnt large areas of the greater glider (southern and central) range in Vic, and further fragmented its distribution as evidenced by surveys and species records (Lumsden et al. 2013; Vic SAC 2015). Following the 2009 bushfires, 79 percent of large living trees with cavities died in the Mountain Ash forests, with no recruitment of new large cavity-bearing trees by 2011 (Lindenmayer et al. 2013). The abundance of greater gliders (southern and central) declined at burned sites, as well as at unburnt sites that were surrounded by burned forest (Lindenmayer et al. 2013). Reoccupation of burnt sites in subsequent years is a slow process due to the small home ranges (1–4 ha) of the species and its limited dispersal capabilities (L Lumsden pers comm, cited in Vic SAC 2015). It also depends on there being no further significant fires in the interim (Vic SAC 2015). Since the 2009 fires, which burnt the Kinglake East Bushland Reserve and nearby areas, spotlighting records of greater gliders (southern and central) in these areas have significantly declined (C Cobern 2015. pers comm 9 November). The occupancy model in Lumsden et al. (2013) predicts that areas most likely to be occupied following the 2009 fires are now patchily distributed.

However, evidence of declines in occupancy in some unburnt sites in the same parts of Vic (Lumsden et al. 2013) suggest that factors other than fire are involved in the species' decline (Vic SAC 2015). A decline in suitable browse due to water stress is probably a contributing factor, as central Vic was significantly hotter and drier than normal during 2001–2009 (Vic SAC 2015). Occupancy modelling by Lumsden et al. (2013) and Wagner et al. (2020) shows that the degree of site occupancy is positively associated with site ruggedness, vegetation lushness and terrain wetness.

In East Gippsland, analysis of results from a survey of 107 sites, comprising 49 sites with previous records of greater gliders (southern and central) and 58 randomly stratified sites, found a decline in occupancy rates of about 50 percent compared to about 20 years ago (L Bluff 2020. pers comm 15 October). The survey was undertaken in 2015 and results were compared to the pre-logging survey period 1988-1995. Although the occupancy rate of all arboreal mammals that were detected in sufficient numbers to enable analysis had declined across the two decades, the greater glider (southern and central) had declined more than other species. The decline in the rate of detection was highest in coastal and foothill forests, while detection rates were high only in wet and damp tableland forest on the Errinundra Plateau and Coast Range.

In the Mount Alfred State Forest, roadside spotlighting on the same route over a 30-year period used to record frequent sightings (10–15 animals on each occasion), but only a single greater glider (southern and central) was sighted in the 18 months leading up to November 2015 (Gippsland Environment Group 2015 pers comm 24 November).

### *New South Wales and the Australian Capital Territory*

At Jervis Bay in Booderee National Park, 110 permanent 1 ha sites (stratified across vegetation types and fire histories) were established in 2002. Lindenmayer et al. (2011) reported a highly significant decline of greater gliders (southern and central), from the species being present in 22 of the sites in 2002, to absence from all sites since 2007. The greater glider (southern and central) has not been recorded in the National Park since 2006 and appears to have been extirpated from the area, for reasons unclear (Lindenmayer et al. 2018b).

At Murphy's Glen in the Blue Mountains, spotlighting undertaken between 1986 and 2014 shows that the species used to be consistently and regularly detected, but by 2010 was difficult to detect and likely no longer present (J Smith 2015. pers comm 22 November). However, spotlighting undertaken in 2015 recorded greater gliders (southern and central) on each of the three occasions (1, 2 and 5 individuals), which indicates that numbers may be recovering (J Smith 2015. pers comm 22 November). Anecdotal reports, including from local ecologists, indicated similar declines elsewhere in the lower Blue Mountains, and the NSW Bionet Atlas confirms a marked drop in records in the region (Blue Mountains National Park: 357 records 1990–2004, eight records 2004–2014. Blue Mountains LGA: 142 records 1990–2004, one record 2004–2014, five records 2018–2020 and only one record for 2020) (J Smith 2015. pers comm 22 November). The decline of the greater glider (southern and central) in the lower Blue Mountains is mostly likely due to the effects of increased temperatures as a result of climate change (Smith & Smith 2018, 2020). An autopsy undertaken in January 2020 on two individuals (which were found walking on the ground in the daytime), reported that they had both died from drought and extreme heat events (i.e. heat stress and dehydration) (P Ridgeway 2021. pers comm 6 January).

An isolated subpopulation at Royal National Park was thought to be lost due to fire and regional-scale decline in the Illawarra area. Following the 1994 bushfire, which burnt more than 90 percent of the park, the first confirmed sighting of a greater glider (southern and central) in Royal National Park was in 2012 (Andrew et al. 2014), although a number of surveys had been conducted since 1994 (Andrew 2001; Maloney 2007; Andrew et al. 2014).

Near Bombala in southern NSW, Kavanagh and Webb (1998) monitored greater gliders (southern and central) in 500 ha of wood production forest, and found that the subpopulation declined in all timber harvesting compartments and had not recovered eight years after harvesting. However, the effects of logging were compounded by the independent effects of predation by powerful owls, and the overall declines of greater glider in this study were attributed to predation (Kavanagh 1988).

About 30 years after clearing of eucalypt forests in Tumut, Lindenmayer et al. (1999) found that the occupancy rate of greater gliders (southern and central) in remnant patches was still lower (21 percent) compared to that in surrounding forest (38 percent), indicating that recolonization following clearing occurs slowly. It is unclear, following such disturbances, whether subpopulations recover to their former levels or persist at lower levels.

In the Dorrigo, Guy Fawkes and Chaelundi Plateaux of north-eastern NSW, surveys for the greater glider (southern and central) at 30 sites in wet sclerophyll forest recorded a density of 27.6 individuals per km, in unlogged forest with no fire history (McLean et al. 2018).

### *Queensland*

In central Qld, the abundance of greater gliders (southern and central) declined by 89 percent across a series of 31 woodland sites sampled initially in 1973−76 and re-sampled in 2001−02 (Woinarski et al. 2006). The species is continuing to decline, based on anecdotal observations over a 20-year period (DEHP 2015) and evidence of a decline in large, hollow-bearing trees due to past timber harvesting activities and repeat prescribed burning (Eyre 2005; Eyre et al. 2010). There has been a decline in living hollow-bearing trees (25 percent) and stags (40 percent) over a 20-year period (1998–2018) in the St. Marys State forest area (T Eyre 2021 pers comm 11 January). Once habitat trees are lost from the system, the length of time required for the development/recruitment of replacement habitat trees appropriate for the species is largely prohibitive (Smith et al. 2015).

### After the 2019-20 bushfires

The full impact of the 2019-20 bushfires on the greater glider (southern and central) has yet to be determined but the population is likely greatly reduced. The fires may have accelerated any ongoing population decline, with approximately 40 percent of the species' distribution overlapping with the fire-affected areas (Legge et al. 2021). These fires covered an unusually large area and, in many places, burnt with an unusually high intensity. Its pre-fire imperilment, together with the extent of mortality as a result of fire and the unfavourable post-fire conditions (loss of hollows, increased susceptibility to predators, and loss of food resources), as well as a reduction in future recruitment, led to the greater glider (southern and central) being identified as one of the highest priority species for urgent management intervention by the Wildlife and Threatened Species Bushfire Recovery Expert Panel (Legge et al. 2020).

It is known that the greater glider (southern and central) is highly susceptible to fire events, with population declines of 50 percent documented in some areas (McLean et al. 2018) and extirpation with slow recovery documented in others (Andrew et al. 2014). Following the 2019-20 bushfires, on-ground surveys in some areas are still to be conducted, and baseline data are missing on population size, distribution and density throughout the range of the species. The majority of records are from the eastern areas of NSW and Vic, which were extensively burnt (DPIE 2020; Parliament of Victoria 2020). Post-fire field survey data available to date are summarised in the section below.

In addition to direct observations (see below), an expert elicitation exercise has been run to estimate the likely decline in greater glider (southern and central) populations due to fires of varying intensity (Legge et al. 2021). This was then combined with a GIS analysis of overlap of the distribution of the greater glider (southern and central) with the fire footprint to provide an overall estimate of the likely population decline due to the fires. The result was an estimated loss of 24 percent of the population (range 17–31%) one year after the fires, assuming current management conditions (Legge et al. 2021). This estimate rises to 33 percent (range 18—48%) three generations after the fires.

### *Victoria*

Surveys currently underway (April 2021) are focused predominantly on lightly burnt and unburnt habitat within the fire ground, but also some areas burnt at moderate to higher severity (DELWP 2021. pers comm 22 April). Surveys have been designed to visit pre-fire records of the greater glider (southern and central) near Swifts Creek and Bendoc in East Gippsland. Interim results for surveys along 500 m transects at 11 sites (one third of all sites planned for surveys) have detected the species at four lightly burnt sites, as well as at two sites that were burnt at higher severity; compared to pre-fire records, the numbers of individuals detected were lower and the species was not detected at five sites where they were previously recorded (J Nelson 2021. pers comm 19 April). Surveys at 30 sites in lower elevation forests in East Gippsland (from Cabbage Tree Creek to Drummer State Forest), that burnt at low severity, did not detect any individuals (DELWP 2021. pers comm 22 April).

Greening Australia recorded nest boxes being utilised by greater gliders (southern and central) post-fire in East Gippsland (D Liepa 2020. pers comm 10 September), and spotlighting surveys (500 m transects at 24 sites) recorded the species in low numbers at some sites. Individuals were detected at seven of the 18 sites where they were previously recorded, suggesting a 60 percent decline due to the fires (B Blake 2020. pers comm 25 September). A further spotlighting survey of 500 m transects undertaken in Mallacoota, Far East Gippsland, detected the species in only one of 12 transects where they were recorded previously, indicating a 90 percent decline (Burns & Atkins 2021). The one detection site had low canopy scorching.

Limited spotlighting surveys undertaken in the Tallarook Range in the Central Highlands, from October 2020 to March 2021, recorded the species within an area of less than 10 $km^2$ (N Stimson 2021. pers comm 24 June). This subpopulation may be geographically isolated and restricted to the central area of the Tallarook Range plateau, however further survey work is required to determine this.

### *New South Wales*

*South Coast*

Spotlighting surveys at 71 sites, undertaken at Murramarang, Meroo and Conjola National Parks, and Corramy Regional Park in May and June of 2020, reported on average a 70 percent decline in the numbers of greater gliders (southern and central) detected at these sites, compared to surveys undertaken prior to the 2019-20 bushfires (NSW NPWS 2020).

Two post-fire surveys were undertaken in the southern tablelands east of Bombala, in November 2020 and April-May 2021 respectively. The sites were distributed across elevations ranging 800–1100 m a.s.l. A total of 18 spotlighting sites/transects (each 1000 m) were surveyed using similar methods to previous surveys undertaken in the area, with sites stratified according to modelled fire severity classes in 2019-20. Greater gliders (southern and central) were previously recorded at all 18 transects on almost every sampling occasion; in 2020-21 the species was still present at all sites but in greatly reduced numbers on the burnt sites. A negative relationship was found between the species' abundance and increasing fire severity in the local landscape, and the number of fires over the past 30 years was also found to be negatively associated with the species' abundance (Kavanagh et al. 2021).

*Blue Mountains Region*

In the Blue Mountains area, sites with greater glider data prior to the 2017-19 drought and 2019-20 fires were re-surveyed during 2020-21. The surveys involved three one-hour spotlight searches of sixteen 500m transects that previously supported the species, comprising eight burnt and eight unburnt transects. In the burnt transects, no greater gliders (southern and central) were detected at the two sites which had total canopy loss, whereas they were detected at reduced numbers at the six transects which had 44–77% canopy loss. The overall result was a 36% decline (p=0.00012) in the mean detection density for the six burnt transects between 2015-18 and 2020-21. However, in the eight unburnt transects there was also a reduction in numbers, with a decline (p=0.014) of 51% between 2015-16 and 2021-21 (P & J Smith 2021, pers comm 24 June).

It is estimated that 84% of known greater glider (southern and central) habitat in the Greater Blue Mountains World Heritage Area (GBMWHA) was burnt in the 2019-20 fires, with 50% burnt at low-moderate severity and 34% burnt at high to extreme severity (P & J Smith 2021. pers comm 24 June). This equates to an estimated overall decline of 60% in the subpopulation as a result of the drought, heatwaves and bushfires of 2019-20. This estimate is preliminary, with further surveys planned later in 2021 (P & J Smith 2021. pers comm 24 June).

*Crookwell*

Using the same methodology as for the Blue Mountains, P & J Smith (2021) surveyed greater gliders (southern and central) in five transects in reserves in the Bigga-Tuena area north-west of Crookwell. The transects were surveyed in both spring 2020 and autumn 2021. The area was unaffected by the 2019-20 bushfires but had experienced the severe drought and heatwaves of 2019. They found that numbers on the three transects where the species was previously recorded declined by 43% (p= 0.014) between 2017-18 and 2020-21. They also found that numbers in the five transects declined by 53% (p=0.006) between spring 2020 and autumn 2021. The reason for the latter decline is unclear. It may be the result of predation by powerful owls, which were recorded on four of the five transects, or long-term physiological impacts from the extreme conditions the gliders endured in 2019.

*Far North Coast*

Two post-fire surveys were undertaken between Coffs Harbour, Dorrigo, Glen Innes and Grafton, in November 2020 and April-May 2021 respectively. The sites were distributed across elevations ranging 30–1330 m a.s.l. A total of 94 spotlighting sites/transects (each 500 m) were surveyed using similar methods to previous surveys undertaken in the area, with sites stratified according to modelled fire severity classes in 2019-20. Greater gliders (southern and central) were recorded at 57 of the 75 sites where they had been recorded previously (76%), and at an additional 3 sites where they had not been recorded previously. Abundance remained similar in many areas after the 2019-20 bushfires, particularly in the higher elevation sites. There was only a slight negative relationship between the species' abundance and increasing fire severity in the local landscape. Many severely burnt areas supported relatively high populations while other similarly burnt areas did not, which may be due to patchiness in fire severity and the proximity of unburnt or low-severity burnt areas nearby. The number of fires over the past 30 years was also found to be negatively associated with the species' abundance (Kavanagh et al. 2021).

### *Queensland*

Major bushfires in 2019-20 burnt part (approximately 10 percent) of the greater glider (southern and central) range in southern Queensland. While there has been no post-fire survey work undertaken for this species in Queensland to date, these fires would have caused direct and indirect mortalities through habitat loss and fragmentation, with a consequent decline in abundance of the species.

### Overall population decline

The greater glider (including *P. minor)* was assessed in 2016, with the species found to be eligible for listing as Vulnerable against this criterion as follows (DoEE 2016a):

> 'There is little other published information on population trends over the period relevant to this assessment (around 21–24 years), and the above sites are not necessarily representative of trends across the species' range. However, they provide sufficient evidence to infer that the overall rate of population decline exceeds 30 percent over a 21–24-year (three generation) period (Woinarski et al. 2014), and indeed may far exceed 30 percent. The population of the greater glider is thought to be declining due to habitat loss, fragmentation, extensive fire and some forestry practices, and this decline is likely to be exacerbated by climate change (Kearney et al. 2010). The species is particularly susceptible to threats because of its slow life history characteristics, specialist requirements for large tree hollows (and hence mature forests), and relatively specialised dietary requirements Woinarski et al. 2014).'

Since that determination, there is no evidence that any of the major threats to this species have substantially reduced, and the effects of climate change are likely worsening (Smith & Smith 2020; Wagner et al. 2020). The effects of the 2019–20 bushfires are in addition to ongoing declines.

Overall decline can be estimated by combining the ongoing decline of 30 percent (see above) with decline due to the 2019–20 bushfires, i.e. *Past decline + Decline due to fires* Population proportion remaining after past decline*. Using decline rates of 24 percent (range 17–31%) one year after the fires and 33 percent (range 18–48%) three generations after the fires, as determined by Legge et al. (2021), gives an overall decline over the past three generations (21 years) of 47 percent (Criterion 1A2) and an overall decline over a three generation period including both the past and the future of 53 percent (Criterion 1A4). However, large-scale fire and catastrophic drought were not accounted for during projections of future declines (Legge et al. 2021). Given that Australia is predicted to continue to experience increased frequency, intensity and scale of bushfires into the future (BOM & CSIRO 2020), declines over a period including both the past and the future may be even greater.

**Conclusion**

Given the uncertainty in the estimates of overall decline, the Committee considers that the species has undergone a severe reduction in numbers of at least 50 percent over the past three generation period (21 years for this assessment) (Criterion 1A2), and over a three generation period that includes both the past and the future (Criterion 1A4). The reduction has not ceased and the cause has not ceased. Therefore, the species has met the relevant elements of Criterion 1 to make it eligible for listing as Endangered.

### Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy

| | | Critically Endangered Very restricted | Endangered Restricted | Vulnerable Limited |
|---|---|---|---|---|
| **B1.** | Extent of occurrence (EOO) | **< 100 km²** | **< 5,000 km²** | **< 20,000 km²** |
| **B2.** | Area of occupancy (AOO) | **< 10 km²** | **< 500 km²** | **< 2,000 km²** |
| **AND at least 2 of the following 3 conditions:** | | | | |
| (a) | Severely fragmented OR Number of locations | **= 1** | **≤ 5** | **≤ 10** |
| (b) | Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals | | | |
| (c) | Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals | | | |

## Criterion 2 evidence

**Not eligible**

The Extent of Occurrence (EOO) for the greater glider (southern and central) is estimated at 1 066 146 km², and the Area of Occupancy (AOO) estimated at 15 316 km². These figures are based on the mapping of point records from 2000 to 2020, obtained from state governments, museums and CSIRO (DAWE 2021). The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2019. Woinarski et al. (2014) noted that the AOO, which they estimated to be 15 244 km², and the EOO which they estimated to be 752 962 km², are likely to be significant underestimates due to limited sampling across the occupied range of the greater glider (southern and central).

Following assessment of the data the Committee considers that the species is not eligible for listing in any category under this criterion as neither the EOO or AOO are limited.

### Criterion 3 Population size and decline

| | | Critically Endangered<br>Very low | Endangered<br>Low | Vulnerable<br>Limited |
|---|---|---|---|---|
| Estimated number of mature individuals | | < 250 | < 2,500 | < 10,000 |
| AND either (C1) or (C2) is true | | | | |
| **C1.** An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future) | | **Very high rate**<br>**25% in 3 years or 1 generation**<br>**(whichever is longer)** | **High rate**<br>**20% in 5 years or 2 generation**<br>**(whichever is longer)** | **Substantial rate**<br>**10% in 10 years or 3 generations**<br>**(whichever is longer)** |
| **C2.** An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions: | | | | |
| (a) | (i) Number of mature individuals in each subpopulation | ≤ 50 | ≤ 250 | ≤ 1,000 |
| | (ii) % of mature individuals in one subpopulation = | 90 – 100% | 95 – 100% | 100% |
| (b) Extreme fluctuations in the number of mature individuals | | | | |

## Criterion 3 evidence

**Not eligible**

There is no reliable estimate of population size, but available estimates suggest that the number of mature individuals is substantially greater than 10 000. Lunney et al. (2008) considered that the greater glider (both southern and northern) had a 'presumed large population' and was 'locally common'. In NSW, Kavanagh (2004) considered it 'widespread and common… particularly in north-eastern NSW'. Density estimates in Vic range from 0.6 to 2.8 individuals per hectare (Henry 1984; van der Ree et al. 2004; Nelson et al. 2018), and across its broader distribution density ranges from 0.01 to 5 individuals per hectare (Kavanagh 1984; Kehl & Borsboom 1984; Smith & Smith 2018; Vinson et al. 2020). However, it is noted that some of these estimates were made prior to recent population declines.

Woinarski et al. (2014) estimated the number of mature individuals to be greater than 100 000. Using a mark-recapture distance sampling approach during surveys of the Strathbogie Ranges in Vic in 2017, the subpopulation in this 21 200 ha area alone was estimated to have 69 000 individuals (Nelson et al. 2018). The Vic Government estimates that approximately 32 percent of the greater glider (southern and central) modelled range within the state was within the fire footprint, and 16 percent was burnt at high intensity. Thus, it is unlikely that the population of greater glider (southern and central) has been reduced to below 100 000 mature individuals.

Following assessment of the data the Committee considers that the species is not eligible for listing in any category under this criterion as the total population size is not limited.

### Criterion 4 Number of mature individuals

| | | | |
|---|---|---|---|
| | **Critically Endangered**<br>**Extremely low** | **Endangered**<br>**Very Low** | **Vulnerable**<br>**Low** |
| **D.** Number of mature individuals | < 50 | < 250 | < 1,000 |
| **D2.**[1] *Only applies to the Vulnerable category*<br>Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time | | | D2. Typically: area of occupancy < 20 km² or number of locations ≤ 5 |

[1] The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the *common assessment method*.

## Criterion 4 evidence

**Not eligible**

Woinarski et al. (2014) estimate the population size to be greater than 100 000 mature individuals (see Criterion 3) and it is highly unlikely that the number of mature individuals is less than 1000. Additionally, the greater glider (southern and central) does not meet the quantitative threshold for Vulnerable under sub-criterion D2. The area of occupancy (AOO) is estimated to be 15 532 km² and the species occurs at more than five locations.

Following assessment of the data the Committee considers that the species is not eligible for listing in any category under this criterion as the number of mature individuals is not low.

**Criterion 5 Quantitative analysis**

| | | | |
|---|---|---|---|
| | **Critically Endangered** **Immediate future** | **Endangered** **Near future** | **Vulnerable** **Medium-term future** |
| **Indicating the probability of extinction in the wild to be:** | ≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.) | ≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.) | ≥ 10% in 100 years |

## Criterion 5 evidence

**Insufficient data to determine eligibility**

Several local-level population viability analyses have been undertaken – e.g. for Yarra State Forest Vic (Possingham et al. 1994), Tumut NSW (Lindenmayer et al. 2001), Brisbane Qld (Taylor & Goldingay 2009) – but none for the full species (Woinarski et al. 2014).

Population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

## Adequacy of survey

The survey effort has been considered adequate and there is sufficient scientific evidence to support the assessment.

## Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 36 business days between 6 May 2021 and 24 June 2021.

## Listing and Recovery Plan Recommendations

The Threatened Species Scientific Committee recommends:

(i) that the list referred to in section 178 of the EPBC Act be amended by **transferring** *Petauroides volans* from the Vulnerable category to the Endangered category

(ii) that there should be a recovery plan for this species.

**Cataloguing data**

This publication (and any material sourced from it) should be attributed as: Department of Climate Change, Energy, the Environment and Water 2022, *Conservation advice for Petauroides volans (greater glider (southern and central))*, Canberra.

This publication is available at the SPRAT profile for *Petauroides volans (greater glider (southern and central)).*

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Australian Government
Department of Agriculture, Water and the Environment

# Conservation Advice for *Phascolarctos cinereus* (Koala) combined populations of Queensland, New South Wales and the Australian Capital Territory

**In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 12 February 2022.**

This document combines the approved conservation advice and listing assessment for the species. It provides a foundation for conservation action and further planning.

*Phascolarctos cinereus* (Koala) © Copyright Karen Ford.

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## Conservation status

The *Phascolarctos cinereus* (Koala) combined populations of Queensland, New South Wales and the Australian Capital Territory were determined to be a species for the purposes of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) (s517) on 27 April 2012 and listed in the Vulnerable category of the threatened species list under the EPBC Act effective from 2 May 2012. For conciseness, it is referred to hereafter as the listed population.

The listed population was reassessed in 2021 by the Threatened Species Scientific Committee to be eligible for listing as Endangered under criteria 1. The Committee's assessment is at Attachment A. The Committee's assessment of the listed population's eligibility against each of the listing criteria is:

- Criterion 1: A2C and A4C: Endangered
- Criterion 2: Ineligible
- Criterion 3: Ineligible
- Criterion 4: Ineligible
- Criterion 5: Insufficient data

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the Species Profile and Threat Database.

## Species information

### Taxonomy

This species is conventionally accepted as *Phascolarctos cinereus* (Koala) (Goldfuss 1817). The koala is a single species whose physical appearance differs with latitude. Morphological differences include size, fur colouration and fur length. Three subspecies of koala were previously described on the basis of morphological differences in size and fur colouration: *Phascolarctos cinereus adustus* (Queensland) (Thomas 1923), *P. c. cinereus* (New South Wales) (Goldfuß & Bischof 1817) and *P. c. victor* (Victoria) (Troughton 1935). There is no genetic evidence to support these subspecies (Wedrowicz et al. 2017). A recent genomic assessment of population structure indicates spatially-organised genetic structure within the species (Kjeldsen et al. 2019), meaning that a large proportion of genetic variation can be attributed to the geographic distance between populations (Eldridge & Lott 2020).

The koala population was sub-divided in 2012 due to substantial differences in management and conservation status across the species range. Under section 517 of the EPBC Act the combined koala populations of Queensland, New South Wales and the Australian Capital Territory were declared to be a species for the purposes of the Act. This entity was listed as Vulnerable. The koala was not found to be eligible for listing at the national scale (SEWPaC 2012b).

## Description

Names applied to the koala by different Indigenous language groups include: Guula and Gulawayn in the Gathang language, Barrandhang, Gurabaan, Naagun and Ginaagun from the Wiradjuri language, Borobi in the Yuambeh language, Doombearpee and Dumirripi in the Jandai language, and Goala from the Kabi language.

The koala is a medium-sized marsupial with a stocky body, large, rounded ears, sharp claws and variable but predominantly grey-coloured fur. Males are typically larger than females. Its morphological appearance changes gradually from south to north across its range, with larger individuals in the south and smaller individuals in the north. The average weight of males is 12 kg in Victoria compared with 6.5 kg in Queensland. In the south, the koala is characterised by longer, thicker, brown-grey fur, whereas in the north it has shorter, silver-grey fur (Martin & Handasyde 1999).

## Distribution

### The National distribution

The koala is a wide-ranging marsupial endemic to Australia. It typically occurs in eastern Australian forests and woodlands of predominantly *Eucalyptus* species. Its historical range extends over 22° of latitude and 18° of longitude (Martin & Handasyde 1999). The koala's distribution is not continuous across this range and it occurs in several subpopulations that are separated by cleared land or unsuitable habitat (Martin and Handasyde 1999; NSW DECC 2008). The koala's distribution includes Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia. The listed population of the koala has a wide but patchy distribution that spans the coastal and inland areas of Queensland north to the Herberton area, extending westwards into hotter and dryer semi-arid climates of central Queensland, New South Wales and the Australian Capital Territory.

Other populations, which are not listed as threatened under the EPBC Act, occur to the south, in Victoria and South Australia. The species is widespread in lowland and foothill eucalypt forests and woodlands across Victoria. Its distribution extends to the south-east corner of South Australia. A number of successful introductions have expanded the distribution in South Australia to locations including Kangaroo Island and mainland areas of the Adelaide Hills, Eyre Peninsular and sites along the Murray River.

The natural range of the koala is determined by specialist food, habitat and environmental requirements. Typically, this includes forests and woodlands dominated by *Eucalyptus* species (Melzer et al. 2000). The koala's home range (the area an individual needs to survive) is highly variable and dependant on life history stage, soil fertility, habitat quality and nutritional requirements. Consequently, home ranges across the species' distribution are highly variable, with home ranges in Queensland and New South Wales reported to vary between 3 and 500 ha (home range data summarised in: Wilmott 2020). Habitat suitability models indicate that koalas are best suited to locations where the mean maximum summer temperatures are 23-26$^{o}$C and mean annual rainfall ranges from 700 -1500 mm (Adams-Hosking et al. 2011). However, koalas can occur in more extreme environments at the limits of their natural range (McAlpine et al. 2015).

The koala's distribution and population size have declined significantly since European colonisation (Melzer et al. 2000; Sherwin et al. 2000). Much of the koala's national distribution now overlaps with human-modified landscapes. Vegetation clearance from activities including urbanisation, grazing, agriculture and mining have significantly reduced the koala's distribution (McAlpine et al. 2015). Climate change drivers (e.g., drought and rising temperatures) have also resulted in a reduction in climatically suitable habitat (Adams-Hosking et al. 2011).

Concerns over the declining koala population in Queensland, New South Wales and the Australian Capital Territory resulted in the koala combined populations of Queensland, New South Wales and the Australian Capital Territory being listed as Vulnerable in 2012 under the EPBC Act (TSSC 2012). Historically, national and regional estimates of koala population size have been limited, fragmented and based on limited data (Melzer et al. 2000). This has made quantitative assessment of koala populations at the national level problematic. The 2012 listing highlighted the lack of peer-reviewed population data (TSSC 2012). In response to this data gap, in 2012, an expert elicitation estimated that the national koala population size was 329,000 (range: 144,000-605,000) (Adams-Hosking et al. 2016). It also indicated a 24 percent decline nationally over the preceding three koala generations (15-21 years). For the listed population in Queensland and New South Wales, the percentage loss was estimated at 53 percent and 26 percent respectively. No data were detailed for the Australian Capital Territory, however the earlier 2012 listing advice (TSSC 2012) suggested a high likelihood of the koala being present in the Australian Capital Territory, though with some populations originating from deliberate introductions from outside the Australian Capital Territory and possibly some natural populations.

For the listed population of koalas in Queensland, New South Wales and the Australian Capital Territory, extent of occurrence (EOO), the area encompassing all known occurrences of a species across its range (IUCN 2019), is estimated to be 1,665,850 km$^2$. This figure is based on the mapping of point records from a 20-year period (2000–2020) obtained from state governments, museums and CSIRO. The EOO was calculated using a minimum convex hull, based on the IUCN Red List Guidelines (DAWE, 2020). During the 2019-2020 bushfire season an estimated 9 percent (>36,800 km$^2$) of the koala's distribution was impacted by fire (DAWE 2021a). This agrees with estimates generated by the NESP Threatened Species Recovery Hub of 9-11.4 percent.

In contrast to the Queensland, New South Wales and Australian Capital Territory populations, koala populations in the southern part of the species' range, in Victoria and South Australia, are robust, and in some cases overpopulation has led to active population control measures being put in place (Menkhorst 2008). Despite historically suffering from population crashes and relocations, koala numbers are currently high in Victoria (Heard and Ramsey 2020) and mainland South Australia (DEW 2018), and those subpopulations are not listed.

Koala translocations have occurred in areas outside their natural range. These have resulted in establishment of new populations both in mainland areas (e.g. Adelaide Hills, Eyre Peninsula, Riverland) and on many islands in South Australia (Kangaroo Island), Victoria (French Island, Phillip Island, Raymond Island, Snake Island) and Queensland (Brampton Island, Magnetic Island, St Bees Island) (Melzer et al. 2000). Koalas have also been re-introduced to areas within their natural range in the Australian Capital Territory, New South Wales, mainland Victoria and the south-east of South Australia.

For the listed population in Queensland, New South Wales and the Australian Capital Territory, modelling of koala distribution indicates that in future it will be further constrained by climatic stressors (Adams-Hosking et al. 2011). In particular, shifts in summer temperatures, humidity and water availability pose a significant threat to the koala as a result of acute physiological stress during heatwaves, compounded by drought (Runge et al. 2021a). Forecasting models predict that a large area of koala habitat may be lost, accompanied by a large reduction in the koala population, under 2070 climate change projections (Adams-Hosking et al. 2011; Runge et al. 2021b). These losses will result in the southwards and eastwards contraction of suitable habitat across their range. Models indicate that koala occupancy is strongly dependant on annual rainfall and the distance to water features (Santika et al. 2014). Koalas may survive in refuge areas where microclimates such as deep gullies, caves, cliffs or dense vegetation provide refuge from heat, and perennial water results in leaf-water content remaining high (Runge et al. 2021a).

## Distribution across the range of the EPBC Act listed koala population: Queensland, New South Wales and the Australian Capital Territory

### Queensland distribution

Koalas are widespread across Queensland (map 1), occurring in patchy and often low-density populations across the different bioregions. They occur as far north as the Einasleigh Uplands and Wet Tropics bioregions with records to the south and west in the Desert Uplands, Central Mackay Coast, Mitchell Grass Downs, Mulga Lands, Brigalow Belt North, Brigalow Belt South, and South Eastern Queensland where they are most frequently sighted (Adams-Hosking et al. 2016). Koalas in Queensland inhabit the moist coastal forests, southern and central western subhumid woodlands, and a number of eucalypt woodlands adjacent to waterbodies in the semi-arid western parts of the state (Melzer et al. 2000). In many locations, koala populations are of low density, widespread and fragmented (Melzer et al. 2018). Surveys in north-western Queensland found that koalas were patchily distributed, associated with creek-lines, areas of higher tree species richness, with higher abundance correlating with leaf-moisture content (Munks et al. 1996).

State-wide estimates of population size are limited, with data and survey effort skewed towards south-east Queensland. In response to this, and the lack of peer reviewed estimates of koala numbers highlighted in the 2012 listing advice (SEWPaC 2012a; TSSC 2012), an expert elicitation exercise was undertaken in 2012 (Adams-Hosking et al. 2016). The data from this expert elicitation are now widely recognised as the most accurate baseline for koala population numbers across the bioregions, states and territories (e.g., NSW Government 2020; Dissanayake et al. 2021) and therefore supersede the 2012 listing data. These data provide a reference point for this Conservation Advice. In 2012, this expert elicitation estimated that that there were 79,264 koalas in Queensland distributed across 8 bioregional areas (Adams-Hosking et al. 2016). The highest population estimates were reported for three bioregions: Brigalow Belt North (15,179), Mulga Lands (15,286) and South East Queensland (15,821). The other bioregions with koalas present included Central Mackay Coast (8857), Desert Uplands (6357), Einasleigh Uplands and Wet Tropics (4750), Mitchell Grass Downs (1943), South Brigalow (11,071). In 2012, it was estimated that Queensland’s koala populations had declined over the three preceding generations (15 to 21 years) by an average of 53 percent (Adams-Hosking et al. 2016).

The eight Queensland bioregions with koalas cover a total area of 1,489,650 km$^2$. This represents a mean density of 0.0005 koalas/ha across the 8 bioregions in Queensland based on 2012 population estimates. Across the state, South East Queensland has the most comprehensive dataset, reflecting higher survey effort. Based on 2012 population estimates (Adams-Hosking et al. 2016), the bioregions with the highest density of koalas in Queensland included the Central Mackay Coast (0.006 koalas/ha) and South East Queensland (0.002 koalas/ha). Both these bioregions were impacted by bushfire in the 2019-2020 bushfires. In 2021, within the eight Queensland bioregions, an estimated 13 percent (194,021 km$^2$) of land area overlapped with the koala species distribution model (DAWE 2021a). Of this, 1,931 km$^2$ of modelled likely koala distribution burnt across the state in the 2019-20 bushfires, representing a total 1 percent of modelled likely koala distribution (DAWE 2021a). Four bioregions were impacted by fire: South East Queensland (2 percent burnt), Central MacKay Coast (2 percent), Brigalow Belt South (1 percent burnt), and New England Tablelands (1 percent). Modelling of future climate-suitable koala distribution indicates a further contraction of 17 to 78 percent by 2030 from the 2011 baseline as a direct result of climate change (Adams-Hosking et al. 2011; Adams-Hosking et al. 2016). The bioregions predicted to be most heavily impacted by climate change included the Mulga Lands (100 percent of climatically suitable koala habitat lost by 2030), the Desert Uplands (100 percent loss by 2030) and the Central Mackay Coast (57 to 96 percent loss by 2030).

**New South Wales distribution**

Koalas in New South Wales occur from the northern border with Queensland. The northern NSW distribution includes the Mulga Lands, Darling Riverine Plains, Brigalow Belt South, Nandewar, New England Tablelands, and South East Queensland (NSW Section) bioregions. Koalas also occur within the eastern coastline bioregions of the NSW North Coast, Sydney Basin and South East Corner at the border with Victoria. Their western distribution extends into the South-Eastern Highlands, NSW South Western Slopes, Cobar Peneplain, Riverina, and Murray Darling Depression bioregions (Map 1). Koalas occupy a wide range of habitats (NSW Government 2019b, a). The majority of koalas in New South Wales are found in forests and subhumid woodlands on the central and north coast , and to the west across the Western Plains and slopes, within Pilliga forest, low woodland and forested areas (TSSC 2012; Adams-Hosking et al. 2016). Low-density populations also occur west of the Great Dividing Range in semi-arid environments. Habitat in these areas is fragmented and this has resulted in a patchy distribution of koalas across their range with significant numbers occurring on privately owned land (Melzer et al. 2000; Lunney et al. 2009; TSSC 2012). Modelling of koala habitat in New South Wales suggests climate-suitable habitat will contract by 8 to 19 percent by 2030 from the 2011 baseline as a direct result of climate change (Adams-Hosking et al. 2011; Adams-Hosking et al. 2016). Koala distribution has shrunk across NSW, with declines documented from the eastern coastal bioregions to the western populations (Predavec et al. 2018). These declines have been driven by habitat loss, temperature increase and drought (Lunney et al. 2014; Santika et al. 2015). Extinction risk is predicted to be greater in western NSW than in the east under future scenarios of climate and land use change (Santika et al. 2014). Predicted changes in the near (2030) and more distant (2070) future include increased maximum temperatures, reduced minimum temperatures, more extremely hot days (where maximum temperature > 35$^{o}$C), shifting rainfall patterns, and an increase in average fire weather days. Modelling indicates that by 2070 the habitat losses will be severe (NSW Government 2014).

In 2012, the mean population estimates for koalas within bioregions indicated that the highest numbers of individuals occurred in the bioregions of South Brigalow and Nandewar (11,133), NSW North Coast (8,367) and the Sydney Basin (5,667) (Adams-Hosking et al. 2016). Other bioregions had smaller, but significant koala populations (<3,000 individuals): Murray-Darling Depression (55), South East corner (655), Cobar Peneplain and Riverina (2,354), Darling-Riverine Plains (9,964), Mulga Lands (711), New England Tablelands (2,771), NSW Southwestern Slopes (2,310), South-Eastern Highlands (1363). This study concluded that the NSW koala population had declined by over 26 percent in the preceding (and potentially future) three koala generations (Adams-Hosking et al. 2016).

In 2018, the NSW Framework for the spatial prioritisation of koala conservation actions (Rennison & Fisher 2018) concluded that both the expert elicitation data (Adams-Hosking et al. 2016) and the available records trend data indicated a significant decline in koalas across the state in recent years. The only bioregion to have convincing evidence of a stable population was the New England Tablelands. Since this framework was developed, this bioregion has been impacted by bushfire (see below).

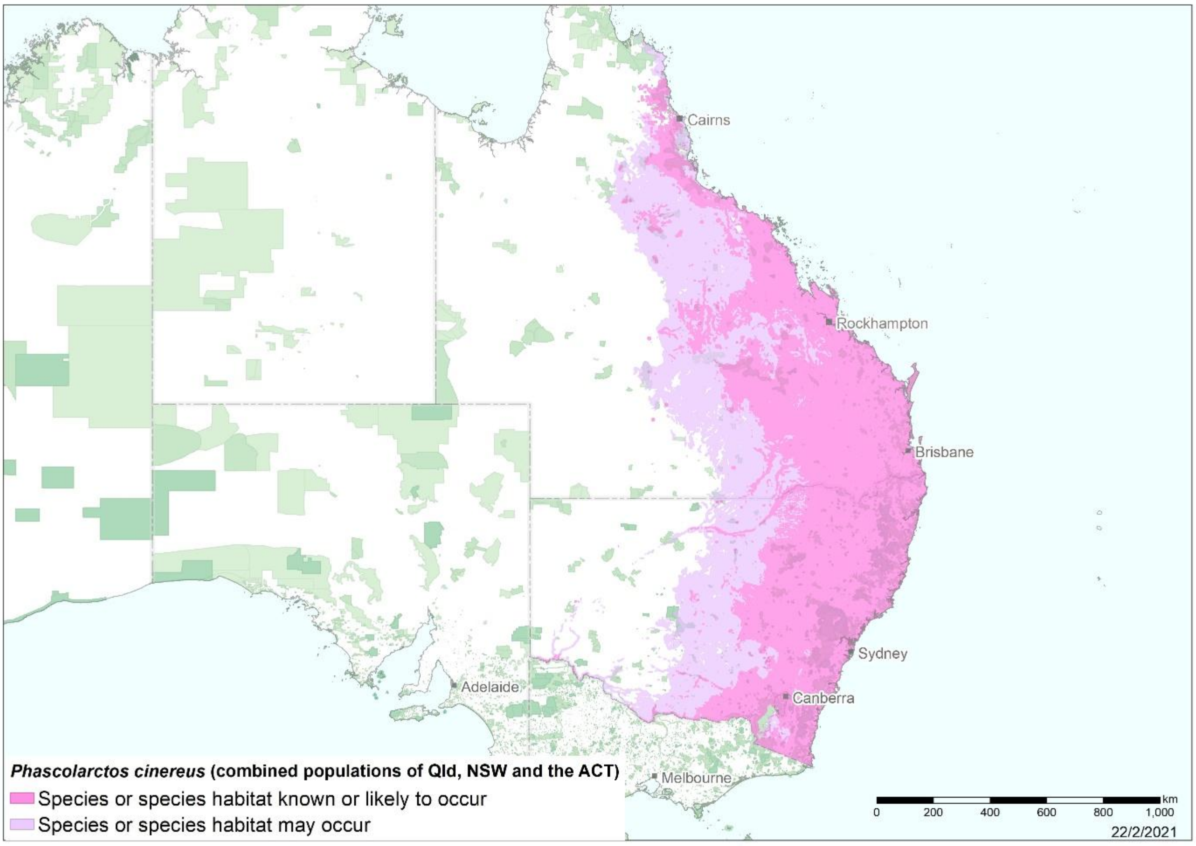
Across the 15 bioregions in NSW containing koalas, nine were impacted by the 2019-20 bushfires with a total of 34,666 $km^2$ burnt (DAWE 2021). The bioregions most heavily impacted by fire included the South East Corner (52 percent burnt), the Sydney Basin (30 percent burnt) and NSW North Coast (30 percent burnt). Other bioregions that contain koalas and were significantly burnt are: South Eastern Queensland (NSW section) (19 percent burnt), South Eastern Highlands (13 percent burnt), New England Tablelands (13 percent burnt), Australian Alps (4 percent burnt), Nandewar (4 percent burnt), and NSW South Western Slopes (2 percent burnt). Koalas have displayed nuanced responses to fire with significant declines in numbers following high severity fire but little change in occupancy or density following low severity fire (NSW Government 2021a). Further research is required to understand how fire impacted koalas across the different bioregions.

**The Australian Capital Territory distribution**
Koalas have historically occurred in the Australian Capital Territory. In 2009, it was suggested that small koala populations were historically present in the Tidbinbilla and Brindabella Ranges, around Bushfold, the Orroral Valley and Namadji National Park (TSSC 2012). These populations were thought to be the result of deliberate introductions as well as remnant, natural koala populations. In the 2012 expert elicitation process the Australian Capital Territory was not considered separately and Australian Capital Territory data were aggregated into NSW estimates (Adams-Hosking et al. 2016).

There have been limited reports of koalas in the Australian Capital Territory along the border with New South Wales. In May 2021 a solitary koala was observed over several days in Oaks Estate near the Molonglo River (K Ford, 2021 pers com May 11). In 2014 a koala was observed crossing the highway close to Defence land, near Canberra airport (Fitzgerald 2014). There are also historic records in the 1980s of koalas on the western borders of the Australian Capital Territory and it was suggested that these were animals dispersing from Brindabella. A koala survey in 2018 was conducted in areas considered to be likely koala habitat and no koalas were recorded (Capital-Ecology 2018). The site selection was based on ACT koala survey guidelines. However, thirteen hard-to-access monitoring sites, which included seven sites in Namadgi National Park, plus an additional fifteen Commonwealth owned Defence sites were not included in the survey. The report recommended that acoustic surveys be conducted in the breeding season to confirm these findings (Capital-Ecology 2018). Currently there are no known resident koala populations and koala surveys are not routinely conducted in the Australian Capital Territory.

The bioregions which contain koala habitat in the Australian Capital Territory include large areas that have been impacted by bushfire. In particular, the Orroral Valley, a location where koalas have historically been observed, burnt in 2003 and again in 2019-2020. In the 2019-20 bushfires, an estimated 23 percent (211 km$^2$) of koala habitat burned (DAWE 2021a). Koala habitat occurs in two bioregions in the Australian Capital Territory, the Australian Alps and South Eastern Highlands, of which 57 percent (102 km$^2$) and 15 percent (109 km$^2$) respectively of the total area burnt in recent bushfires. Modelling suggests climatically suitable koala habitat in the Australian Capital Territory will contract by 10 percent by 2030 from the 2011 baseline as a direct result of climate change (Adams-Hosking et al. 2011; Adams-Hosking et al. 2016).

**Map 1 Modelled species distribution of the listed koala in Queensland, New South Wales and the Australian Capital Territory.** Note that the listed koala distribution does not include Victoria or South Australia.




**Source:** Draft base map Geoscience Australia; species distribution data Species of National Environmental Significance database. The 2021 SDM was modelled using Maxent, with the harmonised habitat mapping subsequently incorporated (Runge et al. 2021b).

**Caveat:** The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.

**Species distribution mapping:** The species distribution mapping categories are indicative only and aim to capture a) the specific habitat type or geographic feature that represents the recent observed locations of the species (known to occur), b) the suitable or preferred habitat occurring in close proximity to these locations (likely to occur); and c) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observation records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

## Cultural and community significance

Koalas are culturally significant for many Indigenous peoples across south-eastern and eastern Australia. They hold a significant and diverse role in many Indigenous cultural practices and belief systems. The koala's name has many interpretations within the different Indigenous languages. The word koala may be a loan word derived from *gula* or *gulawan* from the Dharuk language of the Sydney region (Cahir et al. 2020). Early western spellings also include "coola" and koolah". The name "Koala" may also reflect the fact that koalas rarely or never drink free water. Other local Indigenous names such as "*kaola*" translate as "no drink". Several Indigenous narratives describe the koala as the giver or taker of water (Cahir et al. 2020).

The cultural and community significance of the koala is specific and unique to different Indigenous language groups. In New South Wales, koalas are prominent in creation stories and narratives and are known to be totemic for different language groups (Cahir et al. 2020). They are depicted in rock art and were hunted for meat prior to the arrival of colonists. The skins of the koala were used to make rugs by the Gumbaynggirr peoples, while Elders in the Goulburn Plains region used koala fur in initiation ceremonies (Cahir et al. 2020). In Queensland, their spiritual significance can be linked to epic creation stories while in certain regions koalas were hunted for their skin and fur (Cahir et al. 2021). In Victoria, koalas also have a utilitarian and symbolic significance being a revered animal. Records from the region suggest that in some areas they were traditionally used for food but not for skins or fur (Schlagloth et al. 2018). The historic relationship between Aboriginal communities and koalas across the listed range highlights the importance of consulting with Aboriginal communities when planning and undertaking koala focused conservation activities (Cahir et al. 2021).

The koala forms an integral part of modern Australian identity. From the first colonial exhibits in 1861 at the Melbourne Zoo to today, it has become a national icon that is recognised internationally as a symbol of Australia (Markwell 2020a, b). The koala is depicted widely in art, children's books, television shows and popular culture. Many celebrities opt to be photographed with koalas and they have been used widely in marketing campaigns (e.g., Qantas Airlines from 1967 to 1992) (Markwell 2020b). While considered by many Australians as an intrinsically valuable component of Australian fauna, the koala also contributes significantly to tourism.

## Relevant biology and ecology

Female koalas reach sexual maturity between 2 and 3 years of age (McLean & Handasyde 2007) and may then produce one offspring per year. Females have a 12-month lactation period and young koalas are weaned after this period. Weaning coincides with periods of high food availability and favourable climatic conditions. This ensures the best survival conditions for offspring approaching independence (Ballantyne et al. 2015). Local factors, including population density, food quality and availability, soil type and climate, influence the timing of breeding (McLean & Handasyde 2007; Ballantyne et al. 2015). Koalas may not breed every year if conditions are unfavourable, and breeding can be unsuccessful due to poor body condition or disease (e.g. *Chlamydia*) (McLean & Handasyde 2007).

Koala reproduction is heavily influenced by seasonality, and the breeding season differs between northern and southern populations. In the north, an estimated 60 percent of births occur in summer and early autumn (December-March), and the remainder are distributed throughout the year (Ellis et al. 2010a). The trigger for this increase in birth rate is not known but does coincide with periods of peak rainfall in Queensland. It has been suggested that opportunistic breeding occurs when food availability increases as a response to rainfall (Ellis et al. 2010a). In locations where rainfall is less seasonally variable, joeys are produced at any time of the year. In South Australia, the ratio of male to female births has also been shown to vary with half of male births occurring before the end of November. In contrast, 50 percent of female births do not occur until the end of December (McLean & Handasyde 2007). One explanation for this is that females in good condition, with greater resource availability, produce larger, healthier male offspring due to an increased period of maternal investment. Studies report no evidence of sex ratio differences in the timing of births, or the size of joeys in Queensland (Ellis et al. 2010a).

In the wild, longevity is more than 15 years for females and more than 12 years for males (Martin & Handasyde 1999). Generation length is defined here as: "*the average age of parents of the current cohort (i.e., newborn individuals in the population)*" (IUCN 2019). The generation length of the listed koala is therefore estimated to be 6 to 8 years. This is also consistent with other assessments (Phillips 2000; TSSC 2012; Woinarski 2020).

Koalas are tree-dwelling, obligate folivores (leaf eaters) with a highly specialised diet. The koala's diet is defined by the availability and palatability of a limited variety of *Eucalyptus*, *Corymbia* and *Angophora* species. Koalas are nocturnal and spend significant periods of time moving across the ground between food and shelter trees. Movement increases in the breeding season (typically September to February) (Melzer & Tucker 2011). Koalas are reported to utilise more than 400 different species of tree for their food and habitat requirements with different tree species varying by habitat type and location across their range. Primary food species differ across habitats and may be as few as two at a particular location (Melzer et al. 2000; Tucker et al. 2008; Kjeldsen et al. 2019). Koala browsing preferences show regional differences which are influenced by the chemical profiles and water content of different target food leaves. There is both intra- and inter-species variability in the palatability and nutritional value of the leaves of their preferred food trees (Stalenberg et al. 2014). Their specialist dietary requirements determine their potential habitat and range distributions (Moore & Foley 2005; Moore et al. 2010).

## Habitat critical to the survival

Koala habitat includes both coastal and inland areas that are typically characterised by Eucalyptus forests and woodlands. The wide-ranging distribution of the koala has resulted in a diverse range of habitat associations across different bioregions, influenced by local climate, topographical and landscape associations. Biophysical habitat attributes for the koala include places that contain the resources necessary for individual foraging, survival (including predator avoidance), growth, reproduction and movement. The total amount of resources (including habitat attributes) and how they are arranged in the landscape influence the viability of metapopulations and processes.

For an individual koala, these resources include access to sufficient quality food and shelter trees to meet their daily energetic requirements and reproductive needs, and a place to avoid predators. This includes forests or woodlands, road-side and rail vegetation and paddock trees, safe intervening ground matrix for travelling between trees and patches to forage and shelter and reproduce and access to vegetated corridors or paddock trees to facilitate movement between patches. These resources fall within individual koala's home ranges and allow for interaction with adjacent individuals.

A population of koalas requires a sufficient total amount of resources within their habitat of adequate quality to support a viable biological population where mortality, survival, and recruitment are balanced or recruitment increasing to optimal carrying capacity and within the bounds of natural fluctuations. Crucial habitat elements include patches and corridors for gene flow. Over longer-time frames habitat critical includes climate refugia such as drainage lines, riparian zones and patches that are resilient to drying conditions due to favourable hydrological systems. Additionally, it includes areas that may be temporarily unoccupied, because of seral (maturity or time) changes to habitat quality that arise through processes such as fire, drought, timber harvesting or disease (shifting habitat mosaic) or degradation and are available for future recolonisation.

**Habitat critical to the survival of a species** is defined as: the areas that the species relies on to avoid or halt decline and promote the recovery of the species. Under the EPBC Act, the following factors and any other relevant factors may be considered when identifying habitat that is critical to the survival of a species:

(a) whether the habitat is used during periods of stress (examples: flood, drought or fire);

(b) whether the habitat is used to meet essential life cycle requirements (examples: foraging, breeding, nesting, roosting, social behaviour patterns or seed dispersal processes);

(c) the extent to which the habitat is used by important populations;

(d) whether the habitat is necessary to maintain genetic diversity and long-term evolutionary development;

(e) whether the habitat is necessary for use as corridors to allow the species to move freely between sites used to meet essential life cycle requirements;

(f) whether the habitat is necessary to ensure the long-term future of the species or ecological community through reintroduction or re-colonisation;

(g) any other way in which habitat may be critical to the survival of a listed threatened species or a listed threatened ecological community.

Such areas, if identified, would be expected to include habitat occupied and habitat currently unoccupied, areas necessary for population processes and maintenance of genetic diversity and evolutionary potential, and areas required to accommodate future population increase, recolonisation, reintroduction, or as climate refugia.

The information set out in this conservation advice relating to the functional ecology of the koala and its habitat are likely to form the basis of habitat critical to the survival of the koala. Having regard to the above factors and other relevant factors at the time of completing this document, it is not practicable to identify by description and to provide spatial information on the habitat critical to the survival of the koala. This is because there is insufficient knowledge and data to unambiguously identify and spatially delineate habitat critical to the survival of the koala. A National Koala Monitoring Program was established in 2021 in response to these critical data requirements.

This document provides general guidance for habitat critical to the survival of the listed koala. The EPBC Act referral guidelines are available for potential proponents to navigate the complexity of koala habitat to identify significant impacts (DofE 2014). The guidelines provide guidance on important requirements, survey planning, and standards for mitigation impacts in context of long-term recovery planning for the listed koala.

## Important populations

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

Important populations are defined as those that are valued for cultural, social, and economic reasons as well as for the species conservation.

i) For conservation of the listed koala, among other reasons, it will be imperative to maintain populations that:

  - have the potential to act as source populations to adjacent areas of suitable, or potentially suitable, habitat;
  - exist in areas of climatically suitable refugia during periods of environmental stress including droughts, heatwaves, and long-term climate change;
  - are genetically diverse;
  - are disease free and/or exhibit low rates of infection with important pathogens;
  - contain genes which may confer adaptation to current and future environmental stressors;
  - are geographical or environmental outliers within the species range.

ii) Populations are also valued for social, cultural or economic reasons, and may or may not, overlap with populations listed above. Reasons may include, but not limited to:

  - cultural and spiritual importance to Indigenous people;
  - the social value and enjoyment of having koalas close to residential areas;
  - the economic value brought to local business and tourism;
  - the iconic species value at the national and international political and community level.

### State level important populations

At the state and territory level, New South Wales has identified critical koala populations as “areas of currently known high koala occupancy” (DPIE 2020). Queensland has identified priority areas for management actions to achieve the highest likelihood of conservation outcomes for koalas in South East Queensland. This has included prioritising koalas located in high quality habitat with a high likelihood of successful threat management (DES 2020). Current efforts to assess and identify important populations across the range are hindered by a lack of comprehensive, unbiased data (DPIE 2020; DAWE 2021b) with the majority of study effort focusing on high density koala populations in easily accessible locations. The 2021 National koala Monitoring Program will address these critical data gaps. Examples of important populations are detailed below.

### Genetically important populations

Four spatially distinct, genetic koala management units have been identified nationally (Johnson et al. 2018; Eldridge & Lott 2020). These important genetic populations include: 1) Queensland and New South Wales populations north of the Clarence River Valley, New South Wales; 2) south of the Clarence River Valley, New South Wales to north of the Sydney Basin; 3) south of the Sydney Basin to approximately the New South Wales /Victorian boarder; and 4) Victoria and South Australia populations. Work on the genetic values of different populations is still in its infancy and research is ongoing.

### Climate sensitive populations

Koalas at the western edge of their range are being impacted by shifts in rainfall patterns and increasing frequency of drought and heat stress resulting directly from climate change (Adams-Hosking et al. 2011; Davies et al. 2013; Runge et al. 2021b). The recent national workshop of koala monitoring experts (DAWE 2021b) identified the koala subpopulations at the western edges of Queensland and New South Wales distributions (western edge populations) as a priority for immediate climate-related risk management and conservation efforts. The western edge populations are characterised by low koala densities and a high level of isolation from other populations, as a result of which they are increasingly vulnerable to environmental change and habitat loss. The western-edge populations were identified as potentially containing adaptive genes to environmental stressors indicating they have high conservation value (K Handasyde 2021, pers comm 9 February). The workshop recommendations included: an urgent need for population and ecological data (e.g. fertility rates, longevity, movement patterns, habitat requirements, thermal ecology); research into heat tolerance; action to protect these populations as they may prove critical to New South Wales and Queensland in the future; and consideration of translocation of individuals from these genetically important reservoir population to create an insurance population that could prove critical to future management.

### Other important populations

Populations that have the potential to act as source populations for adjacent areas of suitable habitat and/or potentially suitable habitat. This includes climate-robust populations, large populations that exist in contiguous habitats, and populations that may link two larger populations.

## Threats

The koala is threatened by wide-scale climate change drivers which include the increased frequency and intensity of drought and high temperatures, the increasing prevalence of weather conditions which promote bushfire, and a shrinking climatically suitable area (Adams-Hosking et al. 2011; McAlpine et al. 2015; Runge et al. 2021a). Simultaneously, koala populations are also being impacted by diseases, specifically koala retrovirus (KoRV) and Chlamydia (*Chlamydia pecorum*), human-related activities including habitat loss resulting from land clearance and mining, and mortality due to encounters with vehicles and dogs. These threats can also act synergistically. For example, habitat clearance and climate change drivers are associated with increased levels of physiological stress in wild koala populations (Narayan 2019). This in turn can increase the incidence and impact of localised threats arising from encounter mortality with dogs and vehicles, disease, and food shortages (Narayan 2019).

## Table 1 Threats impacting the koala

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| Climate change driven processes and drivers | | |
| Loss of climatically suitable habitat | • Status: current and future<br>• Confidence: known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: across the entire range | Areas that are climatically suitable for koalas are contracting (Adams-Hosking et al. 2011). Climate change predictions indicate drier, warmer conditions across the koala's range. Current and future climate change projections indicate a progressive eastward and southwards contraction in the koala's suitable climate envelope and consequent suitable habitat (Adams-Hosking et al. 2011).<br>Modelled climatic suitability from 2010 to 2030 indicates a 38-52% reduction for the listed population (Adams-Hosking et al. 2011), and forecast a 62% decline in koala habitat by 2070. This represents a 79% loss in Queensland and 31% loss in New South Wales (Runge et al. 2021a).<br><br>The effects of climate change may play out through increased mortality associated with heat wave events and droughts, declines in reproduction rates associated with changes in food quality and availability, changes to movement patterns, exposure to diseases and other factors, as well as effects of climate change on fire regimes (see below for further details on these mechanisms). |
| Increased intensity/frequency of drought | • Status: historical, current and future<br>• Confidence: known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: across part of its range | Over the last 21 years, South East Australia has experienced two of its worst droughts in the historical record: the Millennium Drought (2000-2009) and the Big Dry (2017-2019). Low rainfall has been linked with physiological stress to koalas due to low moisture levels, causing negative effects on population viability (Davies et al. 2013). These periods of abnormally low rainfall, particularly in the west, have been associated with the decline, and in some cases, the crash of koala populations, forcing population contraction to critical riparian areas in some areas (Seabrook et al. 2011; DPIE 2020). In extreme cases, e.g., Springsure in Central Queensland, the areas worst affected by drought were along creeks where extensive |

| Threat | Status and severity [a] | Evidence |
| --- | --- | --- |
| | | tree death (die back) occurred and negatively impacted koala populations (Ellis et al. 2010b).<br><br>In the future, average winter and spring rainfall are predicted to continue to decline across the koala's range (BoM 2021a). By the late twenty-first century, the frequency of moderate, severe, extreme and exceptional terrestrial water storage droughts is projected to increase substantially due to a reduction in the frequency of near-normal and wet conditions in Australia (Pokhrel et al. 2021). Cumulative frequency of droughts across the koala range are projected to increase by 30% by 2100 under RCP6.0 (the climate pathway we are on) (NOAA 2021). The frequency of severe and extreme droughts (Drought Severity Index >-1.6) will increase from 2.7% to 19.5%. This suggests that koala habitat will be in drought half the time, and severe drought every 5 years, on average. This is an increase from the currently observed frequency of drought every 5 years and severe drought every 30 years. Droughts also interact with threats posed by inappropriate fire regimes. |
| Increased intensity/frequency of heatwaves | • Status: historical/current/future<br>• Confidence: known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: across the entire range | Heatwaves can be defined as ≥ 3 consecutive days of unusually high night-time and day-time temperature (BoM 2021b). Due to climate change, average temperatures across the koala's range will continue to increase across all seasons resulting in an increased frequency and intensity of heat stress days and heat wave episodes (BoM 2021a). Heat stress threats will synergistically interact with drought, further exacerbating the impacts of reduced water availability. During periods of extreme heat stress koalas are also known to stop eating and starve to death (K Youngentob, pers comm 22/3/21). |
| Increased intensity/frequency of bushfire | • Status: historical/current/future<br>• Confidence: known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: across part of its range | During the summer of 2019-2020, > 3.5 million ha of koala habitat burnt across Queensland, New South Wales and the Australian Capital Territory (DAWE 2021a). Recent estimates suggest a population decline of 10% (or as much as 17%, with 80% confidence) one year after the 2019-20 bushfires. Of this, a decline of 7.1% was directly caused by bushfires, the remaining 2.3% |

| Threat | Status and severity [a] | Evidence |
| --- | --- | --- |
| | | decline was due to ongoing and antecedent threats (Legge et al. 2021).<br><br>The future legacy of the 2019-2020 bushfires, assuming no future extreme events over three generations (2021-2042), indicates a population decline of 3.9% caused by the fires; a further population decline of 21.9% is attributed to antecedent and ongoing threats (Legge et al. 2021).<br><br>Koala monitoring records from north-east New South Wales following the 2019/2020 bushfires, indicate that sites characterised by high-severity fire (e.g., canopy scorch) had zero koala occupancy (i.e., zero return/recovery) immediately post fire. At sites where koalas have been detected following fire, refuge areas were present in the surrounding landscape, or fire severity was lower (NSW Government 2021b). While koala's have returned to bushfire impacted locations it is likely to take many years before populations are fully re-established.<br><br>Australia will continue to experience a harsher fire-weather climate into the future (BoM 2019, 2021a). The fire season length is increasing and the number of catastrophic fire days will increase in the future by an estimated 15-70% by 2050 (Climate-Council 2019).<br>A broad range of fire-related threats exist. These include high frequency fire, high severity fire, shifts in fire season, biodiversity loss, declining ecological mechanisms, shifts in biotic interactions including reproduction and fire-predator interactions, fire-drought interactions, fire-fragmentation interactions which can be amplified by land clearing and logging, fire-climate feedback (see above) (Bradshaw et al. 2018; Leavesley et al. 2020). All of these threats will have a significant impact on koala habitat and resident populations. |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| Declining nutritional value of foliage | • Status: historical/current/future<br>• Confidence: suspected/known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: across part of its range | In-situ carbon dioxide ($CO_2$) manipulation experiments on *Eucalyptus tereticornis* and *E. amplifolia* found elevated $CO_2$ levels caused total nitrogen to decline in young eucalyptus leaves (Wujeska-Klause et al. 2019). However, increases in environmental temperature (eT), that will occur in parallel with elevated $CO_2$ in the future, were not included in open air experiments and green house experiments suggest eT may compensate completely for the negative impacts of $CO_2$ on leaf nitrogen in the future (DeGabriel et al. 2009; Robinson et al. 2012). Although elevated $CO_2$ can influence the production of some plant secondary metabolites such as tannins that may also impact the digestibility of leaves, the evidence for this in eucalypts is equivocal and further research is needed. Additional research is required to assess how elevated levels of $CO_2$ affect nitrogen and available nitrogen (which integrates the effects of tannins) (DeGabriel et al. 2009). Bushfire effects on the nutritional value of eucalypt regrowth (e.g., epicormic growth) are unknown and research has been initiated.<br><br>Physical disturbance (e.g., logging during forestry activities and/or fire) alters tree species composition and can favour tree species that do not support the koala's nutritional requirements (Au et al. 2019). |
| Human related activities | | |
| Clearing and degradation of koala habitat | • Status: historical, current and future<br>• Confidence: known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: across the entire range | Human activities (e.g., deforestation and land clearance for grazing, agriculture, urbanisation, timber harvesting, mining and other activities) have resulted in habitat loss, fragmentation and degradation.<br><br>Over 10,000 $km^2$ of forest and woodland within the koala's range was cleared between 2000 and 2017 (Ward et al. 2019). The modelled koala distribution was revised in 2021 and the estimate of habitat loss would be expected to be higher if calculated using the new understanding of koala distribution. Clearing for grazing during this period was the major driver of loss of koala habitat, accounting for most of |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| | | the deforestation within koala distribution (McAlpine et al. 2015; Evans 2016). Clearing for grazing has occurred across the range of the koala. Large areas of woodland have been lost since 2000 in western parts of the species range, including the Brigalow Belt, Mulga Lands, Darling Riverine Plains, Einasleigh Uplands and Desert uplands (Ward et al. 2019). These bioregions are home to large koala populations (Adams-Hosking et al. 2016). Most clearing has occurred on freehold or leasehold land (Ward et al. 2019). Land clearing continues to impact habitat across the koala's range (DES 2018).<br><br>Clearing for mining and urbanisation has had localised impacts on the koala (Evans 2016; Ward et al. 2019). Urban expansion is concentrated along the eastern seaboard fringe of Queensland and NSW (Clark & Johnston 2016), which is also a stronghold of the koala. Low density and peri-urban development are expanding into forested and agricultural landscapes in these areas, while clearing for agriculture continues to occur across the koala's distribution. The expanding coal and coal seam gas developments of the past two decades and recent clearing for renewable energy projects represent additional but localised impacts to koalas (McAlpine et al. 2015). Land-use decisions affecting koalas have been influenced, both positively and negatively, by the policy environment and social attitudes around land-clearing (Heagney et al. 2021; Simmons et al. 2021). |
| Encounter mortality with vehicles and dogs | • Status: historical/current/future<br>• Confidence: known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: across part of its range | Vehicle related mortality occurs regularly on roads in close proximity to occupied koala habitat (Gonzalez-Astudillo 2018; Queensland-Government 2021). Dog attacks are also a significant cause of death and injury especially in areas within and adjacent to peri-urban and residential areas (DPIE 2020). Koalas are unable to adapt to these threats and as human activities continue to expand into koala habitat, trauma from these threats will continue.<br><br>A large proportion of individuals killed by vehicles or dogs are otherwise healthy. This mortality has the potential to remove healthy |

| Threat | Status and severity [a] | Evidence |
|---|---|---|
| | | breeding individuals from the population (Gonzalez-Astudillo 2018). Encounter mortality poses a significant threat during post-weaning dispersal, which occurs at a young age in both male and female koalas. Mature males are increasingly at risk as they have larger home ranges and increased mobility during the breeding season. Young males typically disperse more frequently and over larger distances than their female counterparts and the removal of subadult males by trauma has the potential to critically disrupt geneflow. |
| Disease and health | | |
| Koala retrovirus (KoRV) and Chlamydia (*Chlamydia percorum*) | • Status: historical/current/future<br>• Confidence: known<br>• Consequence: severe<br>• Trend: increasing<br>• Extent: unknown | Wild populations carry disease pathogens. Inadvertent spread of disease also occurred historically following koala translocations. Disease can be a major contributor to population decline and reduces population viability. Chlamydia causes infertility, blindness and death (Polkinghorne et al. 2013). The prevalence of disease (chlamydiosis) has been found to increase following extreme stress from hot weather, drought, habitat loss and fragmentation (Lunney et al. 2012; Davies et al. 2013). |

Status—identify the temporal nature of the threat;

Confidence—identify the extent to which we have confidence about the impact of the threat on the species;

Consequence—identify the severity of the threat;

Trend—identify the extent to which it will continue to operate on the species;

Extent—identify its spatial content in terms of the range of the species.

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with the experts listed in DAWE (2021b) and in-house expertise using available literature.

### Table 2 Risk matrix

| Likelihood | Consequences | | | | |
|---|---|---|---|---|---|
| | **Not significant** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| **Almost certain** | Low risk | Very high risk<br>**Encounter mortality with** | | Very high risk<br>**Clearing of koala habitat** | Very high risk<br>**Shrinking climate envelope** |

| Likelihood | Consequences | | | | |
|---|---|---|---|---|---|
| | **Not significant** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| | | **vehicles and dogs** | | **koala retrovirus (KoRV) and Chlamydia**<br><br>**Increased frequency of drought**<br><br>**Increased frequency of heatwaves**<br><br>**Increasing frequency of high-intensity bushfire** | **resulting in habitat loss** |
| **Likely** | Low risk | Moderate risk | High risk | Very high risk | Very high risk |
| **Possible** | Low risk | Moderate risk | High risk | Very high risk | Very high risk |
| **Unlikely** | Low risk | Low risk | Moderate risk | High risk | Very high risk |
| **Unknown** | Low risk | Low risk | Moderate risk | High risk | Very high risk |

Threats in the above matrix have been classified according to likelihood of threat across the entire range of the listed koala population. It should be noted that at a smaller scale (e.g., regional scale) the risk of individual threats may be classified elsewhere in the table.

### Categories for likelihood are defined as follows:

Almost certain – expected to occur every year

Likely – expected to occur at least once every five years

Possible – might occur at some time

Unlikely – such events are known to have occurred on a worldwide bases but only a few ties

Unknown – currently unknown how often the incident will occur

### Categories for consequences are defined as follows:

Not significant – no long-term effect on individuals or populations

Minor – individuals are adversely affected but no effect at population level

Moderate – population recovery stalls or reduces

Major – population decreases

Catastrophic – population extirpation/extinction

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be ‘very high’ or ‘high’.

# Conservation and recovery actions

The following conservation and recovery actions are identified and should be adhered to in conjunction with the latest guidance documents available on the Species Profile and Threats Database:

http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=85104.

Four supporting strategies and two on-ground (direct) strategies are included.

Supporting strategies:

Strategy 1: **Build and share knowledge**

Strategy 2: **Strong community engagement and partnerships**

Strategy 3: **Increase habitat protection**

Strategy 4: **Koala conservation is integrated into policy, and statutory and land-use plans**

On-ground strategies:

Strategy 5: **Strategic habitat restoration**

Strategy 6: **Active metapopulation management**

*Supporting strategies* provide for governance to coordinate actions, led by the Australian Government in partnership with the states and territory. They provide for research and capacity building to improve effectiveness of actions, from enhanced mapping, monitoring and survey methods; improved data collation, curation and analysis; to better sharing and communication of information; and building on community capacity, support and engagement. They also provide for improved planning frameworks and principles for state-level conservation planning for the listed koala.

Increasing the area of priority koala habitat that is protected is a key strategy to prevent further habitat loss and fragmentation and prevent further loss of koala populations. Once identified (Actions 1a-c), national areas of priority koala habitat should include areas of large intact landscapes that have the greatest potential to retain viable populations and have the potential to also act as source populations to adjacent areas.

*On-ground (direct) strategies* relate to improving habitat quality and restoration, and the suite of collective actions required to ensure metapopulation processes are maintained. The former will generally be implemented at the site-level, while the latter is a holistic landscape-scale approach to metapopulation management.

Many state-level actions have been ongoing, or recently commenced, under various state and territory environment-related, or koala-specific strategies (DES 2020; DPIE 2020).

Priorities assigned to actions under each of the six strategies are interpreted as follows:

**Priority 1:** Urgent. Prompt action is needed in advance of implementation of other management actions, to ensure effective coordination or to provide crucial information for planning and management. Early action might also be necessary to avoid or mitigate the most significant threats.

**Priority 2:** Essential. Action is necessary to avoid or mitigate direct threats, implement planning and management, undertake research, and develop tools towards the long-term recovery.

**Priority 3:** Highly beneficial. Action is desirable, and while not critical, will provide for longer term maintenance of recovery.

## Strategy 1: Build and share knowledge

The actions here comprise knowledge-based inputs or activities that support direct conservation actions. These inputs will provide information for a strategic and coordinated approach to koala conservation, now and into the near future using predictive climate change impacts. Without actioning these inputs, the ability to implement an effective listed koala recovery, will be significantly diminished.

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 1 a | Identify nationally important populations and habitat across the listed koala range under current conditions, and considering future impacts of climate change such as drought, heatwave, and fire, assessed by undertaking habitat distribution, population modelling and analysis (including abundance/density and genetic diversity), allowing for iterative updates using a robust scenario-based approach | Coordinated by the Commonwealth with state and territory government agencies using internal OR external mapping and modelling experts OR Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made OR researchers | Year 1 (1) | To be assessed (TBA) |
| 1 b | Identify spatially and temporally strategic areas of high priority for: (i) restoration and revegetation based on koala and eucalypt population viability; (ii) climate and fire refugia; and (iii) corridors facilitating movement and metapopulation processes of koalas, allowing for iterative updates using a robust scenario-based approach. | Coordinated by the Commonwealth with state and territory government agencies, local government and natural resource management organisation Or NGOs Or researchers. | Year 1 and ongoing (1) | TBA |
| 1 c | Develop prioritisation at regional or other appropriate scales for the long-term implementation of actions. | Coordinated by the Commonwealth with state and territory government agencies using internal OR external mapping and modelling experts OR Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made OR researchers | Year 2 (2) | TBA |

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 1 d | In consultation with each range state and territory, including Victoria and South Australia, scope out and establish a fit-for-purpose long-term National koala Monitoring Program (NKMP) to improve understanding of trends in populations, distribution and population health across the koala's range, and efficacy of management interventions. | Coordinated by the Commonwealth with state and territory government agencies; community groups; non-government conservation organisations; koala research community; koala welfare organisations and the Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made | Year 1-2 (1) | $ 2 million |
| 1 e | Implement National koala Monitoring Program; review design to ensure it remains fit-for-purpose and adaptive | Coordinated by the Commonwealth with state and territory government agencies; community groups; non-government conservation organisations; koala research community; koala welfare organisations and the Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made | Year 1 and ongoing (1) | TBA |
| 1 f | Collate and synthesise existing data that may improve understanding of koala population dynamics and threat profiles across habitats and scales. | Coordinated by the Commonwealth with state and territory government agencies using internal OR external mapping and modelling experts OR Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made OR researchers | Years 1-5 (1) | TBA |
| 1 g | Mapping of key metrics (distribution, habitat restoration, habitat condition and habitat loss) is reviewed at appropriate timeframes to detect changes, is coordinated across jurisdictions, and provides for landscape management now and at least three koala generations into the future. | Coordinated by the Commonwealth with state and territory government agencies using internal OR external mapping and modelling experts OR Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made OR researchers | Ongoing (1) | TBA |
| 1 h | Coordinate pre-existing national and koala databases; coordinate and develop data standards (including metadata standards); survey and sampling design standards to improve the quality of koala monitoring (e.g., Community of Practice). | Coordinated by the Commonwealth with state and territory government agencies; koala research community; koala welfare organisations and the Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made | Years 1-5 (2) | TBA |

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 1 i | Establish national research priorities targeted at applied outcomes, that inform and improve koala management. This action builds on priority research identified by Expert Technical Advisory Panel and the outputs of the first koala expert elicitation workshop for NSW (Hemming et al. 2018). | Coordinated by the Commonwealth with state and territory government agencies; koala research community; koala welfare organisations and the Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made | Ongoing (2) | TBA |
| 1 j | Establish a recurring research forum to enhance existing collaboration among researchers, and between researchers, managers and other interested parties, to make the most effective use of research actions and to identify and address any further key knowledge gaps. | Coordinated by the Commonwealth with state and territory government agencies and Expert Technical Advisory Panel | Annually (2) | TBA |
| 1 k | Facilitate a network to establish and support an active National koala Recovery Team and Expert Technical Advisory Panel, with strong governance in place. | Coordinated by the Commonwealth with state and territory government agencies | Year 1 (1) | TBA |
| 1 l | Share knowledge across experts, government organisations, conservation groups, rescue and welfare groups, Indigenous groups and the general public through regular koala workshops and conferences. This includes a koala conference every five years that brings together researchers, policy makers, planners and interested conservation groups and citizens; and exceptional circumstance workshops, such as following responses after major crises (e.g., fire and drought). | Coordinated by the Commonwealth with state and territory government agencies and Expert Technical Advisory Panel of the National koala Recovery Team to be formed when the recovery plan is made | 5 yearly (3) | TBA |
| 1 m | Facilitate the ongoing capture, storage and subsequent sharing, including intergenerational transfer, of Traditional Knowledge on the koala within the Indigenous community and across civil society. Build and demonstrate the strong connection to koalas and their habitat maintained by Indigenous Australians (e.g., https://koala.nsw.gov.au/culture/) | Coordinated by Indigenous Australians in partnership with Commonwealth, State and Territory government agencies, NGOs and philanthropists | Ongoing (1) | TBA |

## Strategy 2: Strong community engagement and partnerships.

Successful koala conservation relies on a collaborative approach across all sectors, and communities have a key role to play in protecting local koalas. The high level of community support for the conservation of koalas provides an opportunity for a range of actions that contribute to shared goals, from formal partnerships for habitat protection to raising awareness. Actions include engaging citizens in koala conservation science, supporting and training professionals and koala carers in the community.

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
| --- | --- | --- | --- | --- |
| 2 a | Grow partnerships with Indigenous and community groups and local government organisations to co-design opportunities for citizens to be involved in long-term koala monitoring programs and research. | Commonwealth, state and territory government resource in coordination with natural resource management organisations; National koala Recovery Team; Indigenous organisations; NGOs and the Zoo and Aquarium Association. | Ongoing (1) | TBA |
| 2 b | Grow partnerships with Indigenous and community groups, non-government organisations and all level of governments to restore priority areas using best-knowledge revegetation guidelines for koala. | Commonwealth, state and territory government agencies in coordination with natural resource management organisations; National koala Recovery Team; Indigenous organisations and NGOs | Ongoing (1) | TBA |
| 2 c | Develop active communication, education and extension strategies for businesses (developers, industries and rural land-owners' enterprises) aimed at koala habitat protection, incentives, partnership and compliance. | Commonwealth, state and territory government agencies in coordination with local government, natural resource management organisations | Ongoing (2) | TBA |

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 2 d | Recognise the cultural and spiritual importance of the koala to Indigenous communities and engage to utilise, improve or reinvigorate their support and knowledge in koala conservation, citizen science and field activities. Strengthen cross-cultural and inter-generational knowledge exchange and develop partnerships for the management and conservation of koalas. | Commonwealth, state and territory government agencies in coordination with Indigenous land-owners, joint management partners and Indigenous ranger teams supported by natural resource management organisations, the National koala Recovery Team, and NGOs and the Zoo and Aquarium Association. | Ongoing (1) | TBA |
| 2 e | Implement a comprehensive communication strategy for the plan's realisation. | Commonwealth, state and territory natural agencies and National koala Recovery Team; behavioural scientists | Ongoing (1) | TBA |
| 2 f | Collaborate with existing database infrastructure to develop a user-friendly single-site portal for the general public to report koala sightings, together with awareness raising and encouragement; embed processes for regular updates and regular communication of information generated from the data. | Coordinated by the Commonwealth with state and territory government agencies; local NRM organisations and local government; NGOs and the Zoo and Aquarium Association. | Years 2-5 (1) | TBA |

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 2 g | Build on existing guidance information with experts to develop national guidelines for veterinary standards in care, injuries, fertility control, disease treatment, tissue sampling, orphans and release for veterinarians, carers and koala rehabilitation centres; update and review to incorporate new learnings and knowledge. | Coordinated by the Commonwealth with state and territory government agencies, with input from research & veterinary experts; Expert Technical Advisory Panel; National Recovery Team; RSPCA and koala welfare organisations, including the Zoo and Aquarium Association. | Years 2-5 (2) | TBA |
| 2 h | Implement community education and engagement programs in urban and peri-urban areas where impacts on koalas are high, incorporating best-practise understanding of values and attitudes towards koalas, responsible dog ownership and vehicle collisions and other urban issues resulting in koala deaths. These include, and are not limited to, developing and trialling innovative programs in koala aversion by dogs with owners; population and disease awareness; and reporting koala sightings. | State and territory government agencies in coordination with local government, traffic authorities and natural management organisations, welfare organisations, including the Zoo and Aquarium Association, and behavioural scientists; dog training organisations; RSPCA | Ongoing (1) | TBA |

## Strategy 3: Increase habitat protection

Land-use change is the most significant threat to the koala through habitat loss, fragmentation and degradation. Increasing the total area of protected, connected quality koala habitat in priority areas will be important to protect and recover koala populations. As koalas occur across different land tenures, notably private land, this will require a range of incentive mechanisms, including direct land purchases. Improvements in land management practices can also increase habitat protection without changing land use. While direct habitat protection forms some actions, this strategy primarily consists of developing incentives for such protection and thus this strategy has been included as a supporting strategy.

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 3 a | Increase the overall area of protected koala habitat by dedication of Crown land and purchasing land identified as priority koala habitat for incorporation into the state protected areas. Priority areas include those that support viable populations and those that have the greatest potential for population-level recovery. | States; territories; philanthropic investment | Ongoing (1) | TBA |
| 3 b | Establish or expand existing targeted private land incentive mechanisms to increase the area for long-term protection and conservation of areas identified as priority koala habitats. Participation includes, but is not limited to, graziers, agricultural landholders, rural landholders, Indigenous land owners and private forestry. | States; territories; Commonwealth; philanthropic investment and NGOs. Indigenous land-owners and managers | Ongoing (2) | TBA |
| 3 c | Improve the condition of existing koala habitat on both private and public land through altered land management practices, including management of vegetation, fire, weed, and introduced species. | State and territory government agencies; non-government land-owners; NGOs | Ongoing (2) | TBA |
| 3 d | Investigate the potential to increase the protection of priority koala habitat through identification and registration of Critical Habitat where appropriate (i.e., Commonwealth-owned lands). | Commonwealth Government agencies; with strategic input from state and territory government agencies | Years 2-5 (2) | TBA |

## Strategy 4: koala conservation is integrated into policy, and statutory and land-use plans.

Management actions alone will not be sufficient to recover the koala. Actions are needed to ensure harmonisation of existing and future planning and policy settings such that they collectively contribute appropriately to maximising the chances of long-term survival of koalas in the wild.

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 4 a | Review and update EPBC Act referral guidelines for the listed koala to support regulatory decision making. | Commonwealth in consultation with state and territory governments, experts, planners, industry and the wider community, | Yr 1 (1) | $50,000 |
| 4 b | Review, revise, and strengthen where appropriate, statutory planning instruments, policies, and compliance controls at all levels of government, including local government, to avoid or minimise impacts of land use or land management on koala conservation. Embed principals of landscape-scale management. | State and territory government agencies in coordination with local government authorities; Commonwealth. | Yr 1 and ongoing (1) | TBA |
| 4 c | Ensure identification and implementation of any offset decisions are strategic, coordinated, tracked in governments' databases, and informed by relevant planning and mapping documents such as NRM regional plans, Indigenous Heathy Country Plans associated with Indigenous Protected Areas (IPAs) or local government koala strategies. | Commonwealth, state and territory government agencies in coordination with local governments; National Recovery Team, Indigenous IPA managers | Yr 1 and ongoing (1) | TBA |
| 4 d | Incorporate the impacts of climate change such as drought, heatwave and fire, into all strategic koala planning and actions, including restoration guidelines, offsets, translocation guidelines, forestry practices, corridor, reserve and protected area planning, allowing for iterative updates using a robust scenario-based approach | Commonwealth, state and territory government agencies in coordination with local governments | 5 yearly (2) | TBA |
| 4 e | Build on existing information to develop national guidelines or standards for koala-friendly urban design. | Commonwealth to coordinate state and territory government agencies, in consultation with local governments; urban planners | Yr 1 and ongoing (1) | TBA |

## Strategy 5: Strategic habitat restoration

Restoration increases the overall habitat available for koalas and increases the connectivity between areas of habitat, which is important to the long-term survival of koala populations. Many landcare-type organisations are restoring lost and degraded habitat for many species or to improve environmental functions. These activities are to ensure that resources are targeted to the most strategic areas.

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 5 a | Build on and implement landscape-scaled habitat restoration plans, including NRM regional plans, based on up-to-date mapping and spatial analysis that considers potential carrying capacity and landscape-scale | Coordinated approach between states and territory government agencies; local government; natural resource management agencies; NGOs | Ongoing (1) | TBA |

| | | | | |
|---|---|---|---|---|
| | processes such as climate change, fire and drought, and koala movement patterns. | | | |
| 5 b | Develop and implement best practice revegetation and restoration guidelines appropriate to local conditions that include planning for drought, heatwave, fire, and eucalypt responses to climate change using a robust scenario-based approach, consistent with national standards for ecological restoration (SERA 2017) | Coordinated between state and territory government agencies with input from research experts; Expert Technical Advisory Panel; natural resource management agencies and local community groups; NGOs | Years 1-5 (2) | TBA |
| 5 c | Implement on-ground revegetation or restoration programs, following local restoration guidelines for the koala where they exist (e.g., NSW koala habitat revegetation guidelines (Wegner and Taws 2019)), in consultation with experts in koala ecology and plant geneticists. These should include experimental trialling of the establishment of climate resilient and nutritious feeding trees outside traditional ranges of koala habitat trees. | Coordinated approach between states and territory government agencies; local government; natural resource management agencies; local community groups; and NGOs. | Years 1-5 (2) | TBA |

## Strategy 6: Active metapopulation management

Metapopulation management concerns the movement of individuals and genes between populations. It is a complex and multi-faceted discipline. Adaptive management is the core of metapopulation management excellence. It requires consideration of cross-tenure land management, fire planning and operations, understanding of koala movement patterns and behavioural ecology, genetics, infection and disease, and fine-scale and macro-scale habitat needs, among other factors. To complicate these actions, planning instruments (e.g., development zoning) and forest harvesting practices are spatially variable, making it difficult to be prescriptive.

This strategy relies heavily on relevant and up-to-date habitat and distribution mapping and modelling for spatial prioritisation, climate change modelling, principles of landscape processes, and research into koala disease, population genetics habitat requirements, movement patterns, and biology. Management of fire, forest harvesting, and human activities and developments all influence koala metapopulations processes and must be managed to mitigate adverse impacts.

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 6 a | Develop meaningful and measurable metrics of health, genetics, population and distribution, at relevant planning scales, with triggers for management response. Integrate these triggers into metapopulation management, decision-making and programs. Implement response plans. | Commonwealth, state and territory government agencies, with input from research experts; National koala Monitoring Program; Expert Technical Advisory Panel and National Recovery Team | Years 1-5 (1) | TBA |

| Action No. | Description | Potential Partners/Responsibility | Timeframe (Priority) | Est. cost |
|---|---|---|---|---|
| 6 b | Develop or build on existing best-practice koala translocation and post-care release guidelines for wild and captive populations, ensuring they are fit-for-purpose, informed by the latest research in metapopulation processes, genetics, disease and gut flora. Ensure the translocation guidelines are reviewed and updated within the life of this plan to integrate new understandings. If translocations are required, implement koala translocations in accordance with an appropriate decision framework and national guidelines (Wildlife Health Australia 2020), legislative requirements and consistent with international standards (IUCN/SSC 2013). | Coordinated by the Commonwealth with state and territory government agencies, with input from research experts; Expert Technical Advisory Panel & National Recovery Team; koala welfare organisations, including the Zoo and Aquarium Association, and RSPCA | 5 yearly (2) | TBA |
| 6 c | Regionally assess the feasibility, risks and cost-effectiveness of fire management options that seek to deliver long-term, strategic and landscape scale enhancement of the extent, and quality of current and future suitable habitat across tenures. | State and territory agencies with input from fire research experts; Expert Technical Advisory Panel and National Recovery Team; local fire authorities and local government, local landowners, Indigenous fire management practitioners & land-owners | Years 1-5 (1) | TBA |
| 6 d | Develop and implement fire management that effectively secures and promotes long-term, strategic and effective protection of known populations and suitable habitat. | State and territory agencies with input from fire research experts; Expert Technical Advisory Panel and National Recovery Team; local fire authorities and local government; koala welfare organisations and RSPCA | Years 1-5 (1) | TBA |
| 6 e | Develop and implement response and decision-support tools for individual and population management in emergencies such as bushfire, drought and floods. These include support and coordination of carer networks. | Coordinated by the Commonwealth with state and territory government resource agencies, local government agencies, natural resource management agencies and koala welfare organisations, with input from research experts; Expert Technical Advisory Panel and National Recovery Team | Years 1-5 (1) | TBA |

### Recovery plan decision

A decision has been made to have a Recovery Plan due to the 2012 recommendation by the Threatened Species Scientific Committee (TSSC 2012). This recovery plan is currently being drafted in parallel with this document.

## Links to relevant implementation documents

Species Profile and Threats Database: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=85104

Revised provisional list of animals requiring urgent management intervention following the 2019-2020 bushfires: https://www.environment.gov.au/biodiversity/bushfire-recovery/priority-animals

NSW koala Strategy: https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework/nsw-koala-strategy

Saving our species Framework for the spatial prioritisation of koala conservation actions in NSW Iconic koala Project. https://www.environment.nsw.gov.au/research-and-publications/publications-search/framework-for-the-spatial-prioritisation-of-koala-conservation-actions-in-nsw

South East Queensland Koala Conservation Strategy: https://environment.des.Qld.gov.au/wildlife/animals/living-with/koalas/conservation/seq-koala-strategy

Advice to the Minister for Sustainability, Environment, Water, Population and Communities from the Threatened Species Scientific Committee (the Committee) on Amendment to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act): http://www.environment.gov.au/biodiversity/threatened/species/pubs/197-listing-advice.pdf

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The Threatened Species Scientific Committee finalised this assessment on 07 September 2021.

# Attachment A: Listing Assessment for *Phascolarctos cinereus* combined populations of Queensland, New South Wales and the Australian Capital Territory

## Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC, initiated in response to the 2019/20 fires.

## Assessment of eligibility for listing

This assessment uses the criteria set out in the EPBC Regulations. The thresholds used correspond with those in the IUCN Red List criteria except where noted in criterion 4, sub-criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

## Key assessment parameters

Table 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

### Table 3 Key assessment parameters

| Metric | Estimate used in the assessment | Minimum plausible value | Maximum plausible value | Justification |
|---|---|---|---|---|
| **Number of mature individuals** | 92,184 | 86,863 | 92,184 | **Past population data for the listed koala:**<br><br>**2001** population estimate used in calculations: 184,7400<br>Data hindcast from the 2012 expert elicitation (Adams-Hosking et al. 2016).<br><br>**2012** population estimate: 115,600<br>Data source: 2012 expert elicitation (Adams-Hosking et al. 2016).<br><br>**2021** population estimate: 92,200.<br>**2032** population estimate: 63,500.<br>Data sources: 2012 expert elicitation (Adams-Hosking et al. 2016) and 2021 expert elicitation (Legge et al. 2021) |
| **Trend** | contracting | | | |
| **Generation time (years)** | 6.5 years | 6 years | 7 years | Using conservative values of sexual maturity at 3 years and longevity 15 years, generation time is estimated to be approximately 6.5 years. Here the three generation period is considered to be 20 years. |

| | | | | |
|---|---|---|---|---|
| **Extent of occurrence** | 1,665,850 km$^2$ | | | Data provided by Department of Agriculture Water and Environment, Geoscience Australia and PSMA Australia. |
| **Trend** | contracting | | | |
| **Area of Occupancy** | 19,428 km$^2$ | | | The area of occupancy is estimated at 19,400 km$^2$. These figures are based on the mapping of point records from 2000 from state governments, museums and CSIRO. Due to the lack of recent surveys more recent data cannot be used to predict range contraction. |
| **Trend** | contracting<br>Contracting due to climate related threats and habitat loss and land clearance. | | | |
| **Number of subpopulations** | >10 | | | Geographically isolated populations exist throughout the koala's range due to habitat fragmentation resulting from large scale land clearing, drought and bushfire impacts.<br>Populations West of the Great Dividing Range are considered to be isolated from their eastern counterparts (DAWE 2021b). Koala habitat is patchy and fragmented and increasingly prone to threats from drought resulting in multiple subpopulations (n≥3).<br>In, Queensland, koala populations to the north (e.g., Wet Tropics), western inland arid regions (e.g., Mulga Lands) and southern end of the state (e.g., South East Queensland) are increasingly isolated due to habitat loss and fragmentation (DES 2020) (n≥3).<br><br>In New South Wales, the east coast was heavily impacted by 2019-2020 bushfires. While the extent of bushfires was large, the fire intensity varied from low to high. Ongoing research indicates that areas of high intensity fire have zero koala occupancy in 2021. In contrast, low severity and moderate severity fire impacted areas are reported to have 100% koala occupancy (Pers comm., Natural Resources Commission 2021 koala Annual Forum). The high intensity fire impacts are likely to have the worst impact in poorly connected subpopulations (n≥5).<br><br>Preliminary genetic analysis also confirms that there is no longer genetic exchange across the Clarence River in NSW, or from the north to |

| | | | | |
|---|---|---|---|---|
| | | | | the south of the Sydney basin (Eldridge & Lott 2020). |
| **Trend** | Declining<br>The number of subpopulations is declining as climate suitable koala habitat shrinks. | | | |
| **Basis of assessment of subpopulation number** | The number of koala subpopulations is based on the available data and barriers to connectivity. | | | |
| **No. locations** | >10 | | | |
| **Trend** | unknown | | | |
| **Basis of assessment of location number** | The spatial nature of the threats, although stochastic in time and space, is such that there are > 10 geographically or ecologically distinct areas where a single threatening event (e.g., drought or fire) could affect all of the individuals present within a single generation. The geographic location of non-impacted locations will vary between events, but there are always likely to be > 10. | | | |
| **Fragmentation** | Increasingly fragmented–e.g., by the 2019/20 fires. | | | |
| **Fluctuations** | Data deficient. | | | |

### Criterion 1 Population size reduction

| Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4 | | | |
|---|---|---|---|
| | **Critically Endangered**<br>**Very severe reduction** | **Endangered**<br>**Severe reduction** | **Vulnerable**<br>**Substantial reduction** |
| **A1** | ≥ 90% | ≥ 70% | ≥ 50% |
| **A2, A3, A4** | ≥ 80% | ≥ 50% | ≥ 30% |

| | | | |
|---|---|---|---|
| **A1** | Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased. | Based on any of the following | (a) direct observation [except A3]<br>(b) an index of abundance appropriate to the taxon<br>(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat<br>(d) actual or potential levels of exploitation<br>(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites |
| **A2** | Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible. | | |
| **A3** | Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [*(a) cannot be used for A3*] | | |
| **A4** | An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible. | | |

## Criterion 1 evidence

**Eligible under Criterion 1** A2c, A4c **for listing as** Endangered

For the listed koala (Queensland, New South Wales and the Australian Capital Territory):

## Generation length

Female koalas reach sexual maturity between 2 and 3 years of age (McLean & Handasyde 2007). In the wild, longevity can be more than fifteen years for females and more than twelve years for males (Martin & Handasyde 1999). IUCN Guidelines (2019) provide the following as one method for estimation of generation length:

> Age of first reproduction + [ $z$ * (length of the reproductive period)], where $z$ is a number between 0 and 1

For mammals, values of $z$ have been estimated at 0.29 and 0.284 (Pacifici et al. 2013; Keith et al. 2015).

Using conservative values of sexual maturity at 3 years and longevity 15 years, generation time is estimated to be approximately 6.5 years. Here the three generation period is considered to be 20 years.

## Evidence - estimated

## A2 Past population reductions (2001-2021):

The total number of koalas in Queensland, New South Wales, and the Australian Capital Territory in the year 2001 – the starting point for this assessment – was estimated to be between 184,748 and 170,335. This estimate was derived from bioregional population estimates for 2012 provided by Adams-Hosking et al. (2016). These bioregional estimates sum to a total population of 115,614 in 2012 (Adams-Hosking et al. 2016); a figure that is widely accepted by state governments, non-government organisations (NGOs) and researchers and builds on the 2012 EPBC listing advice (TSSC 2012). The 2012 bioregional population estimates were adjusted by Adams-Hosking et al.'s (2016) estimates of the rate of decline in each bioregion over the preceding three generations to yield bioregional population estimates for the year 1992. We then derived bioregional values for the year 2001 by assuming that the form of decline in each bioregion between 1992 and 2012 was either linear (giving the summed estimate of 184,748) or exponential (170,335); note that Adams-Hosking et al. (2016) did not specify the shape of the decline curve over the three-generation period. Total population estimates for the year 2021 were derived similarly, by projecting the bioregional declines from 1992-2012 forward to 2021. The resulting values for the total population in 2021 were 92,184 (linear decline) and 86,863 (exponential decline) (Table 4, Box 1).

Table 4 shows that that for the period 2001 to 2021 the estimated decline of the total population reaches the Endangered threshold of 50 percent under this Criterion. Whether the shape of the decline curve is exponential or linear has little effect on the outcome. Key bioregions (e.g., Mulga Lands) likely did not decline in a linear or exponential fashion, but rather were relatively stable until around 2000 then declined precipitously due to the Millennium Drought (Seabrook et al. 2011). If this "step change" were factored into the calculations in Table 4 it would have the effect of estimating a higher population at the beginning of the assessment period for Criterion A2, and thus a proportionally higher rate of decline.

Additionally, these data do not include the effects of the 2019/20 bushfires. While fire was considered as a threat in the elicitation exercise of Adams-Hosking et al. (2016), fires of the scale of 2019/20 were not anticipated in estimating declines that were likely to occur after 2012 (Hosking, Kavanagh, Lawler, Lunney, Melzer, Menkhorst, Moore pers comm April 2021). Thus again, this analysis likely underestimates the overall decline.

In a project run by the Threatened Species Recovery Hub in 2020-21, expert elicitation was used to estimate the likely mortality of koalas in low/med and high/very high severity fires. These estimates were then combined with spatial estimates of the proportion of the listed koala's range that was burned in those severity classes, to estimate the overall population reduction caused by the fire. It was estimated that populations declined by 10 percent (80 percent confidence 5.0 to 17 percent) by one year after 2019/20 fires, and that they would continue to decline thereafter without returning to their pre-fire population size. This analysis assumed uniform density of koalas across their range. However, the fires occurred predominantly in areas where koala densities are relatively higher than, for example, in large parts of their range west of the Great Divide, and thus this estimate likely underestimates the mortality due to the fires.

The estimated decline sits on the lower threshold for the Endangered category. Thus, while the effects of the "step change" due to drought and the similar sudden drop in numbers due to the 2019/2020 fires cannot be accurately quantified, it can confidently be concluded that they move the estimate well into the Endangered range. They are unlikely to be of sufficient scale to reach the threshold for the Critically Endangered category, which would require an overall decline of ≥80 percent for this criterion (Table 4). Consequently, given that the koala is demonstrably close to the lower threshold of Endangered and that ongoing trends suggest further events likely to be sufficient to worsen the decline, the Committee considers that the koala is eligible for listing as Endangered under this subcriterion A2c.

**Table 4 –** Estimated population sizes for bioregions containing koalas, calculated from the values provided in an expert elicitation study estimating koala sizes and trends +/- three generations from 2012.

Values for 2032 generated directly by applying three generation trends. Values for 2001 estimated by hindcasting three generations back to 1992 then calculated based on assuming either constant linear, or exponential, decline across the three generation period. Values for 2021 also based on constant linear, or exponential, decline between 2012 and 2032. Full details of these calculations are shown in Box 1 for the Brigalow Belt North bioregion as an exemplar.

| Bioregion | 2012 | Past or future change (%) over 3 gens | Hindcast (ca 1992) | 2001 linear | 2021 linear | 2001 exponential | 2021 exponential decline | Forecast (ca. 2032) |
|---|---|---|---|---|---|---|---|---|
| | | | | A2 | | | | A4 |
| Cobar Peneplain & Riverina | 2,354 | -9 | 2,587 | 2,482 | 2,259 | 2,480 | 2,256 | 2,142 |
| Darling Riverine Plains | 964 | -34 | 1,461 | 1,237 | 816 | 1,212 | 800 | 636 |
| Mulga Lands (NSW) | 711 | -31 | 1,030 | 886 | 612 | 872 | 602 | 491 |
| Murray Darling Depression | 55 | -12 | 63 | 59 | 52 | 59 | 52 | 48 |
| New England Tablelands | 2,771 | 6 | 2,614 | 2,685 | 2,846 | 2,683 | 2,845 | 2,937 |
| NSW North Coast | 8,367 | -50 | 16,734 | 12,969 | 6,485 | 12,250 | 6,125 | 4,184 |
| NSW South Western Slopes | 2,310 | -23 | 3,000 | 2,690 | 2,071 | 2,667 | 2,054 | 1,779 |
| South Brigalow & Nandewar | 11,133 | -35 | 17,128 | 14,430 | 9,379 | 14,110 | 9,171 | 7,236 |
| South East Corner | 655 | -46 | 1,213 | 962 | 520 | 919 | 496 | 354 |
| South Eastern Highlands | 1,363 | -19 | 1,683 | 1,539 | 1,246 | 1,531 | 1,240 | 1,104 |
| Sydney Basin | 5,667 | -4 | 5,903 | 5,797 | 5,565 | 5,796 | 5,564 | 5,440 |
| Brigalow Belt North | 15,179 | -63 | 41,024 | 29,394 | 10,876 | 26,226 | 9,704 | 5,616 |
| Brigalow Belt South | 11,071 | -56 | 25,161 | 18,821 | 8,281 | 17,389 | 7,651 | 4,871 |
| Central Mackay Coast | 8,857 | -35 | 13,626 | 11,480 | 7,462 | 11,225 | 7,296 | 5,757 |
| Desert Uplands | 6,357 | -20 | 7,946 | 7,231 | 5,785 | 7,187 | 5,750 | 5,086 |
| Einasleigh Uplands & Wet Tropics | 4,750 | -41 | 8,051 | 6,566 | 3,874 | 6,349 | 3,746 | 2,803 |
| Mitchell Grass Downs | 1,943 | -39 | 3,185 | 2,626 | 1,602 | 2,550 | 1,556 | 1,185 |
| Mulga Lands (QLD) | 15,286 | -73 | 56,615 | 38,017 | 10,264 | 31,408 | 8,480 | 4,127 |
| South Eastern Queensland | 15,821 | -51 | 32,288 | 24,878 | 12,190 | 23,422 | 11,477 | 7,752 |
| **TOTAL** | **115,614** | | **241,312** | **184,748** | **92,184** | **170,335** | **86,863** | **63,549** |
| **Estimated decline over three generations** | | | | **50%** | | **49%** | | **45%** |

**Box 1.** Example of calculations used in calculating time-corrected estimates - Brigalow Belt North Bioregion

**Notes:**
1. Because the estimated declines rates vary between bioregions, the calculations were made for each bioregion and summed across the relevant area to provide overall estimates. One bioregion is shown here as an exemplar.
2. For simplicity, numbers used below are rounded, but this was not the case when calculations were made on a spreadsheet and thus it may appear that there are minor discrepancies with Table 4.

Adams-Hosking et al. (2016) estimated that in 2012 the population of koalas in this bioregion was 15,179 and that the decline over the past, and future, three generations from 2012 was 63 percent.

**Hindcast to previous three generations from 2012 (i.e., approximately 1992)**

$N_{2012} = N_{1992}$*(100%-63%)
$N_{2012} = N_{1992}$*37%
$N_{2012}$/37% = $N_{1992}$
$N_{1992}$ = 15,179/37%
= 41,024

**Forecast to following three generations from 2012 (i.e., approximately 2032)**

$N_{2032} = N_{2012}$*(100%-63%)
= 15,179*.37
= 5,616

**Estimating population at beginning of relevant three generation time period for Criterion A2 (i.e., approx. 2001)**

***Assuming linear decline***

$N_{2012}$ = 15,179
$N_{1992}$ = 41,024
Decline/year = ($N_{2012}$ - $N_{1992}$)/(2012-1992)
= (41,024-15,179)/20
= 25,845/20
= 1292
$N_{2001} = N_{1992}$-(Decline/year)*(2001-1992)
= 41,024-(1292*9)
= 29,394

***Assuming exponential decline***

$N_{1992}$ = 41,024
Decline over 20 years = 63%
Remaining = 37% = 0.37
Decline/year = $0.37^{(1/20)}$ = 0.952
$N_{2001} = N_{1992}*0.952^{(2001-1992)}$
= $N_{1992}*0.952^{9}$
= 41,024*0.639
= 26,226

**Estimating population at end of relevant three generation time period for Criterion A2 (i.e., approx. 2021)**

***Assuming linear decline***

$N_{2012}$ = 15,179
$N_{2032}$ = 5,616
Decline/year = ($N_{2032}$ - $N_{2012}$)/(2032-2012)
= (15,179-5,616)/20
= 9,563/20
= 478
$N_{2021}$ = $N_{2012}$-(Decline/year)*(2032-2012)
= 15,179-(478*9)
= 10,786

***Assuming exponential decline***
$N_{2012}$ = 15,179
Decline over 20 years = 64%
Remaining = 37% = 0.37
Decline/year = $0.37^{(1/20)}$ = 0.952
$N_{2021}$ = $N_{2012}$*$0.952^{(2021-2012)}$
= $N_{2012}$*$0.952^{9}$
= 15,179*0.639
= 9,704

## A3 Population reductions (2021-2042):

The Committee has determined that there are insufficient data to appropriately address Criterion A3 for the koala. As above, the primary data source from which to address both population size and trend is the paper by Adams-Hosking et al. (2016). As that paper addresses the period only until three generations into the future from 2012, extending the period until 2042 would require inappropriately extrapolating by approximately a decade.

## A4 Population reductions (2012-2032):

Table 4 shows a decline rate of 45 percent over the relevant three generation moving window from 2012 to 2032 (without including effects of the 2019/20 bushfires). That this is a lower overall rate than the period 2000-2021 may seem counterintuitive. This is explained by the fact that several of the highest rates of decline within bioregions occur in those bioregions with the largest population size. In earlier years, those populations constitute a higher proportion of the overall population than in subsequent years and lead to a higher overall rate of decline because they decline faster than the overall population. Consequently, as they diminish in size, they contribute less to the overall population decline and this rate itself decreases.

When the 2019/20 bushfires are factored into the declines for relevant bioregions the result approaches or exceeds the Endangered threshold, but it is difficult to quantify this because of the different data structures used in the relevant studies, particularly the absence of partitioning by bioregion by the Threatened Species Recovery Hub analysis (Legge et al. 2021) .

The Committee must also judge the likelihood of an additional event in the next decade sufficient to increase ongoing decline to ≥50 percent. In this context, it is notable that Australia has experienced two severe droughts in the last 20 years (Millennium Drought, Big Dry), several large scale fire events (e.g. 2009 Victorian fires, 2019/20 bushfires) and that climate models suggest both phenomena will become both more common and more severe (Di Virgilio et al. 2019; Abram et al. 2021). Consequently, given that the koala is demonstrably close to the lower threshold of Endangered and that ongoing trends suggest further events likely to be sufficient to worsen the decline, the Committee considers that the koala is eligible for listing as Endangered under subcriterion 1A4c.

**Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy**

| | | | | |
|---|---|---|---|---|
| | | **Critically Endangered**<br>**Very restricted** | **Endangered**<br>**Restricted** | **Vulnerable**<br>**Limited** |
| **B1.** | Extent of occurrence (EOO) | **< 100 km$^2$** | **< 5,000 km$^2$** | **< 20,000 km$^2$** |
| **B2.** | Area of occupancy (AOO) | **< 10 km$^2$** | **< 500 km$^2$** | **< 2,000 km$^2$** |
| **AND at least 2 of the following 3 conditions:** | | | | |
| (a) | Severely fragmented OR Number of locations | **= 1** | **≤ 5** | **≤ 10** |
| (b) | Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals | | | |
| (c) | Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals | | | |

## Criterion 2 evidence

**Eligible under Criterion 2**

**Not eligible**

The extent of occurrence (EOO) is estimated at 1,665,850 km$^2$ and the area of occupancy (AOO) is estimated at 19,428 km$^2$. These figures are based on the mapping of point records from a 20-year period (2000–2020), obtained from state governments, museums, and CSIRO. The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014 (IUCN 2019). The AOO is likely significantly under-estimated due to limited sampling across the occupied range (Woinarski et al. 2014).

The data presented above demonstrate the subspecies is not eligible for listing under this criterion as the EOO is > 20,000 km$^2$ and the AOO is > 2,000 km$^2$.

### Criterion 3 Population size and decline

| | | Critically Endangered<br>Very low | Endangered<br>Low | Vulnerable<br>Limited |
|---|---|---|---|---|
| Estimated number of mature individuals | | < 250 | < 2,500 | < 10,000 |
| AND either (C1) or (C2) is true | | | | |
| **C1.** An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future) | | **Very high rate**<br>**25% in 3 years or 1 generation**<br>**(whichever is longer)** | **High rate**<br>**20% in 5 years or 2 generation**<br>**(whichever is longer)** | **Substantial rate**<br>**10% in 10 years or 3 generations**<br>**(whichever is longer)** |
| **C2.** An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions: | | | | |
| (a) | (i) Number of mature individuals in each subpopulation | ≤ 50 | ≤ 250 | ≤ 1,000 |
| | (ii) % of mature individuals in one subpopulation = | 90 – 100% | 95 – 100% | 100% |
| (b) Extreme fluctuations in the number of mature individuals | | | | |

## Criterion 3 evidence

### Eligible under Criterion 3

**Not eligible**

The estimated population size is > 10,000 mature individuals. The data presented above demonstrates that the koala is not eligible for listing under this criterion.

### Criterion 4 Number of mature individuals

| | | | |
|---|---|---|---|
| | **Critically Endangered**<br>**Extremely low** | **Endangered**<br>**Very Low** | **Vulnerable**<br>**Low** |
| **D.** Number of mature individuals | < 50 | < 250 | < 1,000 |
| **D2.**[1] *Only applies to the Vulnerable category*<br>Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time | | | D2. Typically: area of occupancy < 20 km$^2$ or number of locations ≤ 5 |

[1] The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the *common assessment method*.

## Criterion 4 evidence

**Eligible under Criterion 4**

**Not eligible**

The data presented above demonstrates that the koala is not eligible for listing under this criterion. The number of individuals is > 1,000 and the AOO is > 20 km$^2$, and there are > 5 locations.

### Criterion 5 Quantitative analysis

| | | | |
|---|---|---|---|
| | **Critically Endangered**<br>**Immediate future** | **Endangered**<br>**Near future** | **Vulnerable**<br>**Medium-term future** |
| **Indicating the probability of extinction in the wild to be:** | ≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.) | ≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.) | ≥ 10% in 100 years |

## Criterion 5 evidence

**Eligible under Criterion 5 for listing as** Insufficient data

**Insufficient data to determine eligibility**

Population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

## Adequacy of survey

The survey and modelling effort has been considered adequate and there is sufficient scientific evidence to support the assessment.

## Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 30 business days between 18 May 2021 and 30 July 2021.

## Listing and Recovery Plan Recommendations

The Threatened Species Scientific Committee recommends:

(i) that the list referred to in section 178 of the EPBC Act be amended by transferring *Phascolarctos cinereus* from the Vulnerable category to the Endangered category.

(ii) that there should be a recovery plan for this species.

# Attachment B: Experts consulted with during the preparation of the Conservation Advice

*Note:* A National koala monitoring workshop was held February 1-2, 2021. Koala experts provided direct input to the Conservation Advice during this workshop. The workshop participants are included in the list of experts consulted with alongside other experts who provided additional advice.

| **Name** | **Organisation/Affiliation** |
|---|---|
| Adam Leavesley | ACT Parks and Conservation |
| Adam Roff | NSW Department of Planning, Industry and Environment |
| Allen Mcllwee | NSW Department of Planning, Industry and Environment |
| Andrew Hoskins | CSIRO |
| Anthony Contarino | QLD Department of Environment and Science |
| Ben Moore | Western Sydney University |
| Bill Ellis | University of Queensland |
| Billie Roberts | NSW Department of Planning, Industry and Environment |
| Brad Law | NSW Department of Primary Industries |
| Bronte Kulp | QLD Department of Environment and Science |
| Carsten Kuelheim | Michigan Technological University, USA (formerly at: Australian National university) |
| Cassie Thompson | NSW Natural Resources Commission |
| Catherine George | QLD Department of Environment and Science |
| Chris Meakin | Commonwealth Department of Agriculture, Water and the Environment |
| Sue Fyfe | Commonwealth Department of Agriculture, Water and the Environment |
| Claire Runge | University of Queensland |
| Christine Hosking | The University of Queensland |
| Cristina Vicente | SA Department for Environment and Water |

| | |
|---|---|
| Damian Higgins | University of Sydney |
| Dan Lunney | NSW Department of Planning, Industry and Environment |
| Danielle Stocks | NSW Department of Planning, Industry and Environment |
| David Ramsey | Vic Department of Environment, Land, Water and Planning |
| David Westcott | CSIRO |
| Debbie Saunders | Wildlife Drones |
| Desley Whisson | Deakin University |
| Emma Hickingbotham | Vic Department of Environment, Land, Water and Planning |
| Enhua Lee | NSW Department of Planning, Industry and Environment |
| Grant Hamilton | Queensland University of Technology |
| Harriet Preece | QLD Department of Environment and Science |
| Helen Murphy | CSIRO |
| Helene Marsh | Threatened Species Scientific Committee |
| Ian Sandford | QLD Department of Environment and Science |
| Ivan Lawler | Commonwealth Department of Agriculture, Water and the Environment |
| Jane DeGabriel | NSW Department of Planning, Industry and Environment |
| Jacob Tangey | QLD Department of Environment and Science |
| Jennie Mallela | Commonwealth Department of Agriculture, Water and the Environment |
| Jim Adams | National Landcare Network |
| John Turbill | NSW Department of Planning, Industry and Environment |
| Jonathan Rhodes | University of Queensland |
| Julie Anorov | Commonwealth Department of Agriculture, Water and the Environment |

| | |
|---|---|
| Kaitlyn Close | QLD Department of Environment and Science |
| Kara Youngentob | Australian National University |
| Karen Ford | Australian National University |
| Karl Hillyard | SA Department for Environment and Water |
| Kath Handasyde | University of Melbourne |
| Katherine Belov | University of Sydney |
| Kellie Leigh | Science for Wildlife |
| Kyle Debets | QLD Department of Environment and Science |
| Kylie Madden | NSW Department of Planning, Industry and Environment |
| Lachlan Wilmott | NSW Department of Planning, Industry and Environment |
| Laine Edwards | Commonwealth Department of Agriculture, Water and the Environment |
| Laura Griffiths | Commonwealth Department of Agriculture, Water and the Environment |
| Lauren Smith | Commonwealth Department of Agriculture, Water and the Environment |
| Lily Sekuljica | NSW Department of Planning, Industry and Environment |
| Linda Neaves | Australian National University |
| Lynne McCarthy | Commonwealth Department of Agriculture, Water and the Environment |
| Manda Page | QLD Department of Environment and Science |
| Mark Eldridge | Australian Museum |
| Mathew Crowther | University of Sydney |
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| Rowan Ewing | National Landcare Australia |
| Ryan Witt | University of Newcastle |
| Sarah Bloustein | Commonwealth Department of Agriculture, Water and the Environment |
| Sarah Brown | Commonwealth Department of Agriculture, Water and the Environment |
| Sarah Legge | NESP Threatened Species Recovery Hub |
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| Shane Norrish | National Landcare Australia |
| Steven Howell | QLD Department of Environment and Science |
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| Vural Yazgin | Vic Department of Environment, Land, Water and Planning |
| Warrick McGrath | Vic Department of Environment, Land, Water and Planning |
| Zoe Kemp | QLD Department of Environment and Science |

# Attachment C: Additional Sources of Information Provided during the Public Consultation

***Note:*** Additional sources of information provided during the public consultation process, that are not referred to in the Conservation Advice, are detailed here. Each has been considered with respect to finalising the Committee's recommendation and whether it materially affected the outcome or the recommended conservation actions. The inclusion of a source here does not necessarily indicate that the Committee agrees with its conclusion(s).

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This publication is available at the SPRAT profile for *Phascolarctos cinereus* (Koala).

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## Version history table

| Document type | Title | Date |
| --- | --- | --- |
| Conservation Advice | Department of Sustainability, Environment, Water, Population and Communities (2012). Approved Conservation Advice for Phascolarctos cinereus (combined populations in Queensland, New South Wales and the Australian Capital Territory). Canberra: Department of Sustainability, Environment, Water, Population and Communities. | 02 05 2012 |
| Listing Advice | Threatened Species Scientific Committee (TSSC) (2012). Listing advice for Phascolarctos cinereus (Koala) | 02 05 2012 |

The Minister approved this conservation advice and included this species in the Endangered category, effective from 07/12/2016

# Conservation Advice

# *Adclarkia cameroni*

brigalow woodland snail

## Taxonomy

Conventionally accepted as *Adclarkia cameroni* Stanisic, 2010.

## Summary of assessment

### Conservation status

Endangered: Criterion 2 B2 (a)(b)(i)(ii)(iii)(iv)(v)

The highest category for which *Adclarkia cameroni* is eligible to be listed is Endangered.

*Adclarkia cameroni* has been found to be eligible for listing under the following categories:
Criterion 2: B2 (a)(b)(i)(ii)(iii)(iv)(v): Endangered
Criterion 4: Vulnerable

Species can be listed as threatened under state and territory legislation. For information on the listing status of this species under relevant state or territory legislation, see http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

### Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of information provided by a public nomination.

### Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 31 business days between 20 June 2016 and 1 August 2016. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

## Species information

### Description

Shell medium to large (diameter 20 mm), thin, light brownish yellow, with a reddish band on the whorls (spirals) on the shell (Stanisic et al., 2010). The shell is somewhat flattened, with a low, domed spire. The whorls are rounded and tightly coiled; the last whorl is flared. The sutures (junctions between the whorls) are weakly present. The tip of the shell bares small rounded knobs (Stanisic et al., 2010). Much of the rest of the shell bares fine, scaly knobs on the upper half of the whorls, glossy underneath. The shell also bares very fine, wavy ridges running across each whorl. The animal is grey (Stanisic et al., 2010).

This species differs from *A. dulacca* by having a less flattened shell, with 'looser' coiling (Stanisic et al., 2010).

### Distribution

The brigalow woodland snail (family Camaenidae) is endemic to south-east Queensland, where it occurs in a small number of remnant and scattered *Acacia harpophylla* (brigalow) and eucalypt woodland patches (such as road verges and riparian corridors) on the Condamine River floodplain, especially in the area around Dalby and Chinchilla (Stanisic 2011). This is a highly developed agricultural area (Seaton 2016). These remnant vegetation patches are subject to many disturbances such as excessive drying due to clearing, stock grazing, and fire. The brigalow patches occur on alluvial black soils. The narrow Condamine River riparian corridor is an important refuge for the species, particularly in an area that has been largely cleared for cattle grazing and agriculture. Here the canopy cover is dense, scattered timber (flood debris) is greatest and environmental moisture is at its most stable, even in drier times (Stanisic 2011). The species was first discovered during a major survey of the Queensland Brigalow Lands Bioregion conducted in 1996-1997 (Stanisic 2011), and records are adequate to determine the species' range (Koehler et al., 2016).

The extent of occurrence (EOO) was calculated to be 27 924 $km^2$, and the area of occupancy (AOO) 76 $km^2$, based on locality records from 1976 to the present (DotEE 2016). However, the EOO and AOO are likely to be much less, because the approximately 19 known records include only seven with live individuals (Stanisic 2013). Most of the sampled current populations comprise juveniles and sub-adults, indicating that the brigalow woodland snail is breeding in some locations.

The current distribution of this species is severely fragmented. The brigalow communities within the Condamine River floodplain that were once contiguous in the area of the species' historical distribution have been extensively cleared for agriculture and farming, and the current distribution of the brigalow woodland snail reflects this broad scale clearing (Stanisic 2011).

One population occurs in the State owned St Ruth's Reserve, via Dalby (on the Condamine River), which is managed by Western Downs Regional Council. However, no management of the species in this reserve is currently being undertaken (Stanisic 2011). There are no other populations in reserve systems (Stanisic 2011). The brigalow woodland snail occurs in the 'Brigalow (*Acacia harpophylla* dominant and co-dominant)' ecological community (Seaton 2016), currently listed as Endangered under the EPBC Act (TSSC 2013). The snail may also occur in the 'Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt Bioregions' ecological community, currently listed as Endangered under the EPBC Act (TSSC 2011).

**Relevant Biology/Ecology**

The brigalow woodland snail is known to occur under logs (Stanisic et al., 2010) and leaf litter, where it likely feeds on fungi, lichen, algae and other detritus/biofilm growing on forest debris, thereby recycling nutrients into the soil (Stanisic 2011). Feeding by this species has not been observed, but likely occurs during periods of higher humidity, such as evenings and rain events.

The brigalow woodland snail needs both canopy and on-ground timber cover for survival and egg-laying (Stanisic 2011). Generally, camaenids lay their eggs in depressions in the soil under logs and other debris, and although egg-laying has not been recorded for this species, it is highly likely that it follows a similar pattern (Stanisic 2011). Desiccation is the greatest threat to land snail eggs and hence, in addition to ground debris, an over-storey of trees and shrubs is also required in order to maintain high levels of relative humidity at the substrate level (Stanisic 2011). Land snails can aestivate during drier phases but the extent of this hibernation is limited by their body reserves (Stanisic 2011).

The age at sexual maturity is unknown, but is likely to be approximately two years, based on the growth patterns of other snails from the same family (Stanisic 2011). The life expectancy is also unknown, but is likely to be at least five years, based on the longevity of similar species (Stanisic 2011). Mature snails will lay eggs on an annual basis and, depending on the length of the summer rain period, could lay more than a single clutch of eggs in one year. The number of mature individuals is unknown, and there is no evidence that this species undergoes extreme natural fluctuation in population size (Stanisic 2011).

Snails in seasonally dry environments in the northern half of Australia in particular are generally considered to become sexually mature during their second wet season. The brigalow woodland snail would be expected to follow a similar pattern (Solem 1981, cited in Stanisic 2011). Natural mortality is likely to be most significant for the immature stages, when shell growth has not been fully completed (Stanisic 2011).

The brigalow woodland snail is of very limited mobility. Under favourable conditions, such as rain, this species can move between suitable areas of microhabitat, but the extent to which this occurs will be limited by the spatial arrangement of habitat patches.

### Threats

Table 1 – Threats impacting the brigalow woodland snail in approximate order of severity of risk, based on available evidence

| Threat factor | Threat type | Threat status | Evidence base |
|---|---|---|---|
| Habitat loss and fragmentation | | | |
| Land clearing | known | current | Habitat with tree cover and ground debris is critical to survival of native land snails, and increases the species' ability to disperse and recolonise (Stanisic 2011). Tree cover ensures a level of environmental moisture. Habitat clearing has increased with coal seam gas extraction and coal mining developments in the region (QMDC 2016). The burning of woody debris during land clearing also leads to loss of habitat. The impacts of land clearing on the brigalow woodland snail are ongoing (Stanisic 2016). Clearing of roadsides has also led to habitat loss (Seaton 2016). |
| Habitat disturbance | known | current | Accumulated ground debris provides important shelter for the species. Undisturbed habitat ameliorates the effects of drought events, as desiccation is generally the greatest threat to land snails (Stanisic 2011). The harvesting of timber on the ground for firewood may also threaten this species, although the extent and impact are unknown (Koehler et al., 2016). |
| Invasive species | | | |
| Predation by rats (*Rattus* spp.), mice (*Mus musculus)* and feral pigs (*Sus scrofa*) | known | current | Rats, mice and pigs are known to prey on land snails (Stanisic 2011). The incidence of predation is likely to be high, as rats and mice are nocturnal scavengers, and the brigalow woodland snail most likely also feeds at night. Predation by invasive species is an ongoing threat at all locations (Stanisic 2011), although the impact is unknown. Feral pigs use disturbance corridors for more easy access to native habitat (QMDC 2016). |
| Invasion of buffel grass | known | potential | Buffel grass (*Cenchrus ciliaris*) has replaced native grasses in some areas, and increases in fuel load are correlated with buffel grass invasion (Miller et al., 2010), leading to more intense fires. Increased fire activity in the grassy fringes will damage natural vegetation and facilitate further spread of grass away from the road areas (QMDC 2016). |

| Impacts of domestic species | | | |
|---|---|---|---|
| Trampling by cattle and horses | known | current | Cattle and horses—animals with solid hooves—directly kill the snails and destroy valuable microhabitat (logs and timber), which provides feeding and breeding habitat for snails (Stanisic 2011). Cattle are currently excluded from the St Ruth's Reserve locality, but they are an ongoing threat to all other known populations (Stanisic 2011). |
| Fire | | | |
| High intensity | known | potential | Any fire can cause loss of individuals and negatively impact their habitat. Hot fires in particular not only affect canopy structure but also tend to eliminate ground debris, which is essential habitat for snails (Stanisic 2011). The low mobility of land snails means they are especially susceptible to the effects of fire. The progressive process of habitat decline due to changed fire regimes caused by high biomass grasses (such as buffel grass) is already recognised as a key threat to conservation reserves within the Queensland Murray-Darling Basin (QMDC 2016). |

## How judged by the Committee in relation to the EPBC Act criteria and regulations

| **Criterion 1. Population size reduction (reduction in total numbers)**<br>Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4 | | | |
|---|---|---|---|
| | **Critically Endangered**<br>**Very severe reduction** | **Endangered**<br>**Severe reduction** | **Vulnerable**<br>**Substantial reduction** |
| **A1** | **≥ 90%** | **≥ 70%** | **≥ 50%** |
| **A2, A3, A4** | **≥ 80%** | **≥ 50%** | **≥ 30%** |

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(*a*) *cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

*based on any of the following:*

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

**Evidence:**

**Not eligible**

Habitat destruction is the greatest threat to land snail communities, and land clearance has affected 85 percent of the brigalow communities in Queensland (Stanisic et al., 2010). On a national scale, the brigalow (Acacia harpophylla dominant and co-dominant) Ecological Community has declined to approximately 10% of its former area (TSSC 2001). The greatest decline in extent of this Ecological Community occurred during the decade from 1960 to 1970, (TSSC 2001), and the greatest decline in distribution of the brigalow woodland snail is also likely to have occurred during this period.

Historical decline in the extent of occurrence of the brigalow woodland snail can be inferred based on the reduction in brigalow habitat. The brigalow woodland snail now occurs mostly in small remnant vegetation patches that are subject to many deleterious disturbances such as excessive drying, stock grazing, and fire (Stanisic 2011). However, how much of the original brigalow habitat that was occupied by this species is unknown.

Areas of relatively undisturbed remnant vegetation communities within the EOO of the brigalow woodland snail have been heavily impacted by a regularly spaced pattern of drill sites, infrastructure corridors and service roads constructed in the last 12 years (QMDC 2016), which is within the appropriate period for assessment under this criterion. However, examination of satellite imagery showing the drill sites and access roads indicates that the level of habitat disturbance caused by this threat does not exceed 30 per cent of the EOO of the snail.

Land clearing—mainly for conversion to pasture—is also continuing in the region: the Brigalow Belt bioregion had the highest woody vegetation clearing rate for 2014-15, with 1300 $km^2$ (DSITI 2016). Land clearing is also continuing in the Condamine subcatchment (which comprises a total runoff area of 30 439 $km^2$) (Accad & Neldner 2015), and includes much of the distribution of the brigalow woodland snail. The following table shows the decline in extent of remnant vegetation in the Condamine subcatchment from 2003 to 2013 (Accad & Neldner 2015):

| Year | Extent of remnant vegetation ($km^2$) |
|---|---|
| 2013 | 7355.69 |
| 2011 | 7369.24 |
| 2009 | 7375.43 |
| 2006 | 7395.64 |
| 2005 | 7400.97 |
| 2003 | 7429.66 |

These data show that 74 $km^2$ of remnant vegetation were cleared over this period, representing a decline of approximately 1 percent. However, there has been extensive historical decline in total remnant vegetation in this subcatchment: as at 2013, only 24.2 percent of total remnant vegetation remained (Accad & Neldner 2015).

These data indicate that habitat (remnant vegetation) extent and quality have declined from 2003 to 2013, but at a rate less than the 30 per cent threshold for this criterion.

Although the brigalow woodland snail is very likely to still be declining, there are no data regarding historical distribution of this species to enable any decline over time to be quantified. Following assessment of the data the Committee has determined that the species is not eligible for listing in any category under this criterion as the past, current or future population declines are thought unlikely to exceed 30% in any 3-generation period.

| Criterion 2. Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy | | | |
|---|---|---|---|
| | **Critically Endangered Very restricted** | **Endangered Restricted** | **Vulnerable Limited** |
| B1. Extent of occurrence (EOO) | **< 100 km$^2$** | **< 5,000 km$^2$** | **< 20,000 km$^2$** |
| B2. Area of occupancy (AOO) | **< 10 km$^2$** | **< 500 km$^2$** | **< 2,000 km$^2$** |
| AND at least 2 of the following 3 conditions: | | | |
| (a) Severely fragmented OR Number of locations | **= 1** | **≤ 5** | **≤ 10** |
| (b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals | | | |
| (c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals | | | |

**Evidence:**

**Eligible under Criterion 2 B2 (a)(b)(i)(ii)(iii)(iv)(v) for listing as Endangered**

The extent of occurrence was calculated to be 27 924 km$^2$, using the IUCN convex hull/minimum convex polygon method, based on the mapping of point records from 1976 to 2016 obtained from state governments, museums and the CSIRO (DotEE 2016). The area of occupancy was calculated to be 76 km$^2$, based on locality records from 1976 to 2016 (DotEE 2016), using the 2x2 km grid cell method described in the IUCN Red List Guidelines 2014 (IUCN, 2014).

The distribution of the brigalow woodland snail is severely fragmented. The brigalow communities within the Condamine River floodplain that were once contiguous in the area of the species' historical distribution have been extensively cleared for agriculture and farming, and the known locations of the brigalow woodland snail reflect this broad scale clearing (Stanisic 2011). The brigalow woodland snail now occurs mostly in small remnant vegetation patches that are subject to many disturbances such as excessive drying due to clearing, stock grazing, and fire (Stanisic 2011). Large areas of relatively undisturbed remnant vegetation communities throughout this area have been heavily impacted by a regularly spaced pattern of drill sites, infrastructure corridors and service roads constructed in the last 12 years (QMDC 2016). Land clearing is also continuing in the Condamine subcatchment (Accad & Neldner 2015) (see previous criterion), which includes much of the distribution of the brigalow woodland snail. The species is subject to continuing threats, and is therefore likely to still be declining, although there are no available data on historical distribution or robust measures of current abundance.

The species has very limited mobility, and the capacity for dispersal is therefore also very limited. There is no evidence that this species undergoes extreme natural fluctuation in population size (Stanisic 2011).

The Committee considers that the species' area of occupancy is restricted, with a severely fragmented distribution, and inferred continuing decline in extent of occurrence, area of occupancy, habitat, number of individuals and number of locations due especially to the effects of land clearing. Therefore, the species has been demonstrated to have met the relevant elements of Criterion 2 to make it eligible for listing as Endangered.

| Criterion 3. Population size and decline | | | | |
|---|---|---|---|---|
| | | **Critically Endangered Very low** | **Endangered Low** | **Vulnerable Limited** |
| Estimated number of mature individuals | | **< 250** | **< 2,500** | **< 10,000** |
| AND either (C1) or (C2) is true | | | | |
| C1 | An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future) | **Very high rate 25% in 3 years or 1 generation (whichever is longer)** | **High rate 20% in 5 years or 2 generation (whichever is longer)** | **Substantial rate 10% in 10 years or 3 generations (whichever is longer)** |
| C2 | An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions: | | | |
| (a) | (i) Number of mature individuals in each subpopulation | **≤ 50** | **≤ 250** | **≤ 1,000** |
| | (ii) % of mature individuals in one subpopulation = | **90 – 100%** | **95 – 100%** | **100%** |
| (b) | Extreme fluctuations in the number of mature individuals | | | |

**Evidence:**

**Insufficient data to determine eligibility**

There are no direct measures of abundance for this species. Stanisic (2016) estimated the number of mature individuals to be between 251 and 1000, with a level of confidence of 31-50 per cent.

The Committee considers that there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

| Criterion 4. Number of mature individuals | | | |
|---|---|---|---|
| | **Critically Endangered Extremely low** | **Endangered Very Low** | **Vulnerable Low** |
| Number of mature individuals | **< 50** | **< 250** | **< 1,000** |

**Evidence:**

**Eligible under Criterion 4 for listing as Vulnerable**

There are no direct measures of abundance for this species. Stanisic (2016) estimated the number of mature individuals to be between 251 and 1000, with a level of confidence of 31-50 per cent.

The Committee considers that based on this estimate the total number of mature individuals is low. Therefore, the species has been demonstrated to have met the relevant elements of Criterion 4 to make it eligible for listing as Vulnerable.

| Criterion 5. Quantitative Analysis | | | |
|---|---|---|---|
| | **Critically Endangered Immediate future** | **Endangered Near future** | **Vulnerable Medium-term future** |
| Indicating the probability of extinction in the wild to be: | **≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)** | **≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)** | **≥ 10% in 100 years** |

**Evidence:**

Population viability analysis has not been undertaken.

## Conservation actions

### Recovery plan

A recovery plan for the species is not recommended, because the Approved Conservation Advice provides sufficient direction to implement priority actions and mitigate against key threats.

### Primary conservation actions

1. Prevent land clearing and resulting habitat destruction at all known localities. Any further habitat destruction at known or potential localities will have a significant impact on the species.

### Conservation and management priorities

Land clearing

- Prevent clearing of all brigalow habitat within the species' range, and in other areas where the brigalow woodland snail may occur.
- Investigate formal conservation arrangements, management agreements and covenants on private land, and for crown and private land investigate and/or secure inclusion in reserve tenure if possible. Seek to increase the level of legislative protection and active management planning for localities where this species occurs.

Habitat disturbance and modifications

- Retain a buffer of native vegetation and leaf litter around all occurrences of this species.
- Manage any other likely, potential or emerging threats to habitat quality, such as further invasion of weeds and habitat modification by removal of firewood.
- Erect appropriate signage to indicate conservation of individuals or groups of this species.
- Ensure land managers are aware of the species' occurrence and provide protection measures against key and potential threats.

Invasive species

- Identify and control buffel grass and any other weeds that could threaten the brigalow woodland snail with the careful use of herbicides. Ensure that any mechanical disturbance and overspray associated with chemical control are minimised, and do not impact this species.

- Manage predation and possible trampling by feral pigs at important sites through exclusion fencing or other barriers. Where possible, control feral pigs using appropriate methods (DEH 2005).
- Where possible, manage predation by rats and mice using appropriate methods (e.g. DEWHA 2009). Consider monitoring the impact of feral predator control after any large fire or large rain event.

Impacts of domestic species

- If livestock or horses occur in the area, manage trampling (and potential grazing of native vegetation) at important sites through exclusion fencing or other barriers.

Fire

- Prevent all high intensity fires. Fires must be managed to ensure that prevailing fire regimes do not disrupt the life cycle of the brigalow woodland snail, that they support rather than degrade the habitat necessary to this species, that they do not promote invasion of exotic species, and that they do not increase the impacts of grazing/predation.
- If fire operations are necessary, physical damage to the habitat and individuals of the brigalow woodland snail must be avoided during and after operations, noting that fires during the active life stages of the snail are likely to be highly detrimental.
- Fire management authorities and land management agencies should use suitable maps and install field markers to avoid damage to this species.
- Ensure that a high proportion of the habitat is maintained with a post-fire age sufficient to provide adequate canopy cover (or habitat) for the brigalow woodland snail.
- Ensure that areas of dense ground cover/leaf litter are retained within the habitat if any prescribed low intensity fires are implemented.

Stakeholder Engagement

- Raise awareness of the brigalow woodland snail within the local community. Engage with the relevant land managers (especially managers of private land and the Western Downs Regional Council) and encourage these key stakeholders to contribute to the implementation of conservation management actions.
- Engage with additional stakeholders that could contribute to the implementation of conservation management actions, such as local catchment organisations (e.g. Queensland Murray-Darling Committee), land regeneration and wildlife care groups, local schools, ecological consultants, and the Queensland Museum.
- Land managers (including pastoralists and the Western Downs Regional Council) should be given information about managing fire for the benefit of this threatened species.
- Prepare a management strategy with input from local experts.

### Survey and monitoring priorities

- Conduct targeted surveys throughout the range of the brigalow woodland snail to better define population distribution and abundance, and especially to determine the currency of all known sites. Accurately identify potentially suitable habitat and undertake survey work to locate and map any additional populations. The brigalow woodland snail lives under forest debris and is best detected by turning logs and raking accumulated leaves. The presence of dead shells, particularly of juvenile and sub-adult snails, is usually an indication of living adults (Stanisic 2011). The best times for survey are during the months of summer storms and rain (generally October to March). The snail is nocturnal, suggesting that night surveys would be preferable; however, given the difficulty with night observation of snails in their habitat, daylight searching can be equally effective (Stanisic 2011). Survey effort for recording presence/absence should be at least two person hours targeting areas of preferred snail microhabitat. At all times disturbance should be minimised to avoid damage to live snails (Stanisic 2011).
- Establish and maintain a monitoring programme at all sites based on these data to:
  - determine trends in population size and distribution, mortality and timing of life history stages;
  - determine threats and their relative impacts; and
  - monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.
- Precise fire history records must be kept for the habitat and current populations (confirmed and suspected) of the brigalow woodland snail.

### Information and research priorities

- Prioritise management actions at all sites based on the currency, degree and nature of threats. Population genetic studies could be used to determine where best to focus conservation effort to maximise genetic and morphological diversity within the species (Clark 2016).
- Assess the species' ecological requirements relevant to the persistence of the species. Investigate the impact of microhabitat and substrate on presence and abundance of the brigalow woodland snail at each locality. Assess the relative importance of: coverage of the canopy layer, coverage of the herbaceous layer, size and percentage of on-ground timber cover, size and percentage of rock cover, and leaf litter cover. Assess how they affect moisture/relative humidity at each locality. Assess the presence and abundance of co-occurring species at each locality.
- Where possible, assess the disturbance history at all localities. Where possible, differentiate between the time since disturbance, type of disturbance (e.g. fire history, mechanical disturbance, etc.), and presence of the brigalow woodland snail.
- Investigate optimum conditions and habitat for egg-laying. Record microhabitat characteristics at all sites where eggs are observed.

## Recommendations

(i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **including** in the list in the Endangered category:

*Adclarkia cameroni*

(ii) The Committee recommends that there not be a recovery plan for this species.

Threatened Species Scientific Committee

06/09/2016

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*Environment Protection and Biodiversity Conservation Act 1999* **(EPBC Act) (s266B)**

## Conservation Advice (including listing advice) for the Poplar Box Grassy Woodland on Alluvial Plains

1 The Threatened Species Scientific Committee (the Committee) was established under the EPBC Act to give advice to the Minister for the Environment (the Minister) in relation to the listing and conservation of threatened ecological communities, including under sections 189, 194N and 266B of the EPBC Act.

2. The Committee provided its advice on the *Poplar Box Grassy Woodland on Alluvial Plains* ecological community to the Minister as a draft of this conservation advice in April 2017, an updated version in April 2018 and also in June 2019. The Committee recommended that:
   - the ecological community merits listing as **endangered** under the EPBC Act; and
   - a recovery plan is not required for the ecological community at this time.

3. A draft conservation advice for this ecological community was made available for expert and public comment for a minimum of 30 business days. The Committee and Minister had regard to all public and expert comment that was relevant to the consideration of the ecological community.

4. In 2019, the Minister accepted the Committee's advice, adopted this document as the approved conservation advice and agreed no recovery plan is required at this time. The Minister amended the list of threatened ecological communities under section 184 of the EPBC Act to include the *Poplar Box Grassy Woodland on Alluvial Plains* ecological community in the **endangered** category.

5. At the time of this advice, components of this ecological community were also listed under the Queensland *Vegetation Management Act 1999*.

6. This approved conservation advice was based on the best available information at the time it was approved; this includes scientific literature, advice from consultations, and existing plans, records or management prescriptions for this ecological community.

Poplar Box Grassy Woodland on Alluvial Plains. (Photo credit: Rosemary Purdie)

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# 1 CONSERVATION OBJECTIVE

To prevent further loss and degradation of the ***Poplar Box Grassy Woodland on Alluvial Plains*** ecological community and help recover its biodiversity, function and extent, by protecting it from significant impacts as a Matter of National Environmental Significance under national environmental law and by guiding implementation of management and recovery, consistent with the recommended priority conservation and research actions set out in this advice.

This conservation advice contains information relevant to the conservation objective by:

- describing the ecological community and where it can be found
- identifying the key threats to the ecological community
- presenting evidence (listing advice) to support the ecological community being listed as nationally threatened under national environment law; and
- outlining the priority conservation and research actions that could stop decline and support recovery of the ecological community.

# 2 DESCRIPTION OF THE ECOLOGICAL COMMUNITY AND THE AREA IT INHABITS

The Poplar Box Grassy Woodland on Alluvial Plains ecological community is typically a grassy woodland with a canopy dominated by *Eucalyptus populnea* and understorey mostly of grasses and other herbs. The ecological community mostly occurs in gently undulating to flat landscapes and occasionally on gentle slopes on a wide range of soil types of alluvial and depositional origin (Webb et al. 1980).

This section describes the assemblage of native species[1] that characterises the Poplar Box Grassy Woodland on Alluvial Plains ecological community throughout its range at the time of listing. It outlines the vegetation structure of the ecological community, including some of its characteristic vascular plants and macroscopic[2] animals. The ecological community also includes fungi and cryptogamic plants; however, these are relatively poorly documented. More comprehensive species lists are in Appendix A. However, even these do not mention all the species that make up the ecological community and many sites may have species that are not documented here.

The number and identity of species recorded at a particular site is partly due to natural variation across the range of the ecological community, historical biogeography and other environmental factors, such as disturbance. The species recorded can also be affected by sampling scale, season, effort and expertise. In general, the number of species recorded is likely to increase with the size of the site.

Characteristic species may be abundant, rare, or absent at some sites, and are only a subset of the complete list of species recorded in known examples of the community. Species presence and relative abundance (dominance) depends on many factors, such as soil properties (e.g. moisture, chemical composition, texture, depth and drainage), topography and hydrology. They also change over time, for example, in response to disturbance (by clearing, fire, logging or grazing), or to the climate and weather (e.g. floods, drought and extreme heat or cold).

[1] The EPBC Act defines an 'ecological community' as the “extent in nature in the Australian jurisdiction of an assemblage of native species that inhabits a particular area in nature” (e.g. a group of plants, animals and other organisms interacting in a specific habitat, under relatively similar environmental conditions). The complex range of interactions between the component species provides an important level of biological diversity in addition to genetics and species.

[2] Macroscopic: Large enough to see with the naked eye (i.e. without magnifying optical instruments); not microscopic.

This section also describes the area that the ecological community inhabits, including its location, physical environment, some key ecological processes and other factors that help determine where the ecological community occurs in nature.

## 2.1 Name of the ecological community

This advice follows the assessment of a public nomination to list the '*Poplar/bimble box grassy woodland on alluvial plains'* as a threatened ecological community under the EPBC Act.

It is recommended that the ecological community be named **Poplar Box Grassy Woodland on Alluvial Plains**. The name appropriately describes the dominant canopy species, typical vegetation structure and landscape position that characterises the ecological community. *Eucalyptus populnea* is commonly known as either Poplar Box or bimble box, depending on the region and subspecies that were formerly recognised. As Poplar Box is more widely used and applies to the range of infraspecific taxa, the name of the ecological community is Poplar Box Grassy Woodland on Alluvial Plains (hereafter referred to as Poplar Box Grassy Woodland or the ecological community).

## 2.2 Location and physical environment

The Poplar Box Grassy Woodland is located west of the Great Dividing Range, typically at less than 300 m above sea level (ASL) and between latitudes 20°S to 34°S. The ecological community is scattered across a broad distribution within an area that is roughly:

- south of Charters Towers in Queensland (QLD)
- north of Leeton in New South Wales (NSW)
- west of Ipswich in Queensland and Armidale in NSW
- east of Longreach in Queensland and Hillston in NSW

The ecological community occurs within the Brigalow Belt North, Brigalow Belt South, Southeast Queensland, Cobar Peneplain, Darling Riverine Plains, NSW South Western Slopes and Riverina IBRA bioregions[3].

The ecological community typically occurs on palaeo and recent depositional soils in flat terrain and occasionally along watercourses in undulating country (Webb et al. 1980). The woodland is mainly associated with active and relictual depositional plains and flats including back plains, higher terraces,[4] levees along rivers (particularly in Queensland) and stagnant alluvial plain landscapes (particularly in NSW) (Beeston et al. 1980). The Poplar Box Grassy Woodland is sometimes found in close proximity to ephemeral watercourses and depressions. The soils in these watercourses are considered alluvial and the regularity of flow after heavy rain curtails shrub growth. These areas contain the ecological community where the native vegetation canopy is dominated by Poplar Box and the understorey is not shrubby (see section 3.2). The ecological community commonly occurs on duplex soils in NSW and Queensland, with sodosols being present for much of the extent of the ecological community in Queensland (Fensham et al. 2017; Benson pers comm. 2017). These soils typically occur as clay, clay-loam, loam or sandy-loam. The ecological community is generally absent from sandy soils and siliceous substrates (Benson pers. comm. 2015). The state vegetation mapping units and corresponding soils and landscape positions are given in Table 1. With decreasing soil fertility and increasing topographic relief the Poplar Box Grassy Woodland is replaced by more shrubby types of *Eucalyptus* woodland and Ironbark/cypress pine communities.

[3] IBRA refers to the Interim Biogeographical Regionalisation of Australia. IBRA regions are large geographically distinct areas of similar climate, geology and landform with corresponding similarities in their vegetation and animal communities. The version current at the time of this advice is IBRA v7 (DoE, 2013), which divides Australia into 89 bioregions and 419 subregions, including offshore islands.

[4] River terraces are the remnants of earlier floodplains that existed at a time when a river was flowing at a higher elevation, before its channel down-cut to create a new floodplain at a lower elevation. Terraces can also be left behind when the volume of the river flow declines due to changes in climate or prolonged drought.

**Table 1.** Landscape position of vegetation units that fully or partly correspond with the Poplar Box Grassy Woodland.

| Vegetation unit | Soil | Landscape position |
|---|---|---|
| **New South Wales** | | |
| Poplar Box - Belah woodland on clay-loam soils of the alluvial plains of north-central NSW (PCT56) | Generally occurring on red or red-brown loams or light clay. Can also occur on grey clay, grey earth and solodized solonetz. | In the transition zone between the floodplain and the peneplain in the central and northern plains of the NSW wheatbelt. |
| Poplar Box - Coolabah floodplain woodland on light clay soil mainly in the Darling Riverine Plains Bioregion (PCT87) | Occurs on alluvial yellow earth and grey clay soils, sometimes on gilgai formations (surface mounds and depressions associated with soils containing shrink-swell clays). | On elevated floodplains mainly of the Darling Riverine Plains bioregion. Ecotonal zone between lower floodplains and higher parts of the alluvial plain. |
| Poplar Box grassy woodland on alluvial heavy clay soils in the Brigalow Belt South Bioregion (PCT101) | Occurs on heavy alluvial clay soils derived from volcanic or sedimentary substrates. | On alluvial plains or gently undulating slopes in the Brigalow Belt South Bioregion including in the Liverpool Plains sub-region. |
| Poplar Box grassy/shrubby woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) (PCT244) | Occurs on clay-loam soils. | On flats on alluvial plain and stagnant alluvial plain landscapes. |
| **Queensland** | | |
| *Eucalyptus populnea* woodland on alluvial plains (RE11.3.2) | Variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays. | Occurs on Cainozoic alluvial plains. |
| *Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains (RE11.3.17) | Soils are generally deep texture contrast with thin sandy surfaces. | Occurs on back plains, levees and terraces formed on Quaternary alluvial deposits. |
| *Eucalyptus populnea* with *Acacia harpophyll*a and/or *Casuarina cristata* open forest to woodland on Cainozoic clay plains (RE11.4.7) | Soils are usually texture contrast, but gilgai microrelief with cracking clays and earths may also be present (ancient alluvium). | Usually associated with flat or lower, middle and upper slopes of gently undulating Cainozoic clay plains. |
| *Eucalyptus populnea* woodland on Cainozoic clay plains (RE11.4.12) | Ancient alluvium. | Occurs on eroding edge of Tertiary clay plains. |
| *Eucalyptus populnea* +/- *E. tereticornis* grassy woodland/tall woodland +/- patches of *Acacia harpophylla* and *Melaleuca bracteata* (RE12.3.10) | Cracking clay soils. | Occurs on Quaternary alluvial plains. |

Source: Vegetation units are explained in more detail in section 3.4, where Plant Community Types (PCT), Vegetation Classification and Assessment (VCA) and Regional Ecosystems (RE) are described.

## 2.3 Climate

The Poplar Box Grassy Woodland is distributed over a large geographic area with various environmental conditions. It typically occurs in the D5, E3 and E4 agro-climate classes of Hutchinson et al. 2005 (Table 2). The margins of the ecological community's extent is delineated by the E6 boundary in the west and E7 boundary in the south-east.

As Poplar Box Grassy Woodland has a wide distribution, the mean annual rainfall can range from about 400 mm up to 800 mm per year. The mean minimum daily temperature range in winter is

3.5 to 6.3˚C and the mean maximum daily temperature range in summer is 26.6 to 34.8˚C across the extent of the ecological community.

**Table 2**. Agro-climate classes associated with the Poplar Box Grassy Woodland.

| Agro-climate class | Agro-climate | Location and main land uses |
|---|---|---|
| D5 | Moisture availability high in winter-spring, moderate in summer, most plant growth in spring. | South-east extent of the ecological community in NSW.<br>Forestry, cropping, horticulture, improved and native pastures |
| E3 | Most plant growth in summer, although summers are moisture limiting. Temperature limits growth in winter. | Main extent of the ecological community in NSW. Western slopes of NSW and part of the North Western Plains.<br>Winter cereals and summer crops, grazing. |
| E4 | Growth is limited by moisture rather than temperature and the winters are mild. Growth is relatively even through the year. | Main extent of the ecological community in northern NSW and Queensland. Unique low moisture area for sub-tropical continental eastern Australia and associated with the Brigalow belt of Queensland and NSW.<br>Winter cereals (after summer fallowing), summer crops (including cotton) and sown pastures. |
| E6 | Semi-arid climate. Soil moisture tends to be greatest in winter. | Western edge of the ecological community in NSW and southern Queensland. Southern edge of the arid interior in NSW and Queensland.<br>Primarily grazing. |
| E7 | Moisture is the main limit on growth. Growth index lowest in spring. | Eastern margin of the ecological community in Queensland. Land zone is mostly associated with the coastal areas of south-east Queensland but the ecological community occurs inland and west of the Great Dividing Range where appropriate alluvial flats occur.<br>Sugar, crops and cattle grazing. |

Source: Hutchinson et al. (2005).

## 2.4 Vegetation

The Poplar Box Grassy Woodland occurs in eastern Australia, intergrading with but ranging further west and north than other grassy woodlands that extend through NSW and southern Queensland. The vegetation of the ecological community varies from a grassy woodland to grassy open woodland structure but may occasionally exhibit an open forest structure with an overstorey dominated by *Eucalyptus populnea* (Poplar Box) and an understorey predominantly composed of perennial forbs and $C_4$ grasses[5] (Specht 1970; Beeston et al. 1980; Sivertsen and Clarke 2000; Metcalfe et al. 2003; Benson et al. 2010). The Poplar Box Grassy Woodland may include a low density of shrubs, however patches of the ecological community generally lack a substantial mid

[5] $C_3$ and $C_4$ refer to differing mechanisms plants use to capture carbon dioxide for photosynthesis - $C_4$ plants are better adapted to hotter, drier conditions as they can balance photosynthesis and water loss processes more efficiently. In contrast $C_3$ plants are less efficient at conserving water loss during photosynthesis, so are better adapted to cooler, moister climates.

layer (tall shrub). Shrubby forms of Poplar Box woodland typically occur on lower nutrient sandier soils and are not part of the ecological community.

The structure and composition of vegetation in the ecological community are primarily determined by topography, hydrology, fire regimes, soil fertility, disturbance and management history. The Poplar Box Grassy Woodland is a continuum, comprising different understorey herb and low shrub assemblages at the extremities of the distribution in both an east-west and north-south direction, due to variations in climate and substrate (Metcalfe et al. 2003).

Because the woodland is typically located on active and relictual alluvial plains the ecological community experiences occasional inundation and cyclic changes in the density of the understorey (Tierney and Watson 2009). Vegetative ground cover can be very sparse during dry periods but become mid-dense after rain particularly if fire has been absent for a long time. Where the Poplar Box Grassy Woodland occurs near creek lines and low-lying areas, species adapted to occasional inundation, such as sedges and rushes, may dominate during these wetter periods. The cover of understorey shrubs may increase with distance from watercourses, in lower fire frequencies and lower soil fertility (Clarke and Knox 2002; Graham et al. 2014; Shelly pers comm. 2014). A list of plant species typical of the ecological community is given at Table A1 in Appendix A.

#### *2.4.1 Upper layer (canopy) – trees capable of exceeding 10m*

The canopy of the Poplar Box Grassy Woodland is dominated by *Eucalyptus populnea*[6]. The canopy height of the Poplar Box Grassy Woodland typically ranges up to 20 metres. Poplar Box tends to have a monopodial[7] form in the north to hemi-sympodial form in the south (Groves 1994; Boland et al. 1984; Anderson 2003). Depending on the characteristics of the site, other tree species of a similar height may occasionally occur in the tree canopy, but do not dominate a patch, including *Callitris glaucophylla* (White Cypress Pine), *Casuarina cristata* (Belah), *Eucalyptus Coolibah* (Coolibah), *E. largiflorens* (Black Box) and *E. melanophloia* (Silver-leaved Ironbark). Emergent taller trees may occasionally include *E. microcarpa* (Inland Grey Box) and *E. woollsiana* (Narrow-leaved Grey Box).

An upper layer crown cover of up to 50% is possible during regrowth of *Eucalyptus populnea* but the species will thin out to 10–30% over 100 years (Fensham pers comm. 2015). Beeston et al. (1980) noted that canopy density can average about 100 trees/ha in the north (QLD) and 50 trees/ha in the south (NSW). In the western distribution of the Poplar Box Grassy Woodland, *E. populnea* may also occur as dense copses in moist depressions. Hybrids of *E. populnea* with other eucalypt species may also be present in the canopy layer and are considered to be part of the ecological community (where they contribute to the dominant presence of *E. populnea*).

Poplar Box goes through regular cycles of senescence (aging and death) and regeneration. Poplar Box trees are also susceptible to defoliation by insects, such as psyllids (lerp), and are occasionally lopped for domestic stock fodder. Therefore, the ecological community can include Poplar Box trees that are in a regrowth or defoliated state.

#### *2.4.2 Understorey - Mid layer (small trees and medium shrubs) 1–10m*

Tall shrubs and small trees may occur in the mid layer although they are mostly absent to sparse. They may include *Acacia aneura* (Mulga), *Alectryon oleifolius* subsp. *canescens* (Western Rosewood), *Apophyllum anomalum* (Warrior Bush), *Atalaya hemiglauca* (Whitewood), *Capparis mitchellii* (Native Orange), *Eremophila mitchellii* (Budda) and *Geijera parviflora* (Wilga) (Beeston et al. 1980). These are typically scattered or patchy and variable in composition although dense copses of one or more tall shrubs may occur as localised variation within a patch of Poplar Box Grassy Woodland. The density of the mid layer can influence the ground layer (for example, an absent to open mid layer leads to a more developed ground layer). Where the crown cover of

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[6] The Australian Plant Census database does not currently recognise subspecies of *Eucalyptus populnea*. However, subspecies may be recognised by some authorities within NSW.

[7] Monopodial growth forms have a single main trunk, sometimes with secondary lower branches. This is different to hemi-sympodial tree forms that have a branching lower trunk.

mid layer species rises to 30% or more across a patch, it is indicative that the ecological community may no longer be considered a grassy woodland but approaching a shrubby woodland.

The mid layer may also include juvenile trees of canopy species. In some circumstances, juvenile canopy tree species may occur as thickets in the mid layer. Where this comprises juvenile or resprouting Poplar Box trees, it is accepted as part of the natural regeneration phase for the ecological community that is expected to thin out over time. However, certain other canopy species, notably *Callitris glaucophylla* or *Casuarina cristata*, may form regrowth thickets, often on the fringes of the ecological community's range and in response to disturbance that approach or exceed the 30% crown cover minimum for the mid layer. Such occurrences are excluded from the ecological community as they indicate a transition to a different type of ecological community.

### *2.4.3 Understorey - Ground layer (low shrubs, groundcover, graminoids) < 1m*

The ground layer of the Poplar Box Grassy Woodland can vary in composition depending on local hydrological conditions, rainfall, landscape position, soil type and season. It will also vary depending on fire, grazing and other disturbance regimes. However, many species are common across northern and southern woodlands. The occurrence of grasses varies considerably with the tree and shrub density (Beeston et al. 1980). The ground layer is typically open, low and dominated by a variety of summer-growing or $C_4$ grasses such as *Aristida* spp. (Wiregrass), *Bothriochloa* spp. (Red Grass), *Dichanthium* spp. (Bluegrass), *Heteropogon* sp. and *Themeda* sp. (Kangaroo Grass).

The lighter-textured gradational soils in the western part of the ecological community are dominated by the $C_4$ grasses *Aristida* spp., *Eragrostis* spp. (Lovegrass), *Thyridolepis mitchelliana* (Mulga Mitchell grass) and *Monachather paradoxus* (Bandicoot Grass). To the north-east, heavier-textured soils (duplex or uniform clays) are more common and support the $C_4$ grasses *Bothriochloa* spp., *Dichanthium* spp. and *Heteropogon* sp.. The $C_4$ grasses *Enteropogon acicularis* (Curly Windmill Grass), *Paspalidium* spp. (Box Grass) and *Sporobolus* spp. occur in both northern and southern locations.

In southern winter rainfall areas with heavy-texture soils, the cooler season or $C_3$ grass species *Austrostipa* spp. (Speargrasses) and *Rytidosperma* (formerly *Austrodanthonia*) spp. (Wallaby grasses) may enter the ecological community. Although the $C_3$ grass species *Austrostipa aristiglumis* (Plains Grass) occurs on the richer soils of the ecological community, such as the Liverpool Plains, $C_3$ species are generally absent in northern summer rainfall areas.

Where the ecological community is occasionally prone to inundation in low lying areas, several species characteristic of moist sites, such as the sedges *Carex inversa* (Knob Grass) and *Eleocharis plana* (Flat Spike-sedge), rushes such as *Juncus* spp. and ferns, such as *Marsilea drummondii* (Nardoo) may occur.

In the understorey, seasonal herbs are diverse and include *Bulbine alata* (Bulbine Lily), *Brachyscome dentata* (Lobed-seed Daisy), *Einadia nutans* (Climbing Saltbush), *Erodium crinitum* (Blue Crowfoot), *Oxalis chnoodes* (Wood-sorrell) and *Wahlenbergia* spp. (Bluebells). Low shrubs (<1 m) may also occur in the understorey and can be locally patchy. During drought grass species may decline leaving low shrubs as the most conspicuous ground layer plants. They mostly comprise semi-succulent subshrubs such as the chenopods *Enchylaena tomentosa* (ruby saltbush), *Maireana* spp. (Fissure weeds), *Rhagodia spinescens* (Thorny Saltbush), *Sclerolaena birchii* (Galvanized Burr) and *Sclerolaena muricata* (Black Roly poly).

Plants with a climbing habit may occasionally be present, for example: *Capparis lasiantha* (Bush Caper), *Glycine canescens* (Silky Glycine), *Glycine tabacina* (Glycine Pea) and *Pandorea pandorana* (Inland Wonga Vine).

A list of characteristic plants of the ecological community is at Appendix A.

### *2.4.4 Derived Native Grasslands*

*Eucalyptus populnea* regrows readily from a basal coppice after short-term disturbance and will often persist in the landscape unless regrowth is cleared. Consequently Poplar Box Grassy

Woodland does not commonly occur as a derived natural grassland. Patches lacking the canopy cover and tree regrowth are not considered part of this ecological community, except where these represent a gap in, or on the edge of a larger patch, or where the tree layer is sparse between two patches across a short distance[8] (See section 2.2.3 *Further information to assist in determining the presence of the ecological community and significant impacts*).

## 2.5 Faunal components

The Poplar Box Grassy Woodland exists largely as scattered remnants in a mosaic of various dry temperate woodlands and forests within modified agricultural landscape in many parts of its range. Therefore many fauna species are not restricted to the ecological community. Fauna likely to be part of the ecological community include larger mammalian herbivores (e.g. kangaroos), smaller ground-dwelling mammals (e.g. Short-beaked Echidna, bandicoots), arboreal mammals (e.g. possums, Koalas), bats, woodland birds, reptiles as well as many invertebrates. Given the intensive clearing and fragmentation of grassy woodland remnants across the intensive land use zone of south-eastern Australia, mainly the more common and resilient of vertebrate species remain.

Poplar Box trees are a significant hollow-forming tree, and provide important habitat for a diverse range of native fauna. The Poplar Box Grassy Woodland provides essential resources such as nesting/breeding sites, protection from predators (for example logs and old growth tree hollows) and sources of food (nuts, seeds, nectar from flowers and invertebrate prey). Many animals are only likely to be part of the Poplar Box Grassy Woodland at certain times, for example as a dry season refuge given the ecological community's proximity to riparian vegetation. In addition, seasonal transients through the community, such as honeyeaters, are most likely to visit during the local flowering season. Some bird species, such as *Accipiter fasciatus* (Brown Goshawk) and the nationally vulnerable *Grantiella picta* (Painted Honeyeater) travel widely so use remnants of the ecological community as stepping stones to other woodland patches in an otherwise modified agricultural landscape. The association of the woodland ecological community with floodplains and ephemeral watercourses indicates its importance for birds both as woodland habitat and as nesting sites for colonial breeding waterbirds that rely on occasional wetlands and woodland habitats.

The grassy layers and occasional cracking clays of the Poplar Box Grassy Woodland provide protection for fauna such as *Planigale tenuirostris* (Narrow-nosed Planigale) and *Sminthopsis crassicaudata* (Fat-tailed Dunnart). The ecological community was also likely to have been home to the extinct *Notomys mordax* (Darling Downs Hopping Mouse). Other terrestrial species within the ecological community include the soil engineers *Vombatus ursinus* (Bare-nosed Wombat) and the monotreme *Tachyglossus aculeatus* (Short-beaked Echidna).

Many bat species (insectivores, frugivores and nectivores) commonly use grassy woodlands such as the Poplar Box Grassy Woodland, for example, *Chalinolobus gouldii* (Gould's Wattled Bat), *Mormopterus planiceps* (Inland Freetail Bat), *Nyctophilus geoffroyi* (Lesser Long-eared Bat), *Pteropus poliocephalus* (Grey-headed Flying-fox) and *Vespadelus baverstocki* (Inland Forest Bat). *Chalinolobus picatus* (Little Pied Bat) has been observed to roost in tree hollows of dead and living Poplar Box trees (Pennay and Freeman 2005).

The open structure and grassy understorey of the Poplar Box Grassy Woodland provide various habitats for several functional guilds of bird species notably:

- ground-dwelling species that forage and/or nest on the ground and rely on native grasses, herbs and woody debris;

[8] Where native grassland connects discrete patches of the ecological community in close proximity (up to 30 m apart) then it should be treated as part of a single patch. Also where native grassland is within a gap in, or at the edge of a patch, (up to 30 m from the edge of the tree canopy/saplings) it should be considered to be part of the patch of the ecological community. See also Section 2.6.3.1 (Defining a patch). Native means vegetation dominated by native species; i.e. where 50% or more of the perennial vegetation cover is native.

- species dependent on tree-hollows for shelter or breeding;
- insectivores that forage in the tree foliage and bark;
- birds of prey; and
- mobile and migratory species that track and follow available resources, such as flowers fruits and seeds, across different landscapes and seasons.

Canopy foraging species are typically small arboreal insectivores such as *Pardalotus striatus* (Striated Pardalote), *Smicrornis brevirostris* (Weebill) and *Gavicalis virescens* (Singing Honeyeater) (Hannah et al. 2007). Bark foraging species include *Daphoenositta chrysoptera* (Varied Sitella), *Cormobates leucophaea* (White-throated Treecreeper) and *Climacteris picumnus* (Brown Tree-creeper).

Reptiles that are likely to commonly occur in the Poplar Box Grassy Woodland include: *Ctenotus ingrami* (Unspotted Yellow-sided Ctenotus), *Pogona barbata* (Eastern Bearded Dragon), *Pseudonaja textilis* (Eastern Brown Snake), *Tiliqua rugosa* (Shingleback Lizard) and *Varanus varius* (Lace Monitor).

The ecological community also provides habitat for a range of amphibian species where there are appropriate substrates and microclimates. They include burrowing species such as *Cyclorana novaehollandiae* (New Holland Frog), *Cyclorana verrucosa* (rough Frog) and *Neobatrachus sudellae* (Sudell’s Burrowing Frog), arborial species such as *Litoria peronii* (Peron's Tree Frog) and *Litoria rubella* (Desert Tree Frog) and species breeding in seasonally damp sites for breeding, such as for *Limnodynastes tasmaniensis* (Spotted Grass Frog) and *Crinia sloanei* (Sloane's Froglet).

The ecological community is essential habitat for several fauna species listed as threatened at national and/or state level, including *Lophoictinia isura* (Square-tailed Kite) (NSW), *Nyctophilus corbeni* (South-eastern Long-eared Bat), *Onychogalea fraenata* (Bridled Nailtail Wallaby) (EPBC Act; QLD NC Act[9]) and *Phascolarctos cinereus* (Koala) (EPBC Act). The Poplar Box Grassy Woodland also provides habitat for several fauna species which are declining or locally extinct in the region. For instance, bird species such as *Anthochaera phrygia* (Regent Honeyeater) (EPBC Act), *Geophaps scripta* (Squatter Pigeon) (EPBC Act), *Polytelis swainsonii* (Superb Parrot) (EPBC Act), *Pomatostomus temporalis temporalis* (Grey-crowned Babbler (eastern subspecies) (NSW) and *Stagonopleura guttata* (Diamond Firetail) (NSW). Other locally rare species include *Ardeotis australis* (Australian Bustard) (NSW) and *Dromaius novaehollandiae* (Emu).

Table A3 in Appendix A lists the various fauna species known to be part of the Poplar Box Grassy Woodland and that use it as habitat, including threatened species.

[9] *Queensland Nature Conservation Act 1992*

# 3. GUIDANCE FOR DETERMINING WHETHER THE POPLAR BOX GRASSY WOODLAND ON ALLUVIAL PLAINS ECOLOGICAL COMMUNITY PROTECTED UNDER THE EPBC ACT IS PRESENT

## 3.1 Introduction

The key diagnostic characteristics, condition thresholds and other information in this section are used to:

- identify patches of the threatened ecological community that are protected under national environment law (for example, to determine whether the referral, impact assessment, approval and/or compliance provisions of national environmental law are likely to apply to the patch); and
- distinguish between patches of different quality (to aid environmental protection and management decisions).

National listing focuses legal protection on areas or patches of the ecological community that are the most functional, in a relatively natural state and in comparatively good condition. Because the ecological community exhibits various degrees of disturbance and degradation, condition thresholds, classes and categories have been developed.

This section also includes guidance on defining a 'patch' and on sampling protocols; along with further information to have regard to when considering actions that may have a significant impact on the ecological community.

Protection as a matter of national environmental significance under national environment law is limited to areas of the ecological community that meet the key diagnostic characteristics and the minimum condition thresholds for this ecological community. If a proposed action will, or may have, a significant impact on the threatened ecological community, it must be referred to the Australian Government for approval prior to undertaking that action.

Although very degraded or modified patches are not protected under national environment law, some patches of the ecological community that do not meet the condition thresholds still have important natural values; and they may meet definitions for protection under state and local laws or schemes. These lower quality patches should not necessarily be excluded from recovery and other management actions, because these actions could improve the condition of a patch to the point where it is protected under national environment law. Recovery and management actions should also be designed to restore patches to good or high condition.

In some cases, however, the loss and degradation are irreversible given changes in land use; or rehabilitation is impractical because too many natural characteristics have been lost. For example, most areas that have been converted to crops, exotic pasture or urban development are unlikely to be restored.

The Poplar Box Grassy Woodland exhibits a degree of variation in its natural structure and composition, as well as varying degrees of disturbance and degradation that have influenced the quality of a patch. Notably, much of the ecological community occurs in the more heavily cleared and modified parts of NSW and Queensland. Both the natural variation and influence of degradation have been taken into account in developing the key diagnostic characteristics and condition thresholds for the Poplar Box Grassy Woodland.

## 3.2 Key diagnostic characteristics and condition thresholds

National listing focuses legal protection on patches of the ecological community that are in comparatively good condition i.e. relatively natural (as outlined in the '*Description*') and functional.

*Key diagnostic characteristics* (Section 3.2.1) summarise the main features of the ecological community. They are intended to help identify it, noting that more details are provided in the other sections of this document (for instance, where the ecological community occurs in nature and lists of species that characterise the ecological community). Species composition is influenced by, amongst other things: geographic location, the size of the patch, recent rainfall and disturbance history, including fire and grazing.

*Condition classes, categories and thresholds* (Section 3.2.2) are designed to help identify the relatively good quality patches for protection under national environment law. Because the ecological community has been heavily cleared and fragmented, many remnants are small, isolated and in a modified condition. Any remnants that remain largely intact (in terms of structure and/or diversity of characteristic species), or are connected to other native vegetation and form a large patch, are a high priority for protection and management.

In some cases, the loss and degradation is irreversible; or rehabilitation is impractical because many natural characteristics have been removed. For instance, most areas permanently converted to improved pastures are unlikely to be effectively restored.

The following steps outline how to identify patches of the ecological community that are protected under national environment law (e.g. for EPBC Act referral, assessments and compliance purposes). They are also useful to inform related activities, such as carrying out environmental impact assessments and projects to manage threats or restore the ecological community.

**Step 1**: Use the Key diagnostic characteristics to determine if the ecological community is present – Section 3.2.1.

**Step 2**: Determine the condition and size of the patch, to determine whether it meets at least the minimum Condition thresholds for Moderate quality (i.e. for class C, in Section 3.2.2).

**Note:** Section 3.2.3 (Further information to assist in determining importance and avoiding significant impacts) must also be taken into account when considering the importance of a patch of the ecological community and how to protect it under national environment law.

***For EPBC Act referral, assessment and compliance purposes, the nominated ecological community is limited to patches that meet the following diagnostic characteristics and condition thresholds. The additional factors noted in section 3.2.3 and critical areas noted in section 3.3 also should be taken into consideration.***

### *3.2.1* Step 1 – Key diagnostic characteristics

Ecological classification is a useful, but artificial representation of continuous variation in nature, and is therefore open to subjective interpretation. All units of ecological classification (e.g. ecological communities) exhibit variation within their perceived boundaries and in transition to other units, and are therefore open to subjective interpretation. The ecological community persists in a number of natural, modified and disturbed states. Also, environmental variables, such as climate (and the ecological community's response to them), fluctuate or change over time. For these and other reasons there will be 'atypical' occurrences of the ecological community; and so qualifiers such as "may" and "mostly" are used in the Key diagnostic characteristics. A judgement should therefore be made as to whether the ecological community is present or not, based on: the Key diagnostic characteristics; along with the description of the ecological community and the area it inhabits in Sections 2 and 3.4 of this advice.

The ecological community[10] that is protected under national environment law consists of areas of vegetation (and associated biota) that meet the following key diagnostic characteristics:

Location and physical environment:

- Occurs in the Brigalow Belt North, Brigalow Belt South, Southeast Queensland, Cobar Peneplains, Darling Riverine Plains, NSW South Western Slopes, Riverina and Murray Darling Depression IBRA bioregions.
- Associated with ancient and recent depositional alluvial plains with clay, clay-loam, loam and sandy loam, typically duplex soils or sodosols. This includes areas that may not be part of currently defined floodplains.

Structure:

- A grassy woodland to grassy open woodland with a tree crown cover[11] of 10% or more at patch scale.
- A tree canopy must be present that shows these features:
    - o Canopy tree species are capable of reaching 10 m or more in height;
    - o *Eucalyptus populnea* (Poplar Box) must be present in the canopy and is the dominant[12] tree species;
    - o Where hybrids of Poplar Box with other Eucalyptus spp are present, they should be counted as part of the *Eucalyptus populnea* component of the tree canopy when assessing the previous criterion.
- Mid layer (1-10 m) crown cover of shrubs to small trees[13] is low, about 30% or less.

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[10] The EPBC Act defines an 'ecological community' as the "extent in nature in the Australian jurisdiction of an assemblage of native species that inhabits a particular area in nature" (e.g. a group of plants, animals and other organisms interacting in a specific habitat, under relatively similar environmental conditions).

[11] Crown cover is the percentage of the sample site within the vertical projection of the periphery of the tree crowns with the crowns considered to be opaque (Walker and Hopkins, 1990).

[12] Dominant generally means a species that is most prevalent within an ecological community and influences the biotic conditions of the community. In this document, it refers to a species that accounts for at least 50% of the total crown cover across the patch. Crown cover is the preferred benchmark for dominance; except in regenerating areas with few mature canopy trees. Where this is the case, tree basal area is the next best measure of dominance, since it reflects biomass to some degree. Tree basal area: the cross-sectional area of a tree trunk measured at breast height (1.3 m) over bark. Co-dominant generally refers to a situation where more than one species are of equivalent prevalence and influence in a community; it is regarded here as species that have about equal crown cover in the community. In other cases e.g. where crown cover is less apparent due to dieback, then tree abundance may be an alternative method of determining dominance i.e. number of trees per ha / per species.

[13] Small trees are those typically less than 10m in height at maturity. The 30% or less calculation does not include seedlings and juvenile (or non-mature) trees of poplar box as this represents natural regeneration of the ecological

- A ground layer (<1 m) mostly dominated across a patch by native grasses, other herbs and occasionally chenopods (during extended dry periods), ranging from sparse to thick (in response to canopy development, soil moisture, disturbance and/or management history).
- A list of diagnostic native plant species and some of the key native fauna that make up the ecological community is given at Appendix A; although particular species may be abundant or rare, or not necessarily present, at every location.

#### *3.2.2* **Step 2 – Condition thresholds for national legal protection**

The Condition thresholds for this ecological community are designed to identify the relatively good quality patches for protection under national environment law (i.e. moderate to high value). Table 3 shows the Condition classes, categories and thresholds.

Because the ecological community has been heavily cleared and fragmented, many remnants are small, isolated, and in a modified condition. Any remnants that remain largely intact (in terms of structure and/or diversity of characteristic species), or are connected to other native vegetation and form a large patch, are a high priority for protection and management. Very small (< 1 ha), isolated patches and/or those subject to high disturbance are unlikely to have the structure, composition and function of the ecological community and will not meet the minimum condition thresholds for protection under national environment law (for example, a few Eucalypt trees on a farm or roadside, with limited diversity/structural elements).

The ecological community that is protected under national environment law comprises patches that meet the Key diagnostic characteristics (above) and at least the **minimum condition thresholds** (Moderate and High condition categories A, B, or C) set out in Table 3.

- **Category A1 and A2 describe patches of the ecological community in the best condition, in terms of native understorey vegetation cover and crown cover. These are the highest priorities for protection and provide examples to guide restoration of lower condition patches.**
- **Category C represents the minimum for a patch of the ecological community to be subject to the referral, environment assessment and compliance provisions of the EPBC Act. They retain important conservation values and are a priority for rehabilitation.**

As the ecological community has been heavily cleared and degraded, many of the remnants are fragmented, isolated and modified. Any remnants that remain largely intact, include mature trees, or are connected to other native vegetation and form a large patch are a high priority for protection and management. Small, isolated patches subject to high disturbance, for example, narrow stands of trees without native understorey, either on farms or roadsides do not contribute so greatly to the conservation of the ecological community so may not meet the condition thresholds for national protection.

Table 3 shows Class C is the minimum threshold for remnant native patches to be considered moderate quality and part of the ecological community subject to the referral assessment and compliance provisions of the EPBC Act.

community. However, as noted in section 2.4.2, regrowth thickets of other canopy species (e.g. *Callitris* or *Casuarina*) are included in the 30% crown cover for the mid layer.

**Table 3.** Condition categories and thresholds for the Poplar Box Grassy Woodland on Alluvial Plains ecological community. Note the key diagnostic features also apply. Condition Classes A, B and C are the defined ecological community.

| Category and rationale | Native cover and diversity thresholds | Minimum patch size thresholds* |
|---|---|---|
| **CLASS A HIGHEST QUALITY** | | |
| **Category A1.**<br>Little to no perennial weeds and diverse native understorey | The crown cover of canopy trees in the patch is ≥10%<br>**AND**<br>≥ 90% of perennial vegetation cover in the ground layer** is native<br>**AND**<br>≥ 30 native plant species per patch in the ground layer | ≥ 1 ha |
| **Category A2.**<br>A large patch with low perennial weeds and diverse native understorey | The crown cover of canopy trees in the patch is ≥10%<br>**AND**<br>≥70% of perennial vegetation cover in the ground layer** is native<br>**AND**<br>≥ 30 native plant spp. per patch in the ground layer | ≥ 5 ha |
| **CLASS B GOOD QUALITY** | | |
| **Category B.**<br>A large patch with good quality native understorey or with mature trees | The crown cover of canopy trees in the patch is ≥10%<br>**AND**<br>≥ 50% of perennial vegetation cover in ground layer** is native<br>**AND EITHER**<br>≥ 20 perennial native plant species per patch in the ground layer<br>**OR**<br>≥ 10 mature trees+ per ha with ≥ 30cm dbh*** (and/or hollows) | ≥ 5 ha |
| **CLASS C MODERATE QUALITY** | | |
| **Category C**<br>A large patch with low native cover but retains good native understorey diversity and habitat features of mature trees | The crown cover of canopy trees in the patch is ≥10%<br>**AND**<br>**If** < 50% of perennial vegetation cover in ground layer** is native, then the patch **must** have:<br>≥ 20 native plant spp. per patch in the ground layer<br>**AND**<br>≥ 10 mature trees+ per ha with ≥ 30cm dbh*** (and/or hollows)<br>**AND**<br>smaller trees+, saplings or seedlings suggestive of periodic recruitment | ≥ 5 ha |

* **Minimum patch size thresholds** apply to patches of various shapes but, a minimum patch width threshold applies to linear remnants, such as along roadsides or former travelling stock routes. These are explained in the next section on 'Defining a patch'.

** **Perennial native vegetation cover in the ground layer (**i.e. below the tree canopy) includes vascular plant species of the ground layer with a life-cycle of more than two growing seasons. The ground layer includes grasses and herbs (i.e. forbs) and some low shrubs (woody plants ≤ 1 m high). Measurement of perennial ground layer vegetation cover excludes annuals, cryptogams (i.e. mosses, lichens and related flora), leaf litter or exposed soil.

*** **dbh** (diameter at breast height) refers to the tree diameter measured at 1.3 m above the ground.

**+ Trees** – Refers to *Eucalyptus populnea* (Poplar Box) and/or hybrids of Poplar Box with other Eucalyptus species (for instance Coolibah).

**Note in addition:**

Defining a patch; Revegetated areas and areas of regeneration; and Sampling protocols:

- Assessments of a patch should initially be centred on the area of highest native floristic diversity and/or cover, i.e. the best condition area of the patch;
- Consideration must be given to the timing of surveys and recent disturbance (see Timing of Surveys and seasonal variation in section 3.2.3 for more detail);
- The surrounding context of a patch must be taken into account when considering factors that add to the importance of a patch that meets the minimum condition thresholds;
- A relevant expert (e.g. an ecological consultant, or local, state or regional NRM/Land services officer) may be useful to help identify the ecological community and its condition;
- Boundaries for a patch may extend beyond the site boundary, or beyond the potential area of impact for a proposed action. The entire patch as a whole should be considered.

**Defining a patch**

A patch is a discrete and mostly continuous area of the Poplar Box Grassy Woodland on Alluvial Plains ecological community, which meets the Key diagnostic characteristics and minimum condition thresholds. A patch may include small-scale (<30 m) variations, gaps and disturbances, such as tracks, paths or breaks (including exposed soil, leaf litter, cryptogams and watercourses/drainage lines), or localised variations in vegetation that do not significantly alter the overall functionality[14] of the ecological community. This functionality includes processes such as the movement of wildlife and other pollinators, the dispersal of plant propagules, activities of seed and plant predators, biological water retention, and cycling and many other interactions.

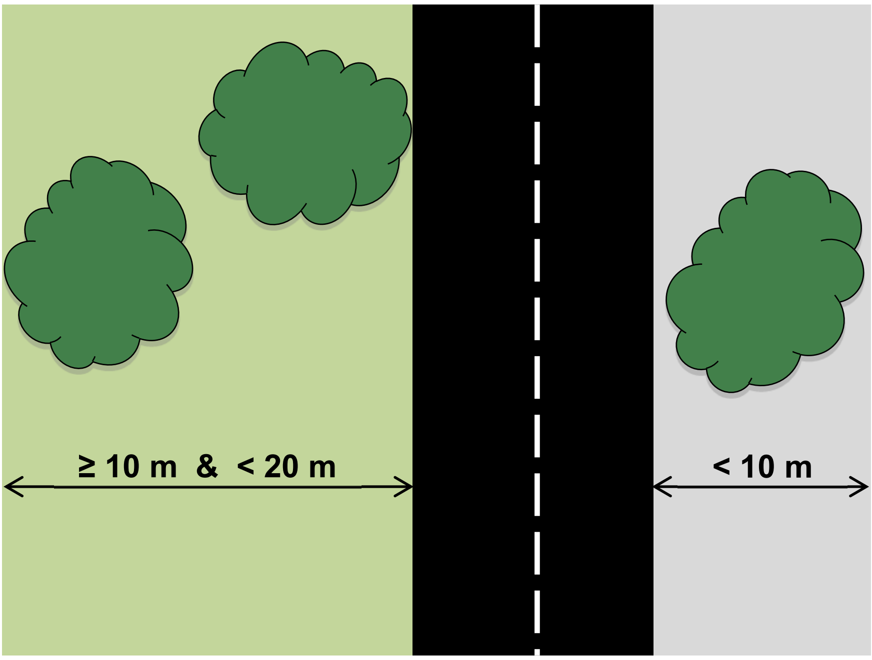
Gaps in the canopy, degraded and regenerating areas of lower quality are still part of the patch, until a decision is made to the contrary. Initially, all areas should be considered together, in terms of identifying the entire patch of the ecological community and considering its protection, under national environment law. Small breaks or gaps are generally included in a patch. However, where there is a break in native vegetation cover, from the edge of the tree canopy of 30 m or more (e.g. due to permanent artificial structures, wide roads or other barriers; or due to water bodies typically more than 30 m wide) then the gap typically shows that separate patches are present. Two patches of the ecological community can also be separated by a different type of native vegetation (e.g. a eucalypt forest dominated by a different tree species, or non-eucalypt forest).

When interpreting linear patches, such as a roadside verges and travelling stock routes, the following should be considered:

- Remnants must be at least 10 m or more wide on either side to be included if they meet the description, key diagnostic characteristics and condition threshold criteria (Diagram 1)
- Where one side is more than 20 m wide and the other 10 m or more, then they are considered as one patch despite any intervening road or other linear break (Diagram 2).

[14] Functionality refers to processes such as the movement of wildlife and pollinators, the dispersal of plant propagules, activities of seed and plant predators and many others.

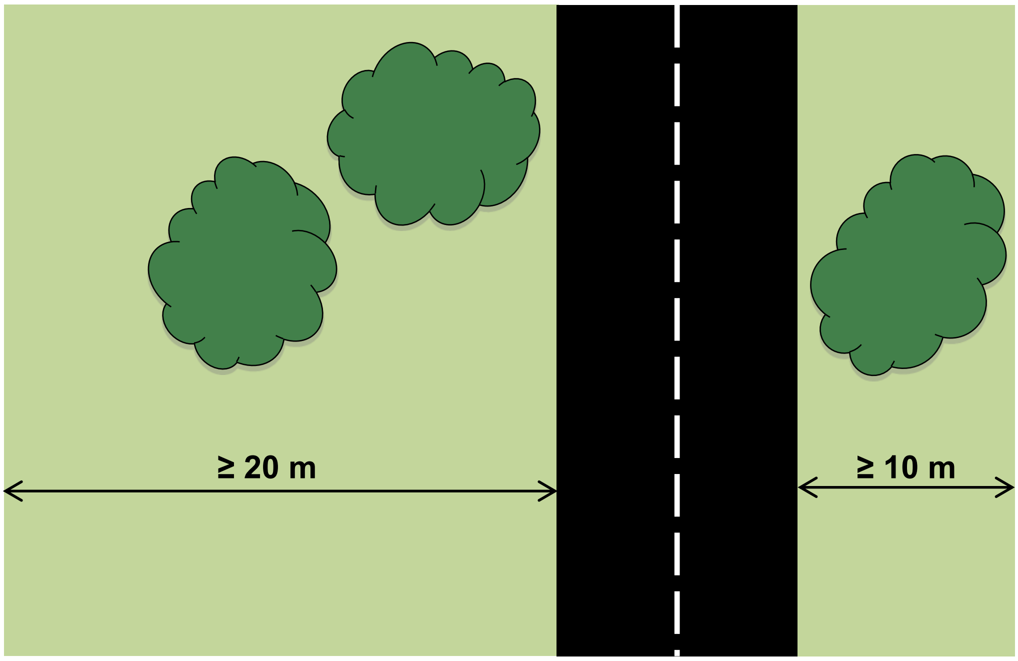
**Diagram 1.** Patch width thresholds for linear remnant roadside vegetation containing Poplar Box Grassy Woodland. Linear patches must be ≥ 10 m in width.




The ecological community if key diagnostics and condition thresholds are met

Not the ecological community

**Diagram 2.** Patch width thresholds for linear remnant roadside vegetation containing Poplar Box Grassy Woodland. Linear patches ≥ 20 m in width.




The ecological community if key diagnostics and condition thresholds are met

Differences in cover, quality or condition of vegetation across a patch should not initially be considered to be evidence of multiple patches. Patches can be spatially variable and are often characterised by one or more areas within a patch that meet the key diagnostic characteristics and condition threshold criteria amongst areas of lower condition. Average cover and quality across the broadest area that meets the general description of the ecological community should be used initially in determining overall canopy cover, shrub cover and ground layer vegetation condition. Also note any areas that are either significantly higher or lower in quality, gaps in canopy cover and the condition categories that would apply across different parts of the site respectively. Where the average vegetation cover or quality falls below the minimum thresholds or the shrub cover is above 30%, the next largest area or areas that meet key diagnostics and minimum condition thresholds should be specified and protected. This may result in more than one patch of the ecological community being identified within the larger area first considered. The patch may then be further divided into areas of high, good and moderate quality if that is useful to further conservation decision making.

Where native understorey (whether derived from the ecological community or not) connects discrete patches of the ecological community in close proximity (up to 30 m apart) then it should be treated as a single patch. Also, where native understorey is within a gap in or at the edge of a patch (up to 15 m from the edge of the tree canopy or saplings) it should be considered to be part of the ecological community. Native in this context means that 50% or more of the perennial vegetation cover comprises native species.

#### *3.2.3 Further information to assist in determining the presence of the ecological community and significant impacts on the ecological community*

Land use history influences the current condition state of a patch of the Poplar Box Grassy Woodland. The structural form of the ecological community will also influence its species richness and diversity. The position of a patch relative to surrounding vegetation also influences how important a patch of the ecological community is in the broader landscape. For example, if it enables movement of native fauna or plant material or supports other ecological processes.

#### Buffer zone

A buffer zone is a contiguous area immediately adjacent to a patch of the Poplar Box Grassy Woodland that is important for protecting its integrity. The purpose of the buffer zone is to minimise any risk of damage from actions close to the patch by guiding land managers to be aware when the ecological community is nearby and take extra care around the edge of patches. The buffer zone will help protect the root zone of trees and other components at the edge of the ecological community at most risk from spray drift (fertiliser, pesticide or herbicide sprayed in adjacent land) and other threats, such as weed invasion, and most other impacts. Its purpose is not specifically to extend the patch through regeneration, although this would be beneficial.

The buffer zone is not part of the ecological community so it is not formally protected as a matter of national environmental significance. For EPBC Act approval, changes in use of the land that falls within the buffer zone must not have a significant impact on the ecological community, but there are exemptions for continuing use (e.g. cropping, grazing or maintaining existing fire breaks). If the use of an area that directly adjoins a patch of the ecological community will be intensified, approval under the EPBC Act may also be needed to avoid adverse impacts. The buffer zone may also be a suitable focus for revegetation or other restoration initiatives.

Judgement should be exercised to determine an appropriate buffer distance depending on circumstances of how a patch may be impacted. The recommended minimum buffer zone is 30 m from the outer edge of the patch (as defined as 15 m from the edge of the tree canopy) as this distance accounts for likely influences upon the root zone. A larger buffer zone should be applied, where practical, to protect patches that are of particularly high conservation value, or if patches are down slope of drainage lines, a source of nutrient enrichment or groundwater drawdown.

An ideal buffer zone is native vegetation so such areas should be maintained. Patches of native grasslands associated with other intergrading woodlands (e.g. Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia ecological community) are an important part of the broader ecosystem and may have potential for future restoration. They contain much of the native plant biodiversity present in the understorey of grassy woodlands and act as a seed bank and source of genetic material. Native grasslands also act as buffer zones which protect woodland remnants from adjacent activities, and support the movement of some fauna between remnant woodlands. For this reason they should also be considered as part of the surrounding environment and landscape context for patches of Poplar Box Grassy Woodland when considering a buffer zone.

**Revegetated areas and areas of regrowth**

Revegetated or replanted sites, or areas of vegetation regeneration, can be included as part of the protected ecological community, provided that the revegetated area meets the Key diagnostic characteristics and at least the minimum condition thresholds. The inclusion of patches of natural and managed regeneration reflects the ecological community's ability to regenerate. Degraded patches that are actively managed (i.e. with weeds removed and/or with supplementary planting) may be capable of re-establishing themselves and supporting a good ecologically functional state (as can be indicated by meeting minimum condition thresholds). However, it is recognised that reconstruction/revegetation often requires long term effort and commitment and results are uncertain. Reconstructing an ecological community to a state that resembles appropriate reference sites can, at best, be extremely slow and may ultimately prove unsuccessful (Wilkins et al. 2003).

**Sampling protocols**

Evaluating/sampling a patch can involve developing a quick/simple map of the vegetation condition, diversity, landscape qualities and management history (where possible) of the site. An appropriate sampling strategy should be used that captures the diversity of the site and recognises any variation e.g. due to topography.

Thorough and representative on-ground surveys are essential to accurately assess the extent and condition of the ecological community. NSW Native Vegetation Type Standard (Sivertsen 2009) and the Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain 2009) provides relevant guidance for vegetation.

Patches can vary markedly in their shape, size, condition and features. As a general principle, sampling protocols and the number of sample plots/transects should include, or allow for:

- area(s) with the highest apparent number of different native plant species to determine estimates of native species richness in each patch;
- significant variation in the vegetation, landscape qualities and management history (where known) across the patch; for instance localised weed cover, drainage lines, grazed areas, saline zones; and
- an appropriate size and number of plots or transects to provide a representative sample across the full extent of the patch (taking into consideration the shape and condition across the site, as well as providing a good representation of the species present).

The application of plots/transects per patch must take into consideration the size, shape and condition across the site. Recording the search effort (identifying the number of person hours spent per plot/transect and across the entire patch; along with the surveyor's level of expertise and limitations at the time of survey) is useful for future reference.

**Timing of surveys and seasonal variation**

The timing of surveys is an important consideration because the Poplar Box Grassy Woodland can be variable in its appearance throughout the year and between years depending on drought-rain cycles. Seasonal factors also determine the visual dominance of taxa. For example, native grasses such as *Bothriochloa* spp. are easily recognised when flowering in summer and early autumn; however, the same sites when surveyed in June or July may be dominated by exotic annuals. There may also be a flush of non-native species in early spring.

Ideally, surveys should be held in more than one season to maximise the chance of detecting all species present. In years of low rainfall, assessment should recognise that many species may not be detectable. In these situations it is preferable that surveys are carried out over more than one year. For example, during prolonged dry periods, many grass species may not be apparent with drought tolerant forbs and low species e.g. chenopods, dominating the understorey for a time. Where possible, pool results of all surveys across years. However, where multiple surveys are not achievable an assessment should occur in spring to early summer, when the greatest number of species is likely to be detectable and identifiable.

As well as considering the detectability of flora species in the ground layer at different times of their life cycle, timing of surveys should also allow for recovery after recent disturbances to the ecological community (whether natural, or human-induced). For example, after a severe fire or flood one or more vegetation layers may be absent for a time. Ideally, to maximise the assessment of understory condition, sites should be assessed during a good season, six months after cessation of disturbance (fire/flood/grazing/mowing/slashing) and within two months of effective rain. At a minimum, it is important to note recent climate conditions and what kind of disturbance may have happened within a patch and when that disturbance occurred.

**Surrounding environment and landscape context and other considerations**

Actions that may have 'significant impacts'[15] on any patches of the Poplar Box Grassy Woodland that meet the minimum *Condition thresholds* (in Section 3.2.2) should be referred under the EPBC Act.

The ecological importance of a patch is influenced by its surrounding landscape; for example, if it is connected to, or near, other areas of native vegetation the patch may contribute substantially to landscape connectivity and function. Similarly, actions beyond the boundary of a patch may have a significant impact on the patch (for example, through changes in hydrology). For this reason, when considering actions likely to have impacts on this ecological community, it is important to also consider the environment surrounding any patches of the ecological community. Other patches may occur in isolation and in addition to requiring protection may also need management of the surrounding area and/or linking them with other native vegetation.

In some cases patches do not currently meet *Condition thresholds*, and so are not recognised as part of the nationally protected ecological community (i.e. they are not a Matter of National Environmental Significance). However, in the context of their surroundings, recovery to a higher condition may be possible, so these areas should be considered as a priority for management and funding and for inclusion in buffer zones.

The following indicators of the ecological context provided by the areas surrounding patches of the ecological community are some of the key considerations both when assessing the impacts of actions or proposed actions under the EPBC Act, or when considering priorities for recovery, management and funding:

- Large size and/or a large area to boundary ratio – patches with larger area to boundary ratios are less exposed and more resilient to edge effects (from disturbances such as weed invasion and other anthropogenic impacts). However, patches that occur in areas where the ecological community has been most heavily cleared and degraded, or that are at the natural edge of its range, may also have importance due to their rarity, genetic significance, or because of the absence of some threats;
- Evidence of recruitment of key native plant species or the presence of a range of age cohorts (including through successful revegetation). For example, tree canopy species are present as saplings through to larger hollow-bearing trees;
- Good faunal habitat as shown by: diversity of landscape, the diversity of plant species, patches containing mature trees (particularly those with hollows), logs and that contribute to movement corridors;
- High species richness, as shown by the variety of native plant species or high number of native fauna species;
- Patches that contain a unique combination of species and/or rare or important species in the context of the particular ecological community or local region (for example, a patch with unique

[15] A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Further information regarding 'significant impact' and the EPBC Act is available at DOTE (2015).

fauna and/or understorey flora composition; or a patch that contains flora or fauna that has largely declined in the broader ecological community or region);

- Presence of EPBC and state listed threatened species or key functional species such as key pollinator and dispersal animals;
- Areas of minimal weeds and feral animals or where these can be efficiently managed;
- Presence of cryptogams, soil crust and leaf litter on the soil surface, which may indicate low recent disturbance to natural soil structure and potential for good functional attributes such as nutrient cycling;
- Connections to other native vegetation remnants or restoration works (e.g. native plantings) in particular, a patch in an important position between (or linking) other patches in the landscape (taking into account that connectivity should not exacerbate the incidence or spread of threats e.g. weeds). This can contribute to movement of fauna and transfer of pollen and seeds; and
- Linear road reserves or stock routes often contain remnant native vegetation in good to moderate condition, representing a diverse range of upper storey, mid storey and ground layer species. These areas also act as important corridor links to larger patches of nearby vegetation. In many instances linear reserves can represent the only remnant native vegetation occurring in an area where adjacent land has largely been cleared.

## 3.3 Area critical to the survival of the ecological community

The areas most critical to the survival of the ecological community are the best quality, most intact patches of the ecological community (as outlined in Class A – Highest condition of Table 3). These represent those parts of the ecological community that retain the highest diversity and degree of structure and ecological functions. They represent those sites closest to the original, benchmark states of the ecological community and that must retain their inherent values through protection and ongoing management.

However, this does not mean that areas that otherwise meet the minimum condition thresholds (i.e. good to moderate condition classes in Table 3) are unimportant for the future survival of the ecological community. Many of these sites may contain suites of species or habitat features that are unique or important in a regional or local context. Some of these elements can still be critical to the survival of the Poplar Box Grassy Woodland.

Additional areas such as buffer zones around patches, adjoining native vegetation, and areas that meet the description of the ecological community but not the condition thresholds are also important to the survival of the ecological community. They should still be taken into consideration as part of the surrounding environment and landscape context, as outlined in the previous section (Section 3.2.3).

## 3.4 National context and other existing protection

### Caveat

Any reference to vegetation and mapping units as corresponding to an equivalent or partial degree with a national ecological community, at the time of listing, should be taken as indicative rather than definitive. There are various systems of classification and nomenclature used, many of which have been created for a particular mapping exercise, so the descriptive units used do not fully correspond with each other.

Consideration of whether an ecological community that is protected under national environment law is present at a particular site should focus on how the patch of vegetation and its faunal components meets the description for the ecological community (section 2), particularly the key diagnostic characteristics and the minimum condition thresholds (section 3).

NSW (Plant Community Type) and Queensland (Regional Ecosystem) classifications are not the ecological community being listed. However, for many sites (but not all) certain vegetation map units will correspond sufficiently to provide indicative mapping for the national ecological community, where the description matches.

### 3.4.1 Relationships to the National Vegetation Information System (NVIS)

Under the National Vegetation Information System (NVIS), the Poplar Box Grassy Woodland can be classified within:

Major Vegetation Group (MVG)

- 5 - Eucalypt woodlands; and
- 11 - Eucalypt Open Woodlands

Major Vegetation Subgroup (MVS)

- 9 - *Eucalyptus* woodlands with a tussock grass understorey; and
- 48 - *Eucalyptus* open woodlands with a grassy understorey.

### 3.4.2 Relationship to New South Wales vegetation classification

NSW has classified its vegetation under various schemes. Under the broad-scale classification by Keith (2004), the Poplar Box Grassy Woodland align with the following formations and classes:

- Grassy woodlands - Floodplain transition woodlands
- Semi-arid Woodlands (Grassy sub-formation) - North-west floodplain woodlands

Finer-scale vegetation units have been determined for the NSW Plant Community Type (PCT) database (based on the Vegetation Classification and Assessment units – VCA, Benson et al. (2006; 2010)). These provide a descriptive basis for identifying vegetation communities in NSW and have since been subsumed into the NSW Vegetation Information System (VIS) database. The following Plant Community Type (PCT) identification units best correspond to the Poplar Box Grassy Woodland:

- PCT56 - Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW
- PCT87[16] - Poplar Box - Coolabah floodplain woodland on light clay soil mainly in the Darling Riverine Plains Bioregion
- PCT101 - Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion
- PCT244 - Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)

The ecological community may also occur as minor components of PCT88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion

The reports for the NSW PCT provide a detailed summary of information about the ecological community, including a summary of previous vegetation mapping and classifications (Benson et al. 2006; 2010).

Vegetation community descriptions also were developed for the NSW biometric system that is linked to the NRM regionally-based vegetation management system. The following Biometric vegetation types correspond to the Poplar Box Grassy Woodland:

- Border Rivers/Gwydir region: BR186, BR187, BR189, BR190
- Central West region: CW167, CW168, CW172
- Namoi region: NA182, NA183, NA185, NA186
- Lachlan region: LA175, LA178
- Western region: WE78, WE136, WE138

[16] PCT87 is ecotonal between EPBC Act and NSW TSC Act listed Coolabah Woodlands and Poplar Box woodland but would qualify for this ecological community when dominated by poplar box and the other key diagnostics are met.

### 3.4.3 Relationship to Queensland vegetation classification

Queensland classifies its vegetation using a system of Regional Ecosystems (RE). The Poplar Box Grassy Woodland mostly occurs in the Brigalow Belt bioregion extending into the South Eastern Queensland bioregion. It is associated with Land Zone 3 (Recent Quaternary Alluvial Systems, derived from sediments that are mass deposited from channelled stream flow or over-bank stream flow) and Land Zone 4 (Paleogene-early Quaternary Clay Plains that originate from ancient alluvial deposits and aeolian clays (parna)) that is elevated above Land Zone 3. The following REs best correspond with the Poplar Box Grassy Woodland:

- RE11.3.2 *Eucalyptus populnea* woodland on alluvial plains
- RE11.3.17 *Eucalyptus populnea* woodland with *Acacia harpophilla* and/ or *Casuarina cristata* on alluvial plains
- RE11.4.7 *Eucalyptus populnea* with *Acacia harpophyylla* and/or *Casuarina cristata* open forest to woodland on Cainozoic clay plains
- RE11.4.12 *Eucalyptus populnea* woodland on Cainozoic clay plains
- RE12.3.10 *Eucalyptus populnea* woodland on alluvial plains

There may be some variants recognised within these Regional Ecosystems that are not part of the national ecological community. For instance, areas mapped as RE11.3.2a *Eucalyptus conica* woodland are unlikely to be the national ecological community because *Eucalyptus conica* dominates the canopy.

Queensland also has a higher level vegetation classification, the Broad Vegetation Group (BVG), of which the ecological community generally corresponds to one type:

- 17a - Woodlands dominated by *Eucalyptus populnea* (Poplar Box) or *E. brownii* (red river box) on alluvium, sand plains and footslopes of hills and ranges.

Note that woodlands dominated by *E. brownii* mainly occur further north than Poplar Box and are not part of the ecological community.

### 3.4.4 Relationships to State-listed ecological communities

All five Queensland Regional Ecosystems that best correspond to the national ecological community, are listed as threatened under the Queensland *Vegetation Management Act 1999* and *Environmental Protection Act 1994* (Table 4).

**Table 4.** Legislative status of Queensland Regional Ecosystems that correspond to the Poplar Box Grassy Woodland on Alluvial Plains ecological community.

| Regional ecosystem | Vegetation Management Act class | Biodiversity status |
|---|---|---|
| RE11.3.2 | of concern | of concern |
| RE11.3.17 | of concern | endangered |
| RE11.4.7 | endangered | endangered |
| RE11.4.12 | endangered | endangered |
| RE12.3.10 | endangered | endangered |

Source: Accad and Neldner (2015)

There are no vegetation types which correspond with the national ecological community that are formally recognised as threatened in NSW, as at April 2017. However, the following ecological communities listed under NSW legislation may contain minor components, intergrade with, or occur adjacent to, the national Poplar Box Grassy Woodland:

- Artesian Springs Ecological Community (NSW: Endangered).
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions (NSW: Endangered).

- Carbeen Open Forest community in the Darling Riverine Plains and Brigalow Belt South Bioregions (NSW: Endangered).
- Coolibah-Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregion (NSW: Endangered).
- Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions (NSW: Endangered).
- Native Vegetation on Cracking Clay Soils of the Liverpool Plains (NSW: Endangered).
- White Box Yellow Box Blakely's Red Gum Woodland (NSW: Critically Endangered).

### 3.4.5 Listed threatened flora and fauna species associated with the ecological community

As at March 2018, the ecological community provides habitat for 15 fauna and 6 flora species that are listed nationally. There are also nine state listed threatened plant species and 50 state listed threatened animal species (see Appendix A).

### 3.4.6 Conservation reserves

The majority of the remaining area of the ecological community occurs on private or leasehold land. However, approximately 16 750 ha (1.5%) occurs in conservation reserves (Table 5).

**Table 5.** Conservation reserves containing the Poplar Box Grassy Woodland on Alluvial Plains ecological community

| Vegetation unit | Conservation Reserve |
|---|---|
| **Queensland** | |
| RE11.3.2 | Carnarvon NP, Taunton NP, Expedition (Limited Depth) NP, Dipperu NP, Homevale RP 2, Chesterton Range NP, Homevale NP, Expedition RP, Tregole NP, Nuga Nuga NP, Isla Gorge NP, Blackdown Tableland NP, Narrien Range NP, Bouldercombe Gorge RP 2, Epping Forest NP, Lake Broadwater RP |
| RE11.3.17 | Carnarvon NP, Culgoa Floodplain NP |
| RE11.4.7 | Humboldt NP |
| RE11.4.12 | Nil |
| RE12.3.10 | Nil |
| **New South Wales** | |
| PCT56 | Bobbiwaa SCA, Boomi and Boomi West NR, Boronga NR, Gamilaroi NR, Killarney SCA, Macquarie Marshes NR |
| PCT87 | Boomi West NR, Budelah NR, Culgoa NP, Narran Lake NR |
| PCT88 | Bobbiwaa SCA, Brigalow SCA, Bullawa NP, Coolbaggie NR, Gamilaroi NR, Timallallie NP, Trinkey SCA |
| PCT101 | Gunyerwarildi NP |
| PCT244 | Boomi NR, Boomi West NR, Boronga NR, Budelah NR, Midkin NR |

NP - National Park; NR - Nature Reserve; RP - Regional Park; SCA - State Conservation Area

Additional information on similar and intergrading ecological communities is located at Appendix D.

## 4 SUMMARY OF THREATS

The key threats to the ecological community are:

- **Clearance and fragmentation**. Historically mainly from agricultural development and currently includes mining and gas development.
- **Weed invasion**. Weeds compete with locally indigenous flora species for available resources (water, light, nutrients) and lead to a decline in the diversity and regenerative capacity of native vegetation. For example, weed species impacting diversity in the ground layer of the ecological community include: buffel grass (*Cenchrus ciliaris*) in QLD; Coolatai grass (*Hyparrhenia hirta*) in southern QLD and northern NSW; African lovegrass (*Eragrostis curvula*) in NSW; and lippia (*Phyla canescens*) at sites subject to occasional inundation.
- **Inappropriate fire and grazing**. Fire intensity, frequency, seasonality and patchiness in addition to grazing by domestic stock and pest animals, influence vegetation composition and structure as well as the success of weeds. More intense and frequent fires, as a result of introduced grasses for grazing, can substantially reduce the understorey diversity within the Poplar Box Grassy Woodland and further their spread into the ecological community.
- **Dieback** within the Poplar Box Grassy Woodland occurs via a range of causes, such as insect and vertebrate herbivory, water stress, salinity and pathogens, can lead to widespread long-term decline in tree health. Ongoing defoliation can exhaust tree energy reserves, particularly when combined with other environmental stresses, such as unfavourable weather conditions, leading to death and medium to long term loss of canopy species.
- **Chemical impact and spraydrift** from agricultural chemicals. As the canopy trees and grassy/herbaceous understorey of the Poplar Box Grassy Woodland are dependent on surface and groundwater, and given the ecological community mainly occurs on alluvial soils in agricultural areas, the application of chemicals, inorganic fertilisers or pesticide/herbicide e.g. spray drift of chemicals via various pathways can adversely impact on the integrity of the ecological community.
- **Hydrological changes** (including altered groundwater levels). Largely due to modification of the landscape through overclearing, changed aquifer and river levels that can lead to dieback of *Eucalyptus populnea* and other key flora and fauna species. Changes in ground water levels can also increase soil salinity.
- **Salinization**. Largely due to modification of the landscape and hydrology through overclearing. Poplar Box Grassy Woodland occurs on duplex soils and sodosols. Salinity affects both the understorey and overstorey species in remnant native woodlands particularly the growth and health of Poplar Box trees during drought.
- **Nutrient enrichment**. Nutrient enrichment of native grassy woodland such as the ecological community is highly detrimental to the many native plant species that have adapted to the lower nutrient status of most Australian soils. This can occur through the spread of inorganic fertilisers, incidental drift from adjacent farmland or accumulation of manure from livestock. Increased availability of soil nutrients following soil disturbance also contributes to the establishment of weeds into grassy systems such as the Poplar Box Grassy Woodland.
- **Invasive fauna**. The Poplar Box Grassy Woodland provides habitat for many ground dwelling birds and animals. Pest species such as foxes and cats impact these small to medium native animal species through predation and also compete for resources. Rabbits can selectively remove the most palatable herbs and grasses and suppress regeneration. Goats damage trees and can cause erosion, while pigs damage groundlayer vegetation by digging and turning over soil thus impacting on the structure and integrity of the ecological community.
- **Climate change** is a potential threat across the distribution of Poplar Box Grassy Woodland. It will likely involve increases in temperatures, seasonality and intensity of rainfall, with unknown compounding effects on other disturbances such as fire. In addition to directly threatening species that cannot adapt, climate change can alter resource availability and the competitive relationships between species, plus can exacerbate existing threats such as habitat loss, fire, dieback and invasive species.

More information on threats to the ecological community is provided in Appendix B – Description of threats.

### 4.1. Key threatening processes

Key threatening processes have been defined at the national level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and for NSW under the NSW *Threatened Species Conservation Act 1995* (TSC Act). Those most relevant to the Poplar Box Grassy Woodland (at March 2017) are listed in Table 6:

**Table 6.** Potentially relevant key threatening processes identified in the Threatened Species and Communities Act (NSW) and the EPBC Act.

| NSW TSC Act | EPBC Act |
|---|---|
| • Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners, *Manorina melanocephala* (Latham, 1802) | • Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*) |
| • Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands | |
| • Anthropogenic climate change | • Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases |
| • Clearing of native vegetation | • Land clearance |
| • Competition and grazing by the feral European rabbit *(Oryctolagus cuniculus)* | • Competition and land degradation by rabbits |
| • Competition and habitat degradation by feral goats (*Capra hircus*) | • Competition and land degradation by unmanaged goats |
| • Competition from feral honey bees (*Apis mellifera*) | • Novel biota and their impact on biodiversity |
| | • Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*) |
| • Exotic vines and scramblers | • Novel biota and their impact on biodiversity |
| • Herbivory and environmental degradation caused by feral deer | • Novel biota and their impact on biodiversity |
| • High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition | |
| • Infection by Psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations | • Psittacine circoviral (beak and feather) Disease affecting endangered psittacine species |
| • Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae | • Novel biota and their impact on biodiversity |
| • Invasion and establishment of the cane toad (*Bufo marinus*) | • The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*) |
| • Invasion of native plant communities by exotic perennial grasses | • Invasion of northern Australia by Gamba Grass and other introduced grasses |
| • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants | • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants |
| • Loss of hollow-bearing trees | • Land clearance |

| NSW TSC Act | EPBC Act |
|---|---|
| • Predation and hybridisation of feral dogs (*Canis lupus*) | |
| • Predation by the European red fox (*Vulpes vulpes*) | • Predation by European red fox |
| • Predation by the feral cat (*Felis catus*) | • Predation by feral cats |
| • Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) | • Predation, habitat degradation, competition and disease transmission by feral pigs |
| • Removal of dead wood and dead trees | |

Source: OEH (2016); DotE (2016).

The following approved EPBC threat abatement plans[17] are considered relevant to the Poplar Box Grassy Woodland:

- Threat abatement plan for competition and land degradation by unmanaged goats;
- Threat abatement plan for competition and land degradation by rabbits;
- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi;*
- Threat abatement plan for predation by European red fox;
- Threat abatement plan for predation by feral cats;
- Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads;
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs; and
- Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses

[17] The threat abatement plan for beak and feather disease affecting endangered psittacine species ceased on 1 October 2015. A non-statutory threat abatement advice is being developed.

## 5 RECOMMENDATIONS BY THE THREATENED SPECIES SCIENTIFIC COMMITTEE

### 5.1 Recommendation on eligibility for listing against the EPBC Act criteria.

On the basis of available scientific information, it is recommended that the *Poplar Box Grassy Woodland on Alluvial Plains* ecological community is **eligible** for listing as **Endangered**. This was the highest conservation category triggered at the time of this assessment.

Detailed assessments against each of the EPBC Act listing criteria are at Appendix C - *Detailed assessment of eligibility for listing against the EPBC Act criteria*. The key conclusions are summarised here.

Criterion 1 - Decline in geographic distribution

The pre-1750 extent of the ecological community across its entire range is estimated to be almost 5.1 million hectares and the current extent is estimated to be almost 1.3 million ha. The ecological community has therefore undergone a decline in extent of at least 75%. The Committee judges the ecological community has undergone a **severe** decline in its geographic extent and is therefore eligible to be listed as **Endangered** under this criterion.

Criterion 2 - Restricted geographic distribution coupled with demonstrable threat

Neither the extent of occurrence or area of occupancy are limited for this ecological community. Patch size data are insufficient across the entire range of the ecological community while timeframes for ongoing threats also are not clear. Consequently there is **insufficient information** to determine the eligibility of the ecological community for listing against Criterion 2.

Criterion 3 - Loss or decline of functionally important species

Whilst threats are likely to have broadly impacted upon functionally important species such as small burrowing mammals and woodland bird species, particularly insectivores and terrestrial granivores, specific data related to the decline of such species in this ecological community are not available. There is **insufficient information** to determine the eligibility of the ecological community for listing under any category of Criterion 3.

Criterion 4 - Reduction in community integrity

Substantial clearing, severe fragmentation, weed invasion, inappropriate fire and grazing, and associated changes to vegetation structure and loss of faunal components have substantially reduced the integrity of the ecological community. The very long lag time to recover vegetation structure, with adequate representation of large old trees, limits the likelihood of recovery in the near future. The intractability of other problems, such as the loss of fauna regionally, and the nature of existing land and water use in the ecological community's extent further reduces the potential for recovery. The reduction in integrity experienced by the ecological community across most of its geographic distribution is severe, as indicated by **severe** degradation of the community and its habitat. Therefore, the ecological community is eligible for listing as **Endangered** under this criterion.

Criterion 5 - Rate of continuing detrimental change

There is evidence of ongoing clearing of the Poplar Box Grassy Woodland over the previous two decades though the rate of clearing has been variable, at least for the Queensland occurrences, during that period. The nature of development pressures, especially mining, facing the region where the ecological community occurs indicates a likelihood in the immediate future, of landscape-level impacts to the ecological community. The ecological community meets this criterion as **Vulnerable** for listing under Criterion 5.

Criterion 6 - Quantitative analysis showing probability of extinction

There are no quantitative data available to assess this ecological community under this criterion. As such there is **insufficient information** to determine the eligibility of the ecological community for listing under any category of Criterion 6.

### 5.2 Recommendation on whether to have a recovery plan

The Conservation Advice for the *Poplar Box Grassy Woodland on Alluvial Plains* ecological community outlines priority actions needed for the conservation and recovery of the ecological community (see Section 6), the main threats faced by the ecological community, and the criteria by which the ecological community is eligible for listing. The Committee is required to advise the Minister as to whether the ecological community should also have a Recovery Plan.

For the *Poplar Box Grassy Woodland on Alluvial Plains* ecological community the Committee advises that listing plus implementation of the actions in the Conservation Advice would provide sufficient protection from extinction and guidance on the recovery of the ecological community. Therefore, a decision to have a Recovery Plan is unlikely to lead to substantial additional conservation benefits given the resources required to develop a plan. Consequently, the Committee advises that a Recovery Plan is **not recommended** at this time. The Minister agreed to the Committee's recommendation and reasons for it on 24 June 2019.

# 6 PRIORITY CONSERVATION AND RESEARCH ACTIONS

## 6.1 Principles and standards that guide the actions below

To undertake priority actions to meet the conservation objective, the overarching principle is that it is preferable to maintain existing areas of the ecological community that are relatively intact and highest quality. There are good, practical reasons to do so. It is often more cost-effective to retain an intact remnant than to allow degradation and then attempt to restore it or another area. The more disturbed and modified a patch of the ecological community, the greater the recovery effort that is required. Also, intact remnants are likely retain a fuller suite of native plant and animal species, and ecological functions. Many species may not be easy to recover in practice, if lost from a site. Retention of intact patches is particularly important if they are characterised by high richness and/or local endemism of native species.

This principle is highlighted in the National Standards for the Practice of Ecological Restoration in Australia (SERA Standards Reference Group (2017):

> *"Ecological restoration is not a substitute for sustainably managing and protecting ecosystems in the first instance.*
>
> *The promise of restoration cannot be invoked as a justification for destroying or damaging existing ecosystems because functional natural ecosystems are not transportable or easily rebuilt once damaged and the success of ecological restoration cannot be assured."*
>
> *SERA Standards Reference Group (2017) – Appendix 2.*

The principle serves to dissuade 'offsets' or 'trade-offs' where intact remnants are removed with an undertaking to set aside and/or restore other sites. The destruction of intact sites actually represents a net loss of the functional ecological community because there is no guarantee all the species and ecological functions of the intact site can be replicated elsewhere (also see section 6.3 – Offsets).

Where restoration is to be undertaken, it should be planned and implemented with reference to the *National Standards for the Practice of Ecological Restoration in Australia*. These Standards guide how ecological restoration actions should be undertaken and are available online from the Standards Reference Group SERA (2017). They outline the principles that convey the main ecological, biological, technical, social and ethical underpinnings of ecological restoration practice. More specific guidance regarding restoration of Poplar Box Grassy Woodland, or information that is regionally specific, may also become available. As restoration ecology is continually developing, it is also important to reflect on the experience of others who have worked on restoring the ecological community or other woodlands, as well as adapting restoration projects as site-level experience accumulates.

To achieve cost-effective investments in conservation management it is important to consider the likely interaction of the various management actions being undertaken at any one site, as these may be synergistic or antagonistic. There are also likely to be interactions between sites. Additionally, when allocating management resources it is important to consider what is the minimum investment required for success and the follow-up required to secure long-term recovery (for example, for how many years should weed management be repeated).

## 6.2 Priority protection, conservation management and recovery actions

Priority actions are recommended for the abatement of threats and to support recovery of the ecological community. Actions inconsistent with these recommendations that are likely to significantly affect the ecological community should not be undertaken. In assessment of activities that may have a significant impact on the ecological community, incorporate relevant actions listed below when determining recommendations, including conditions of approval. Applications to Australian Government funding programs should also consider prioritising the restoration activities below.

The four key approaches to achieve the conservation objective are:

PROTECT the ecological community to prevent further loss of extent and condition;

RESTORE the ecological community within its current and potential range by active abatement of threats, revegetation and other conservation initiatives;

COMMUNICATE - ENGAGE WITH AND SUPPORT people to increase understanding of the value and function of the ecological community and encourage their efforts in its protection and recovery; and

RESEARCH AND MONITORING to improve our understanding of the ecological community and methods for restoration and protection over the long-term.

These approaches are overlapping in practice and form part of an iterative approach to management that should include research, planning, monitoring and review. Key groups to communicate with include: landholders, land managers, land use planners, researchers, community members, and the Indigenous community.

Specific management, research and other conservation priorities for Poplar Box Grassy Woodland on Alluvial Plains are described below.

### 6.2.1 PROTECT

***Preventing vegetation clearance and direct habitat degradation***

Highest priorities

- Prevent further clearance, fragmentation or detrimental modification of remnants of the ecological community and of surrounding native vegetation for example, through land use zoning and during land development, raw materials extraction, and associated infrastructure development.
    - High conservation value, unmodified and older growth areas (e.g. stands of more mature trees) are particularly important for retention and management (refer to condition thresholds in section 3.2.2 for guidance). Identify high quality remnants in advance of zoning and development planning decisions and avoid clearing or damaging them.
    - Recognise the landscape position of remnants of the ecological community and ensure that planning supports increased resilience within the landscape (for example, by retaining appropriate connectivity between remnants of all naturally occurring ecological communities).
    - Prevent impacts to native vegetation, native fauna, hydrology or soil structure from any developments and activities adjacent to or near patches of the ecological community by planning for and appropriately avoiding or mitigating off-site effects. For instance, apply recommended buffers of at least 30 m (native vegetation buffers are preferred) around patches of the ecological community and avoid activities that could cause significant hydrological change. Wider buffers may be required where there is larger scale landscape change, for example hydrological modifications.
    - Protect mature trees, particularly with hollows, even if they are dead. Large and old trees may have numerous fissures that provide shelter; support diverse insects and their predators; and act as 'stepping stones' for fauna moving between remnants in an otherwise cleared landscape.
- Minimise further conversion of moderate, good or highest condition remnants of the ecological community to cropping, improved pasture or mines/wells where possible.
    - Ensure that any further mineral and energy extraction and exploration activities minimises direct impacts to the ecological community or indirect effects on its ecological functionality.

- Ensure that any further development of river and ground water infrastructure and water storage minimises impacts on the ecological function of the ecological community. Avoid significant changes to water table levels and /or run-off, salinity, pollution and water flow patterns arising from developments, such as through mineral and gas extraction.
    - Prevent impacts from any developments and activities adjacent to or near patches that might result in further degradation, by planning for and appropriately mitigating off-site effects (for example, by avoiding disturbances to native vegetation, fauna, hydrology or soil structure, and applying recommended buffer zones around the ecological community).
    - Retain other native vegetation remnants and mature isolated trees near patches of the ecological community where they are important for connectivity or as buffers.
    - Manage access to remnants to prevent, for example, disturbance and spread of weeds and plant pathogens.
- Ensure that areas that form important landscape connections, such as wildlife corridors or other patches of particularly high quality or regional importance are considered for inclusion in formal reserve tenure or other conservation related land tenure, such as conservation covenants, for protection and management in perpetuity.
- Liaise with local councils and State authorities to ensure that cumulative impacts, from activities undertaken as part of broader or related projects (e.g. road works, developments), are reduced when planning individual activities.

Other priorities

- Protect the native soil seed bank by minimising soil disturbance and removal.
- Retain habitat features for fauna, noting species requirements (e.g. fallen timber) or particular vegetation structure. For example, for many bird species the quality of native vegetation as habitat can be improved by leaving fallen logs and leaf litter in situ (shrubs may be important at some sites), controlling weed species, taking care of the canopy by controlling dieback and controlling wildfires by public awareness and vigilance.
- Prior to removal of any trees, or use of heavy machinery that may also damage the understorey, ensure comprehensive flora and fauna surveys have identified threatened species on site and their potential shelter and nesting sites, for example hollows, burrows and tree crevices, as well as visible nests. Damage to these should be avoided altogether, but if approved for removal, care should be taken to appropriately relocate fauna.
- Increase the size and condition of patches by promoting regeneration of and replanting canopy trees and a diversity of understorey species. As part of this create or restore appropriate wildlife corridors and linkages, including stepping stones.

***Preventing weeds, feral animals, tree dieback and other diseases***

Highest priorities

- Prevent weed invasion by minimising soil disturbance.
- Following disturbances implement a weed control program that responds to weed establishment, particularly in the following 1–2 years after disturbance. It typically requires less resources to control weeds at this time.
- Do not plant (or spread) known, or potential, environmental weeds within or near the ecological community:
    - prevent activities such as planting potentially invasive species near the ecological community; or dumping garden waste in or near patches of the ecological community.

- review the planting schedule for new developments to ensure that potential weeds or other inappropriate plants (e.g. likely to contaminate the local gene pool) are not included. Use plants from accredited nurseries (e.g. see the Nursery Industry Accreditation Scheme: Nursery and Garden Industry Australia, undated).

- Implement effective control and management techniques for invasive grasses, such as *Cenchus ciliaris* (buffel grass).
- Control runoff to prevent movement of weed material into natural areas.
- Avoid the use of fertilisers and cultivation, which can favour invasive species, in subcatchments.
- Detect and control weeds early. Small infestations should be a priority for removal. For example, weeds have invaded to varying extents along access tracks and such areas should be considered a priority for weed control.
- Prevent further introduction of feral animals and contain domestic animals within new development areas.
- Target management of existing weed problems to sites of high diversity or where threatened or regionally significant species are known to occur.
- Monitor for signs of new disease such as myrtle rust or incursions by new weeds (for example, African boxthorn or blackberry), or pest animals, (for example goats, rabbits and deer) and manage early for local eradication.
- Ensure stock do not carry weeds into patches of the ecological community (for example, hold stock in weed management paddocks for an appropriate time prior to introduction).
- Use appropriate hygiene to minimise the introduction or spread of weeds and diseases at susceptible sites. For example, keep vehicles and machinery to dedicated roads and out of remnants wherever possible. If vehicles must be taken into remnants ensure vehicles are washed first to remove soil, potential fungal pathogens and weed seeds.
- Implement strategic responses to rural tree dieback, in particular, implement preventative measures.

***Fire***

- Use a landscape-scale approach and available knowledge on fire histories and age of stands, to identify priority conservation sites that need fire for biodiversity conservation.
- Fires must be managed to ensure that where possible, prevailing fire regimes do not disrupt the life cycles of the component species of the ecological community, that they support rather than degrade the habitat necessary to the ecological community, that they don't promote invasion of exotic species, and that they do not increase impacts of other disturbances such as grazing or predation by feral predators. Faunal populations in isolated patches may be vulnerable to local extinction following intense fires.
- Implement appropriate fire management regimes for the ecological community that take into account results from research. Appropriate actions relating to burning may include:
    - clearing fuel away from the base of old trees prior to burning; minimising high intensity fires and extinguishing tree bases after the fire front has passed to retain old and /or hollow trees and roost sites;
    - when burning to control annual weeds, where they dominate, take into consideration the requirements of any threatened species or characteristic flora, and fauna species;

    - do not burn during peak reproductive seasons, e.g. flowering and fruiting seasons, for threatened, functionally important or characteristic native flora and fauna species within the ecological community;
    - do not burn if soil moisture is very low, or dry conditions are predicted for the coming season, because native grass recovery will be slow and erosion may occur, or weeds may become established or recover quicker than native species while the groundcover is reduced;
    - within large patches burn different parts in rotation, rather than the whole area in any one season;
    - avoid native vegetation removal as part of fire management or creation of new tracks or use of machinery through bushland. Slashing to maintain low native understorey as a fire break is preferred over a mineral earth fire break;
    - consider fire regimes appropriate for nearby ecological communities and threatened species when planning burning (for example, where wetlands are adjacent).

***Preventing grazing damage***

- Integrate appropriate grazing management regimes with fire management requirements.
- Persistent grazing can negatively affect understorey species composition and impact diversity. Provide alternative shelter and watering areas for stock, for example, by planting shade trees, particularly Poplar Box, in nearby cleared or non-native areas.
- Where feral herbivores (e.g. rabbits) are present or there is an overabundance of native herbivores (e.g. kangaroos) install temporary or permanent fencing to protect regrowth, revegetation areas, or sites with threatened, regionally important or diverse understorey species.
- Manage populations of feral grazing animals that damage native vegetation.
- Ensure that livestock grazing, if it occurs in the area, uses an appropriate management regime and stocking rate that does not detrimentally affect the ecological community:
    - occasional grazing may be beneficial for reducing grass cover, encouraging herb growth and minimising shrub regeneration; however, if stock could carry noxious weeds into the remnant, then it would be preferable to exclude stock altogether or admit them only at times when weeds are not producing seed;
    - wherever possible avoid grazing during peak native plant flowering and seeding times (spring and summer); and
    - avoid long term grazing at high stocking densities.

***Climate change***

- Enhance the resilience of the ecological community to the impacts of climate change by relieving other pressures, in particular by implementing actions in this advice regarding vegetation clearance, invasive species and fire.

### 6.2.2 RESTORE

The Standards Reference Group identifies six principles as 'key principles of ecological restoration practice', the details of which are provided by the SERA Standards Reference Group (2016):

1. Ecological restoration practice is based on an appropriate local indigenous reference ecosystem.
2. Restoration inputs will be dictated by level of resilience and degradation.
3. Recovery of ecosystem attributes is facilitated by identifying clear targets, goals and objectives.
4. Full recovery is the goal of ecological restoration but outcomes may take long timeframes.
5. Science is essential to good practice but the two processes are synergistic.
6. Social aspects are critical to successful ecological restoration.

***Restoration***

Highest priorities

- Implement optimal restoration strategies (including regeneration, revegetation) for the ecological community, across the landscape. In general, use locally collected seed where available to create an appropriate canopy, including *Eucalyptus populnea*, and diverse understorey. However, choosing sources of seed closer to the margins of their range may increase resilience to climate change.
- Ensure restoration is site specific, as this is important to the success of restoration efforts.
- Restore wildlife corridors and linkages (e.g. travelling stock routes/reserves) and ensure that these areas or other patches of particularly high quality or regional importance are considered for inclusion in formal reserve tenure or other conservation related tenure in perpetuity.
- Create habitat linkages (where appropriate) between remnants for the ecological community and other areas of native vegetation (e.g. other listed threatened ecological communities such as Brigalow (*Acacia harpophylla* dominant and co-dominant), or reconstructed habitat to reduce fragmentation and isolation.
- Increase the size and condition of patches by promoting regeneration of and replanting canopy trees and a diversity of understorey species.
- Consider particularly the needs of species of conservation concern or known to be of functional importance for the ecological community.
- Survey and monitor recovery, through estimates of extent and condition assessments for the ecological community.
- Allow juvenile Poplar Box trees to naturally thin out and grow to maturity.

Other priorities

- Where appropriate, fence significant remnants in or adjacent to agricultural and development areas and limit access for vehicles, in consultation with local and state authorities.
- If necessary, supplement, (but do not replace) fauna habitat by placing artificial hollows (e.g. various sized nest boxes) in, or near to, the ecological community. Maintain the boxes, including controlling invasive species such as bees and monitor outcomes.
- Encourage appropriate use of local native species in developments and revegetation projects through local government and industry initiatives. It is important to use seeds and plants that will be resilient to future changes in climate.
- Implement effective adaptive management regimes using information from relevant research (e.g. SERA 2016).

***Control and eradicate invasive species and diseases***

Highest priorities

- Map weed occurrence and prioritise management of weeds in highest quality patches or where threatened or regionally significant species are known to occur.
- Implement effective control and management techniques for weeds currently affecting the ecological community integrating this with alternative habitat provision and predator control.

Other priorities

- Control introduced pest animals through consolidated landscape-scale programs.
- Manage weeds before and after fires, and during revegetation works to maximise success of restoration.
- Manage weeds at the sides of new roads and housing and industrial developments near to the ecological community by regular monitoring, and control by targeted herbicide spraying or manual removal for several years after the works are complete.
- Ensure actions to control invasive or other pest species avoid impacts on non-target species and do not have any long-term adverse impacts upon the ecological community:
    - ensure workers are appropriately trained in the use of relevant herbicides and pesticides, best methodologies (e.g. spot-spraying, stem injection) and what to target;
    - avoid chemical spray drift and off-target damage within or near to the ecological community, having regard to minimum buffer zones.
- Control run-off to prevent dispersal of weeds and plant diseases.

### 6.2.3 COMMUNICATE - ENGAGE WITH AND SUPPORT

***Maintain a recovery team***

- Support the development of a Recovery Team, with broad community involvement.

***Education, information and local regulation***

- Develop a communication strategy, education programs, information products and signage to help local communities and managers recognise:
    - when the ecological community is present and why it is important to protect it;
    - how to appropriately manage patches of the ecological community; and
    - responsibilities under state and local regulations and the EPBC Act.
- Promote knowledge about local weeds, means to control these and appropriate local native species to plant.
- Develop education programs to discourage damaging activities such as the removal of dead timber, the dumping of rubbish (particularly garden waste), creation of informal paths and the use of off-road vehicles in patches of the ecological community.
- Encourage local participation in recovery efforts, removing threats and actively protecting and restoring existing patches, as well as facilitating these. This may be achieved by setting up a recovery team(s) with appropriate expert and local participants; adoption of patches by local conservation groups; or encouraging short term involvement through field days and planting projects, with appropriate follow-up.
    - Ensure planners and participants are aware of appropriate species to plant and which species to avoid in woodland revegetation projects across the range of the ecological community (taking into account local sub-communities), the best opportunities to restore

landscape connectivity and encourage natural regeneration and the best known techniques for the site conditions and species being planted.

  - Ensure land managers are given information about managing fire for the benefit of threatened species and ecological communities.
  - Ensure commitment to follow-up after planting, such as care of newly planted vegetation by watering, mulching, weeding and removal of tree guards.

- Promote awareness and protection of the ecological community by relevant agencies and industries. For example with:
  - state and local government planning authorities, to ensure that planning around towns takes the protection of remnants into account, with due regard to principles for long-term conservation;
  - land developers, mining and construction industries, to minimise threats associated with land development;
  - local councils and state authorities, to ensure road widening and maintenance activities (or other infrastructure or development activities) involving substrate or vegetation disturbance do not adversely impact the ecological community. This includes avoiding the introduction or spread of weeds and avoiding planning new roads or paths through patches of the ecological community;
  - the use of signage to identify key sites of the ecological community that occur along road verges and other public lands such as travelling stock reserves; and
  - natural resource management groups, consultant agronomists and livestock industry.
- In new developments include measures to limit additional impacts from domestic animals and invasive plants. These may include:
  - public education, including the use of signs to both identify good examples of the ecological community and explain beneficial and detrimental activities.
  - cat exclusion areas;
  - requirements for registering and sterilising cats;
  - requirements for dogs to remain on leash in natural areas;
  - lists of suitable species for gardens to provide habitat and complement natural areas;
  - lists of invasive plant species to avoid planting in gardens.
- Liaise with local fire management authorities and agencies and engage their support in fire management of the ecological community. Request these agencies to use suitable maps and install field markers to avoid damage to the ecological community.

***Incentives and support***

- Support opportunities for traditional owners or other members of the Indigenous community to manage the ecological community.
- Implement formal conservation agreements (for example, covenants) for sites on private tenure that contain the ecological community.
- Develop coordinated incentive projects to encourage conservation and stewardship on private land, and link with other programmes and activities, especially those managed by regional catchment groups, local natural resource management authorities or Local Land Services.

### 6.2.4 RESEARCH AND MONITORING PRIORITIES

Relevant and well-targeted research and other information gathering activities are important in informing the protection and management of the ecological community. Coordination with individuals and groups with responsibilities for planning and on ground management is important to ensure that research questions and methods are well chosen, and that the information gathered can be applied to the benefit of the ecological community. Research and ongoing management activities can often be integrated to achieve the best results in the face of ongoing change. It is important that any monitoring is planned before management commences, considering data requirements to address research questions. Monitoring must also be resourced for the duration of the management activities, especially for those using a novel approach.

High priority research and monitoring activities to inform protection, management and restoration of the ecological community include the following:

- Review data: consolidate information over entire extent of the ecological community and improve and update maps of the ecological community across its range:
  - Support field survey and interpretation of other data such as aerial photographs and satellite images to more accurately document current extent, condition, threats, function, presence and use by regionally significant or threatened species.
  - Support and enhance existing programs to: model the pre-1750 extent across the entire range of the ecological community to inform restoration; identify the most intact, high conservation value remnants and to gain a better understanding of variation across the ecological community.
- Reassess the conservation status of the ecological community.
- Undertake dieback mapping and risk assessment of dieback susceptible areas.
- Undertake or support ongoing research aimed at managing major weeds and feral animals.
- Research the effects of fire on floristics and structure of vegetation, native fauna and invasive species in patches and across the broader landscape:
  - Keep precise records of fire history;
  - Monitor the response of the ecological community to fire, using an appropriate measure (structure, species composition, population of key species, habitat features etc) with a monitoring design that aims to improve understanding of the response to fire of the ecological community;
  - Identify and publish appropriate fire management regimes to conserve key species and the broader ecological community. For example, address the effects of fire intervals and timing on seedbank accumulation and seedling recruitment to inform the identification of fire regimes that maintain or recover floristic diversity and an open grassy structure; and
  - Monitor and manage how the outcomes of fire interacts with the management of other threats, for instance ongoing weed management and management of feral predators.
- Develop a weed management strategy that includes integrated weed management over large areas.
- Undertake research aimed at managing feral animals and major weeds, such as African boxthorn (*Lycium ferocissimum)*, African lovegrass (*Eragrostis curvula*), buffel grass (*Cenchrus ciliaris*), Coolatai grass (*Hyparrhenia hirta*), lippia (*Phyla canescens*), mother of millions (*Bryophyllum delagoense*), parthenium weed (*Parthenium hysterophorus*), perennial veldt grass (*Ehrharta calycina*), Rhodes grass (*Chloris gayana*) and prickly pear (*Opuntia* spp. and related genera).
- Conduct research leading to the development of effective landscape-scale rehabilitation and maintenance of vegetation condition for the ecological community. Investigate the

interactions between threats (e.g. fire and grazing regimes, climate change, dieback, hydrological changes) to determine how an integrated approach to threat management can be implemented.

- Research the effects of alternative grazing regimes, identify optimal and sustainable grazing regimes, and determine appropriate management prescriptions to maintain plant diversity and/or faunal habitat quality.
- Investigate key ecological interactions, such as the role of fauna in pollination, seed dispersal and nutrient cycling. Also investigate the mechanisms of mammal decline and understanding the ecological role of mycophagous mammals; and decline of other fauna, e.g. pollinators.
- Investigate the most cost-effective options for restoring landscape function, including:
  - re-vegetation or assisted regeneration of priority areas, potentially buffering, connecting and protecting existing remnants;
  - weed, and predator control options such as trapping and baiting, urban containment, exclusion fencing; re-introduction of key fauna;
  - re-introduction of key fauna.
- Determine optimal management regimes and best practice management standards including for integrated fire, grazing and invasive species best practice for each region within its broad range (e.g. Brigalow Belt North and NSW South Western Slopes IBRA Bioregions, Central West Local Land Services, Condamine Alliance Natural Resource Management organisation).
- Undertake analysis of the hydrological needs of the ecological community including groundwater, surface water flow, impacts from dryland salinity, the legacy effects of water table decline and possible management responses.
- Further assess the vulnerability of the ecological community to climate change and investigate ways to improve resilience through other threat abatement and management actions.

### 6.3 Offsets

Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment. Further clearance and damage to this ecological community should not occur. Therefore, offsetting is a last resort. It should only be proposed as an attempt to compensate for damage to the ecological community that is deemed unavoidable. The ecological outcomes of offsetting activities are generally uncertain: offsetting with replanted areas is insufficient as there is no guarantee that reconstruction of the ecological community will be successful and, given the long ecological lags in the potential recreation of a resilient and functioning patch of the ecological community, the loss of mature trees, for example, severely compromises the viability of the ecological community. Replication of all species and function has yet to be demonstrated in any Australian system over decadal time scales (Maron et al 2012, 2016).

Areas that already meet the condition thresholds are protected by this listing, so are not to be used as an offset unless there is a substantial net conservation benefit such as a perpetual change in land tenure for conservation purposes, with ongoing threat abatement measures and monitoring put in place. With regard to any proposals involving offsets for this ecological community, which has been greatly reduced in spatial extent and condition, the aims are to:

- enable options to avoid the need to offset;
- retain remaining patches rather than offset;
- ensure that offsets are consistent with the wording and intent of the EPBC Act Environmental Offsets Policy (Commonwealth of Australia 2012), including:
  - 'like-for-like' principles based on meeting the overall definition of the ecological community and considering the particular species composition, maturity of trees, vegetation

structure and other habitat and landscape features at a particular site (e.g. do not use offsets distant from the site of impact, as there is local variation of the ecological community);

    - how proposed offsets will address key priority actions outlined in this Conservation Advice and any other relevant recovery plans, threat abatement plans and any other Commonwealth management plans.

- demonstrate that offsets are feasible (i.e. by reference to successful applications elsewhere) with outcomes expected within reasonable time frames to offset development impacts;
- match any offsets to the same ecological community, as it is not appropriate to offset losses of one ecological community with another ecological community;
- avoid offsetting a particular component of the national ecological community with a different component, e.g. loss of a certain Queensland regional ecosystem should be offset with patches that are the same regional ecosystem, where possible;
- do not use offsets too distant from the site of impact, given the broad distribution and inherent variation within the ecological community;
- maintain (or increase) the overall area, quality and ecological function of the remaining extent of the ecological community and improve the formal protection of high quality areas through a combination of the following measures:
    - protecting and managing offset sites in perpetuity in areas dedicated under legislation for conservation purposes; that is, do not allow reduction in their size, condition and ecological function in the future through ongoing threat abatement measures and adaptive management based on monitoring; and/or
    - increase the area and improve ecological function of the woodlands, for example by enhancing landscape connectivity (e.g. protecting and linking smaller remnants), habitat diversity and condition; and/or
    - restoring patches to improve their condition, particularly to ensure that any offset sites add additional value to the remaining extent.

### 6.4 Existing plans/management prescriptions

There are no approved state recovery plans for the ecological community, as defined in this listing. However, relevant management prescriptions exist in various forms, including threat abatement plans and recovery plans for some species occurring in the ecological community. These include:

Biosecurity SA (2012). South Australia Buffel Grass Strategic Plan: A plan to reduce the weed threat of buffel grass in South Australia. Government of South Australia. Available on the internet at: http://www.pir.sa.gov.au/__data/assets/pdf_file/0019/237340/SA_Buffel_Grass_Strategic_Plan.pdf

Crawford P (2008). Challenges, opportunities and strategies. Lippia (*Phyla canescens*) management. The National Lippia Working Group.

Commonwealth of Australia (2012). Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy. Available on the internet at: https://www.environment.gov.au/system/files/resources/12630bb4-2c10-4c8e-815f-2d7862bf87e7/files/offsets-policy_2.pdf

Department of the Environment (2015). Threat abatement plan for predation by feral cats, Commonwealth of Australia. Available on the internet at: http://www.environment.gov.au/system/files/resources/78f3dea5-c278-4273-8923-fa0de27aacfb/files/tap-predation-feral-cats-2015.pdf

Department of the Environment (2015). Draft Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*). Commonwealth of Australia. Available on the internet at: http://www.environment.gov.au/system/files/resources/e8344ac9-5527-4402-aca9-cc0c4b533b3a/files/draft-tap-feral-pigs-2015.pdf

Department of Environment and Climate Change (NSW) (2008). Recovery plan for the koala (*Phascolarctos cinereus*). Available on the internet at: http://www.environment.nsw.gov.au/resources/threatenedspecies/08450krp.pdf

Department of Environment and Conservation (NSW) (2006). Southern Brown Bandicoot (*Isoodon obesulus*) Recovery Plan. NSW DEC, Hurstville NSW. Available on the internet at: http://www.environment.nsw.gov.au/resources/nature/SouthernBrownBandicootFinalRecoveryPlan.pdf

Department of the Environment and Heritage (2006). Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis. Available on the internet at: www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis

Department of Environment and Heritage Protection (2012). Koala-sensitive design guideline. A guide to koala-sensitive design measures for planning and development activities. Available on the internet at: http://www.ehp.qld.gov.au/wildlife/koalas/legislation/pdf/koala-sensitive-design-guideline.pdf

Department of Sustainability, Environment, Water, Population and Communities (2011). Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads. Available on the internet at:

http://www.environment.gov.au/system/files/resources/2dab3eb9-8b44-45e5-b249-651096ce31f4/files/tap-cane-toads.pdf

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Threat abatement plan for competition and land degradation by rabbits, DEWHA, Canberra. Available on the internet at: http://www.environment.gov.au/system/files/resources/7097f100-4a22-4651-b0e1-df26e17c622c/files/tap-rabbit-report.pdf

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Threat abatement plan for competition and land degradation by unmanaged goats, DEWHA, Canberra.
Available on the internet at: http://www.environment.gov.au/system/files/resources/2109c235-4e01-49f6-90d0-26e6cb58ff0b/files/tap-goat-report.pdf

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Background document for the threat abatement plan for predation by the European red fox, DEWHA, Canberra.
Available on the internet at: http://www.environment.gov.au/system/files/resources/1846b741-4f68-4bda-a663-94418438d4e6/files/tap-fox-background.pdf

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Threat abatement plan for predation by the European red fox, DEWHA, Canberra.
Available on the internet at: http://www.environment.gov.au/system/files/resources/1846b741-4f68-4bda-a663-94418438d4e6/files/tap-fox-report.pdf

Menkins I (1998). Draft report for survey of *Homopholis belsonii* C.E. Hubb on the Darling Downs. Toowoomba and Region Environment Council Inc, Toowoomba.

National Lippia Working Group (2008). Lippia (*Phyla canescens*) Management: Challenges, opportunities and strategies.

NSW Department of Environment, Climate Change and Water (2010) National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland. Department of Environment, Climate Change and Water NSW, Sydney.
Available on the Internet at: http://www.environment.gov.au/resource/white-box-yellow-box-blakelys-red-gum-grassy-woodland-and-derived-native-grassland-national

Ross C (2013). Fact sheet: Dieback in south-east Australia. Greening Australia.
Available on the internet at: http://murrumbidgeelandcare.asn.au/files/Dieback%20fact%20sheet.pdf

Sinclair Knight Merz (2008). Central West Catchment Environmental Weeds Strategy. Sinclair Knight Merz, Newcastle, NSW.

Threatened Species Scientific Committee (2008). Commonwealth Conservation Advice on *Acacia lauta*. Department of the Environment and Heritage, Canberra.
Available on the internet at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/4165-conservation-advice.pdf

Threatened Species Scientific Committee (2008). Commonwealth Conservation Advice on *Homopholis belsonii*. Department of the Environment, Water, Heritage and the Arts, Canberra.
Available on the internet at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/2406-conservation-advice.pdf

# APPENDICES

## Appendix A – Species lists

### Table A1. Characteristic plant species of the Poplar Box Grassy Woodland

This is a characteristic rather than comprehensive list of plant species that may be present in the ecological community. Patches may not include all species on the list (only a low proportion of listed species are expected to be found at any one site) and may include other species not listed. Scientific names are nationally accepted at January 2018.

Source: Hodgkinson 1979; Beeston et al. 1980; Walker et al. 1981; Downey 1998; White et al 2002; Prober and Thiele 2004; Benson et al. 2006; Wang et al. 2008; Benson et al. 2010; Fritz 2012; Accad and Neldner 2015.

| Scientific name | Common name |
|---|---|
| **Upper layer (*canopy trees typically > 10 m*)** | |
| *Acacia harpophylla* | Brigalow |
| *Acacia pendula* | Weeping Myall, Boree |
| *Acacia salicina* | Native Willow, Willow Wattle, Broughton Willow |
| *Alectryon oleifolius* | Western Rosewood |
| *Allocasuarina luehmannii* | Buloke |
| *Angophora leiocarpa* | |
| *Atalaya hemiglauca* | Cattle Bush, Whitewood |
| *Brachychiton populneus* | Kurrajong |
| *Callitris columellaris* | Coastal Cypress Pine |
| *Callitris glaucophylla* | White Cypress Pine |
| *Casuarina cristata* | Belah |
| *Corymbia tessellaris* | Carbeen |
| *Eucalyptus albens* | White Box |
| *Eucalyptus camaldulensis* | River Red Gum |
| *Eucalyptus chloroclada* | Baradine Red Gum |
| *Eucalyptus Coolibah* | Coolibah |
| *Eucalyptus crebra* | Grey Ironbark, Narrow-leaved Ironbark |
| *Eucalyptus largiflorens* | Black Box |
| *Eucalyptus melliodora* | Yellow Box |
| *Eucalyptus melanophloia* | Silver-Leaved Ironbark |
| *Eucalyptus microcarpa* | Western Grey Box |
| *Eucalyptus moluccana* | Inland Grey Box |
| *Eucalyptus populnea* (dominant) | Poplar Box, Bimble Box |
| *Eucalyptus tereticornis* | Forest Red Gum |
| *Eucalyptus woollsiana* (formerly *E. pilligaensis*) | Grey Box, Narrow Leaved Grey Box, Pilliga Box |
| *Geijera salicifolia* | Flintwood |
| *Grevillea striata* | Beef Oak |
| *Ventilago viminalis* | Barndaragu, Supplejack |

| Scientific name | Common name |
|---|---|
| **Mistletoes and vines** | |
| *Amyema cambagei* | Needle-leaved Mistletoe |
| *Amyema congener* | Erect Mistletoe |
| *Amyema gibberula* | Hakea Mistletoe |
| *Amyema linophylla* | Buloke Mistletoe |
| *Amyema maidenii* | Pale-leaved Mistletoe |
| *Amyema miquelii* | Box Mistletoe |
| *Amyema miraculosa* | Fleshy Mistletoe |
| *Amyema preissii* | Wire-leaved Mistletoe |
| *Amyema quandang* | Grey Mistletoe |
| *Dendrophthoe glabrescens* | Smooth Mistletoe, Orange Mistletoe |
| *Diplatia grandibractea* | Coolibah Mistletoe |
| *Eustrephus latifolius* | Wombat Berry |
| *Glycine tomentella* | Woolly Glycine |
| *Jasminum suavissimum* | Native Jasmine |
| *Lysiana exocarpi* | Harlequin Mistletoe |
| *Lysiana spathulata* | |
| *Lysiana subfalcata* | Northern Mistletoe |
| *Muellerina bidwillii* | |
| *Parsonsia ventricosa* | Acuminate Silkpod |
| *Viscum articulatum* | Square-stemmed Mistletoe |
| *Viscum whitei* | |
| **Mid layer (*small trees, medium shrubs typically 1–10 m*)** | |
| *Abutilon macrum* | |
| *Abutilon malvifolium* | Bastard Marshmallow |
| *Abutilon oxycarpum* var. *subsagittatum* | Flannel Weed |
| *Acacia aneura* | Mulga |
| *Acacia curranii* | Curly-Bark Wattle |
| *Acacia elongata* | |
| *Acacia excelsa* | Ironwood |
| *Acacia lauta* | Tara Wattle |
| *Acacia stenophylla* | River Cooba, River Myall, Belalie |
| *Acacia tenuinervis* | |
| *Acacia victoriae* subsp. *arida* | Prickly Wattle |
| *Alectryon diversifolius* | Scrub Boonaree, Holly Bush |
| *Alectryon oleifolius* subsp. *canescens* | Western Rosewood |
| *Alectryon oleifolius* subsp. *elongatus* | Western Rosewood |

| Scientific name | Common name |
|---|---|
| *Allocasuarina muelleriana* | Slaty Sheoak, Common Oak-Bush |
| *Alstonia constricta* | Bitter Bark, Quinine Bush |
| *Apophyllum anomalum* | Broom Bush, Warrior Bush |
| *Atalaya salicifolia* | Brush Whitewood |
| *Bridelia leichhardtii* | Leichardt's Ironbark |
| *Bursaria spinosa* | Blackthorn, Boxthorn, Sweet Bursaria, Kurwan |
| *Capparis lasiantha* | Bush Caper, Nepine |
| *Capparis mitchellii* | Bimbil, Native Orange |
| *Carissa ovata* (QLD) | Currant Bush |
| *Carissa spinarum* (NSW) | Currant Bush |
| *Cassinia laevis* | Cough Bush, Dead Finish |
| *Chenopodium album* | Fat Hen |
| *Chenopodium nitrariaceum* | Branching Goosefoot, Nitre Goosefoot |
| *Citrus glauca* | (Australian) Desert Lime |
| *Denhamia cunninghamii* | Yellow-Berry Bush |
| *Denhamia oleaster* | |
| *Dodonaea viscosa* | Broad Leaf Hopbush |
| *Dodonaea viscosa* subsp. *angustissima* | Narrow-Leaf Hop-Bush |
| *Dodonaea viscosa* subsp. *spatulata* | Sticky Hop-Bush |
| *Duma florulenta* | Lignum |
| *Enchylaena tomentosa* | Barrier Saltbush, Ruby Saltbush |
| *Eremophila bignoniiflora* | Dogwood, Eurah |
| *Eremophila deserti* | Turkeybush |
| *Eremophila glabra* | Black Fuchsia |
| *Eremophila longifolia* | Berrigan, Emubush |
| *Eremophila mitchellii* | Bastard Sandalwood, Budda |
| *Exocapos aphyllus* | Currant Bush, Leafless Ballart |
| *Flindersia dissosperma* | Scrub Leopardwood |
| *Geijera parviflora* | Wilga |
| *Grevillea parallela* | Beefwood |
| *Hakea tephrosperma* | Hooked Needlewood |
| *Jasminum didymum* subsp. *lineare* | Desert Jasmine |
| *Maireana aphylla* | Leafless Bluebush |
| *Myoporum acuminatum* | Boobialla |
| *Myoporum montanum* | Western Boobialla |
| *Myoporum platycarpum* subsp. *perbellum* | Sugarwood |
| *Notelaea linearis* | |
| *Notelaea microcarpa* | Native Olive |

| Scientific name | Common name |
|---|---|
| *Notelaea microcarpa* var. *microcarpa* | Velvet Mock Olive |
| *Olearia pimeleoides* | Burrabunga |
| *Owenia acidula* | Emu Apple |
| *Pandorea pandorana* | Inland Wonga Vine |
| *Pimelea neo-anglica* | Poison Pimelea |
| *Pittosporum angustifolium* | Weeping Pittosporum |
| *Psydrax johnsonii* | |
| *Psydrax odorata* | Lamboto |
| *Psydrax oleifolia* | |
| *Rhagodia spinescens* | Berry Saltbush, Thorny Saltbush |
| *Santalum acuminatum* | Quandong |
| *Santalum lanceolatum* | Blue Bush, Northern Sandalwood |
| *Senna artemisioides* subsp. x *petiolaris* | Woody Cassia |
| *Senna artemisioides* subsp. *zygophylla* | |
| *Sesbania cannabina* | Sesbania Pea |
| *Sida hackettiana* | Golden Rod, Spiked Sida, Queensland Hemp |
| *Spartothamnella juncea* | Bead Bush |
| *Templetonia stenophylla* | Leafy Templetonia |
| *Tephrosia dietrichiae* | |
| *Vachellia farnesiana* | Mimosa Bush |
| **Ground layer (*herbs and shrubs typically <1m*)** | |
| *Achyranthes aspera* | Chaff Flower |
| *Actinobole uliginosum* | Camel Dung, Flannel Cudweed |
| *Ajuga australis* | Austral Bugle |
| *Alternanthera denticulata* | Lesser Joyweed |
| *Alternanthera nana* | Hairy Joyweed |
| *Alternanthera nodiflora* | Common Joyweed |
| *Ammannia multiflora* | Many-flower Ammannia |
| *Apowollastonia spilanthoides* | |
| *Arabidella eremigena* | Priddiwalkatji |
| *Arabidella nasturtium* | Yellow Cress |
| *Asperula conferta* | Common Woodruff |
| *Atriplex leptocarpa* | Creeping Saltbush |
| *Atriplex muelleri* | Annual Saltbush |
| *Atriplex semibaccata* | Creeping Saltbush, Berry Saltbush |
| *Atriplex stipitata* | Bitter Saltbush |
| *Boerhavia dominii* | Tar Vine |
| *Brachyscome basaltica* | Basalt Daisy, Swamp Daisy |

| Scientific name | Common name |
|---|---|
| *Brachyscome ciliaris* | Variable Daisy |
| *Brachyscome curvicarpa* | |
| *Brachyscome debilis* | Weak Daisy |
| *Brachyscome dentata* | Lobed-seed Daisy |
| *Brachyscome multifida* | Cut-leaved Daisy, Rocky Daisy, Hawkesbury Daisy |
| *Brunoniella australis* | Blue Trumpet |
| *Bulbine alata* | Native Leek |
| *Bulbine bulbosa* | Bulbine Lily, Native Onion |
| *Calandrinia eremaea* | Small Purslane |
| *Calocephalus sonderi* | Pale Beauty Heads |
| *Calotis cuneifolia* | Bindi-eye, Purple Burr-daisy |
| *Calotis hispidula* | Bogan Flea |
| *Calotis lappulacea* | Mallee Burr-daisy, Yellow Burr-daisy |
| *Calotis scabiosifolia* | Rough Burr-daisy |
| *Calotis scapigera* | Tufted Burr-daisy |
| *Camptacra barbata* | |
| *Centipeda minima* | Spreading Sneezeweed |
| *Cheilanthes distans* | |
| *Cheilanthes sieberi* | Mulga Fern |
| *Chenopodium cristatum* | Crested Goosefoot, Crested Crumbweed |
| *Chenopodium curvispicatum* | Cottony Saltbush |
| *Chenopodium desertorum* | Desert Goosefoot |
| *Chenopodium desertorum* subsp. *anidiophyllum* | |
| *Chenopodium desertorum* subsp. *desertorum* | Frosted Goosefoot |
| *Chrysocephalum apiculatum* | Common Everlasting |
| *Commelina cyanea* | Scurvy Weed, Wandering Jew, Creeping Christian |
| *Commelina diffusa* | Forget-Me Not |
| *Commelina lanceolata* | |
| *Convolvulus clementii* | Desert Bindweed |
| *Convolvulus erubescens* | Blushing Bindweed |
| *Convolvulus graminetinus* | Grassland Bindweed |
| *Cotula australis* | Bachelor’s Buttons |
| *Crassula sieberiana* | Austral Crassula |
| *Cullen tenax* | Tough Scurf-pea, Emu-foot, Emu Grass |
| *Cyanthillium cinereum* | Ironweed |
| *Daucus glochidiatus* | Australian Carrot |
| *Desmodium brachypodum* | Large Tick-trefoil |

| Scientific name | Common name |
|---|---|
| *Desmodium rhytidophyllum* | |
| *Desmodium varians* | Slender Tick Trefoil |
| *Dianella caerulea* | Blue Flax-lily |
| *Dianella longifolia* | Flax-lily |
| *Dianella rara* | |
| *Dianella revoluta* | Black- anther Flax-lily |
| *Dichondra spp.* | Kidney Weed |
| *Diuris tricolor* | Spotted-Throat Cowslip |
| *Dysphania melanocarpa* | Black Crumbweed |
| *Dysphania pumolio* | Clammy Goosefoot, Small Crumbweed |
| *Einadia hastata* | Berry Saltbush, Saloop |
| *Einadia nutans* subsp. *nutans* | Nodding Saltbush, Climbing Saltbush |
| *Einadia polygonoides* | |
| *Eremophila debilis* | Winter Apple, Amulla |
| *Erodium crinitum* | Blue Storkbill, Blue Crowfoot |
| *Euchiton sphaericus* | |
| *Euphorbia dallachyana* | Caustic Weed |
| *Euphorbia drummondii* | Creeping Caustic, Balsom, Mat Spurge, Flat Spurge, Milkweed |
| *Evolvulus alsinoides* | |
| *Galium gaudichaudii* | Rough Bedstraw |
| *Glossocardia bidens* | Cobbler's Tack |
| *Glycine canescens* | Silky glycine |
| *Glycine latifolia* | |
| *Glycine tabacina* | Glycine Pea |
| *Goodenia bellidifolia* | Daisy-leaved Goodenia |
| *Goodenia cycloptera* | Cut-leaf Goodenia, Serrated Goodenia |
| *Goodenia fascicularis* | Silky Goodenia |
| *Goodenia glabra* | Smooth Goodenia |
| *Goodenia pinnatifida* | Cut-leaf Goodenia, Scrambled Eggs |
| *Haloragis stricta* | |
| *Hibiscus trionum* | Flower-Of-An-Hour |
| *Hyalosperma semisterile* | |
| *Isoetopsis graminifolia* | Grass Cushions, Grass Cushion |
| *Leiocarpa brevicompta* | Flat Billy-Buttons |
| *Leiocarpa leptolepis* | Pale Plover-daisy |
| *Lepidium aschersonii* | Spiny Peppercress |
| *Lepidium pseudohyssopifolium* | Peppercress |

| Scientific name | Common name |
|---|---|
| *Lobelia concolor* (synonym *Pratia concolor*) | Poison Pratia |
| *Lobelia purpurascens* | Whiteroot |
| *Maireana brevifolia* | Cottonbush |
| *Maireana coronata* | Crown Fissure-Weed |
| *Maireana decalvans* | Black Cotton Bush |
| *Maireana enchylaenoides* | Wingless Fissure-weed |
| *Maireana humillima* | |
| *Maireana microphylla* | Small-leaf Bluebush, Eastern Cottonbush |
| *Malvastrum coromandelianum* | Prickly Malvastrum |
| *Marsdenia australis* | Doubah |
| *Marsdenia viridiflora* subsp. *viridiflora* | Native Pear |
| *Marsilea costulifera* | Nardoo |
| *Marsilea drummondii* | Common Nardoo |
| *Menkea australis* | Fairy Spectacles |
| *Mentha satureioides* | Creeping Mint, Native Pennyroyal |
| *Minuria integerrima* | Smooth Minuria |
| *Neobassia proceriflora* | Soda Bush |
| *Neptunia gracilis* | Native Sensitive Plant |
| *Nyssanthes erecta* | |
| *Osteocarpum acropterum* var. *acropterum* | Water Weed |
| *Oxalis chnoodes* | |
| *Oxalis exilis* | |
| *Oxalis perennans* | |
| *Phyllanthus virgatus* | |
| *Plantago turrifera* | Crowned Plantain |
| *Plantago varia* | Variable Plantain |
| *Portulaca filifolia* | |
| *Portulaca oleracea* | Pig Weed |
| *Pratia concolor* (NSW) | Poison Pratia |
| *Pratia purpurascens* (NSW) | Whiteroot |
| *Pterocaulon sphacelatum* | Applebush |
| *Ptilotus nobilis* subsp. *nobilis* | Pink Mulla Mulla |
| *Pycnosorus chrysanthus* | |
| *Pycnosorus globosus* | Drumsticks |
| *Ranunculus inundatus* | River Buttercup |
| *Rhynchosia minima* | |
| *Rostellularia adscendens* subsp. *adscendens* | Pink Tongues |
| *Rumex brownii* | Swamp Dock |

| Scientific name | Common name |
|---|---|
| *Rumex spp.* | Dock |
| *Salsola australis* | Soft Rolypoly |
| *Sclerolaena bicornis* | Flannel Burr, Goathead Burr |
| *Sclerolaena birchii* | Blue Burr, Galvanised Burr |
| *Sclerolaena decurrens* | Green Copper Burr |
| *Sclerolaena diacantha* | Grey Copper Burr |
| *Sclerolaena muricata* | Black Roly-poly |
| *Sclerolaena stelligera* | Star Copperburr |
| *Sclerolaena tricuspis* | Giant Red Burr |
| *Senecio hispidulus* | Hill Fireweed |
| *Senecio quadridentatus* | Cotton Fireweed |
| *Sida ammophila* | Sand Sida |
| *Sida corrugata* | Corrugated Sida |
| *Sida cunninghamii* | Ridge Sida |
| *Sida rohlenae* | Shrub Sida |
| *Sida* sp. Musselbrook (M.B. Thomas+ MRS437) (synonym *Sida filiformis*) | Fine Sida |
| *Sida spinosa* | Paddy's Lucerne |
| *Sida trichopoda* | High Sida |
| *Solanum ellipticum* | Potato Bush, Potato Weed |
| *Solanum esuriale* | Potato Bush, Quena |
| *Solanum nodiflorum* | |
| *Sphaeromorphaea australis* | Spreading Nut-heads |
| *Stackhousia monogyna* | Candles, Creamy Stackhousia |
| *Stuartina muelleri* | Spoon Cudweed |
| *Swainsona galegifolia* | Smooth Darling-pea |
| *Swainsona murrayana* | Slender Darling-pea |
| *Tetragonia eremaea* | New Zealand Spinach |
| *Tetragonia moorei* | Annual Spinach |
| *Tetragonia tetragonioides* | Warrigal Greens |
| *Tricoryne elatior* | Yellow Autumn-lily, Yellow Rush-lily |
| *Triptilodiscus pygmaeus* | Common Sunray |
| *Velleia paradoxa* | Spur Velleia |
| *Vittadinia cuneata* | Fuzzweed |
| *Vittadinia dissecta* var. *hirta* | |
| *Vittadinia pustulata* | |
| *Vittadinia sulcata* | Furrowed New Holland Daisy |
| *Wahlenbergia communis* | Tufted Bluebell |

| Scientific name | Common name |
|---|---|
| *Wahlenbergia fluminalis* | River Bluebell |
| *Wahlenbergia gracilis* | Australian Bluebell |
| *Wahlenbergia luteola* | |
| **Grasses, sedges and rushes** | |
| *Ancistrachne uncinulata* | Hooked-Hairy Panic Grass |
| *Anthosachne scabra* | Common Wheatgrass |
| *Aristida behriana* | Bunch Wiregrass |
| *Aristida benthamii* var. *benthamii* | Bentham's Wiregrass |
| *Aristida calycina* var. *calycina* | Dark Wiregrass |
| *Aristida caput-medusae* | Many Headed Wiregrass |
| *Aristida echinata* | Blue Wire-Grass |
| *Aristida gracilipes* | Three-Awn Speargrass |
| *Aristida jerichoensis* | Jericho Wiregrass |
| *Aristida jerichoensis* var. *jerichoensis* | Jericho Wiregrass |
| *Aristida latifolia* | Feathertop Wiregrass |
| *Aristida leptopoda* | White Speargrass |
| *Aristida personata* | Purple Wire-Grass |
| *Aristida queenslandica* | |
| *Aristida ramosa* | Purple Wiregrass |
| *Aristida vagans* | Three-Awned Spear Grass |
| *Arundinella nepalensis* | Dardy's Oats, Reedgrass |
| *Austrostipa aristiglumis* | Plains Grass |
| *Austrostipa bigeniculata* | Vanganbil, Tall Speargrass |
| *Austrostipa scabra* subsp. *scabra* | Rough Speargrass |
| *Austrostipa setacea* | Corkscrew Grass |
| *Austrostipa verticillata* | Slender Bamboo Grass |
| *Bothriochloa biloba* | Lobed Blue-grass |
| *Bothriochloa bladhii* | Forest Blue-grass |
| *Bothriochloa decipiens* | Pitted Blue-grass |
| *Bothriochloa ewartiana* | Desert Bluegrass |
| *Brachyachne convergens* | Common Native Couch, Spider Grass |
| *Carex inversa* | Knob Sedge |
| *Chloris divaricata* | Slender Chloris |
| *Chloris truncata* | Windmill Grass |
| *Chloris ventricosa* | Plump Windmill Grass, Tall Windmill Grass |
| *Chloris virgata* | Feather Fingergrass, Feathery Rhodes-grass , Feather Windmillgrass |
| *Chrysopogon fallax* | Golden Beardgrass |

| Scientific name | Common name |
|---|---|
| *Cymbopogon ambiguus* | Lemon Grass |
| *Cymbopogon refractus* | Barbed Wire Grass |
| *Cynodon dactylon* | Bermuda Grass |
| *Cyperus betchei* | |
| *Cyperus betchei* subsp. *betchei* | |
| *Cyperus bifax* | Downs Nut-grass |
| *Cyperus concinnus* | Trim Flat-sedge |
| *Cyperus cyperoides* | |
| *Cyperus difformis* | Variable Flatsedge |
| *Cyperus fulvus* | Sticky Sedge |
| *Cyperus gracilis* | Slender Flat-sedge |
| *Cyperus iria* | |
| *Cyperus laevis* | |
| *Cyperus subulatus* | Pointed Flat-sedge |
| *Deyeuxia decipiens* | Devious Bent-grass |
| *Dichanthium sericeum* subsp. *sericeum* | Silky Blue-grass, Queensland Bluegrass |
| *Dichanthium setosum* | Bluegrass |
| *Dichelachne micrantha* | Shorthair Plumegrass |
| *Digitaria ammophila* | Cotton Panic |
| *Digitaria brownii* | Cotton Grass |
| *Digitaria diffusa* | Open Summer-Grass |
| *Digitaria divaricatissima* | Umbrella Grass |
| *Digitaria hystrichoides* | Umbrella Grass |
| *Digitaria parviflora* | Small-flowered Finger Grass |
| *Digitaria porrecta* | Finger Panic Grass |
| *Dinebra divaricatissima* | |
| *Dipelachne fusca* subsp. *muelleri* (QLD) (synonym *Diplachne muelleri*) | |
| *Dipelachne muelleri* (NSW) (synonym *Dipelachne. fusca* subsp. *muelleri*) | |
| *Echinochloa colona* | Awnless Barnyard Grass |
| *Eleocharis acuta* | Common Spike Rush |
| *Eleocharis blakeana* | |
| *Eleocharis cylindrostachys* | |
| *Eleocharis pallens* | Pale Spike-sedge |
| *Eleocharis plana* | Flat Spike-sedge |
| *Enneapogon gracilis* | Slender Bottle-washers |
| *Enneapogon nigricans* | Nine-awn Grass |
| *Enteropogon acicularis* | Curly Windmill Grass |

| Scientific name | Common name |
| --- | --- |
| *Enteropogon ramosus* | Curly Windmill Grass |
| *Eragrostis brownii* | Brown's Lovegrass |
| *Eragrostis elongata* | Clustered Lovegrass |
| *Eragrostis eriopoda* | Woollybutt Grass |
| *Eragrostis lacunaria* | Purple Lovegrass |
| *Eragrostis leptostachya* | Paddock Lovegrass |
| *Eragrostis megalosperma* | |
| *Eragrostis parviflora* | Weeping Lovegrass |
| *Eragrostis setifolia* | Neverfail |
| *Eragrostis spartinoides* | |
| *Eragrostis trachycarpa* | |
| *Eriochloa crebra* | Cup Grass |
| *Eriochloa procera* | Spring Grass |
| *Eriochloa pseudoacrotricha* | Early Spring Grass |
| *Eulalia aurea* | Silky Browntop |
| *Fimbristylis dichotoma* | Common Fringe Sedge |
| *Fimbristylis neilsonii* | |
| *Heteropogon contortus* | Black Speargrass |
| *Homopholis belsonii* | Belson’s Panic |
| *Iseilema membranaceum* | Small Flinders Grass |
| *Juncus aridicola* | Tussock Rush |
| *Juncus subsecundus* | Finger Rush |
| *Lomandra confertifolia* | Mat-rush |
| *Lomandra filiformis* | Wattle Mat-rush |
| *Lomandra longifolia* | Spiny-head Mat-rush |
| *Lomandra multiflora* | Many-flowered Mat-rush |
| *Lomandra teres* | |
| *Monachather paradoxus* | Bandicoot Grass |
| *Panicum buncei* | |
| *Panicum decompositum* | Native Millet |
| *Panicum effusum* | Branched Panic |
| *Panicum queenslandicum* | Yadbila Grass, Coolabah Grass |
| *Panicum simile* | Two-colour Panic |
| *Paspalidium caespitosum* | Brigalow Grass |
| *Paspalidium constrictum* | Knottybutt Grass |
| *Paspalidium distans* | |
| *Paspalidium globoideum* | Shotgrass |
| *Paspalidium jubiflorum* | Warrego Grass |

| Scientific name | Common name |
|---|---|
| *Poa sieberiana* | Snowgrass |
| *Rytidosperma* spp. | Wallaby Grass |
| *Rytidosperma auriculatum* | Lobbed Wallaby Grass |
| *Rytidosperma caespitosum* | Ringed Wallaby Grass |
| *Rytidosperma fulvum* | Wallaby Grass |
| *Rytidosperma setaceum* | Smallflower Wallaby Grass |
| *Sporobolus actinocladus* | Katoora Grass |
| *Sporobolus caroli* | Fairy Grass |
| *Sporobolus creber* | Slender Rat's Tail Grass |
| *Sporobolus mitchellii* | Rat's Tail Couch |
| *Thellungia advena* | Coolibah Grass |
| *Themeda avenacea* | Native Oatgrass, Oat Kangaroo Grass |
| *Themeda triandra* | Kangaroo Grass |
| *Thyridolepis mitchelliana* | Mulga Mitchell Grass |
| *Tragus australianus* | Small Burrgrass |
| *Triraphis mollis* | Purple Needlegrass |
| *Walwhalleya proluta* | Rigid Panic |

**Table A2. Threatened plant species that may occur in the Poplar Box Grassy Woodland**

| Scientific name | Common name | NSW | QLD | National |
|---|---|---|---|---|
| *Acacia curranii* | Curly-bark Wattle | vulnerable | vulnerable | vulnerable |
| *Acacia lauta* | Tara Wattle | | vulnerable | vulnerable |
| *Dichanthium setosum* | Bluegrass | vulnerable | | vulnerable |
| *Digitaria porrecta* | Finger Panic Grass | endangered | near threatened | |
| *Diuris tricolor* | Pine Donkey Orchid | vulnerable | | |
| *Homopholis belsonii* | Belson's Panic | endangered | endangered | vulnerable |
| *Lepidium aschersonii* | Spiny Peppercress | vulnerable | | vulnerable |
| *Lomandra teres* | | | vulnerable | |
| *Swainsona murrayana* | Slender Darling Pea | vulnerable | vulnerable | vulnerable |

Source: NSW TSC Act: New South Wales *Threatened Species Conservation Act 1995*; QLD NC Act: Queensland *Nature Conservation Act 1992*; EPBC Act: National *Environment and Biodiversity Conservation Act 1999*.

**Table A3. Native fauna that may occur in the Poplar Box Grassy Woodland.**

Some species may be resident in eucalypt woodlands and use it as key habitat while other species may only be transient within the ecological community. The scientific and common names and national distributions of species were checked using The Atlas of Living Australia website and were current as at January 2018.

Source: Anstis 2002; Gibbons and Lindenmayer 2002; Sass 2006; Burbidge et al 2008; Churchill 2008; Morcombe 2010; Wilson and Swan 2010; Curtis et al. 2012.

| **Scientific name** | **Common name** | **Conservation status** | | | **Likely to use tree hollows** |
|---|---|---|---|---|---|
| | | **EPBC Act** | **NSW** | **QLD** | |
| **Mammals** | | | | | |
| *Aepyprymnus rufescens* | Rufous Bettong | | Vulnerable | | |
| *Antechinomys laniger* | Kultarr | | Endangered | | |
| *Canis familiaris* | Dingo | | | | |
| *Chalinolobus gouldii* | Gould's Wattled Bat | | | | Y |
| *Chalinolobus picatus* | Little Pied Bat | | Vulnerable | | Y |
| *Isoodon obesulus obesulus* | Southern Brown Bandicoot | Endangered | Endangered | | |
| *Macropus giganteus* | Eastern Grey Kangaroo | | | | |
| *Macrotis lagotis* | Greater Bilby | Vulnerable | Extinct | Endangered | |
| *Mormopterus eleryi* | Hairy-nosed Freetail-bat | | Endangered | | Y |
| *Mormopterus planiceps* | Inland Freetail Bat | | | | Y |
| *Miniopterus schreibersii oceanensis* | Eastern Bentwing-bat | | Vulnerable | | Y |
| *Notamacropus rufogriseus* | Red-necked Wallaby | | | | |
| *Notamacropus parryi* | Whiptail Wallaby, Pretty Face Wallaby | | | | |
| *Nyctophilus corbeni* | South-eastern Long-eared Bat | Vulnerable | Vulnerable | Vulnerable | Y |
| *Nyctophilus geoffroyi* | Lesser Long-eared Bat | | | | Y |
| *Nyctophilus gouldi* | Gould's Long-eared Bat | | | | Y |
| *Onychogalea fraenata* | Bridled nailtail Wallaby | Endangered | Extinct | Endangered | |
| *Osphranter robustus* | Common Wallaroo, Euro | | | | |
| *Osphranter rufus* | Red Kangaroo | | | | |
| *Petaurus breviceps* | Sugar Glider | | | | Y |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Petaurus norfolcensis* | Squirrel Glider | | Vulnerable | | Y |
| *Phascolarctos cinereus* | Koala | Vulnerable (combined populations of QLD, NSW and the ACT) | Vulnerable | Vulnerable (only in SE QLD Bioregion) | |
| *Phascogale tapoatafa* | Brush-tailed Phascogale | | Vulnerable | | Y |
| *Planigale tenuirostris* | Narrow-nosed Planigale | | | | |
| *Pteropus poliocephalus* | Grey-headed Flying-fox | Vulnerable | Vulnerable | | |
| *Pseudomys delicatulus* | Delicate Mouse | | | | |
| *Saccolaimus flaviventris* | Yellow-bellied Sheaftail Bat | | | | Y |
| *Scoteanax rueppellii* | Greater Broad-nosed Bat | | Vulnerable | | Y |
| *Scotorepens balstoni* | Inland Broad-nosed Bat | | | | Y |
| *Scotorepens greyii* | Little Broad-nosed Bat | | | | Y |
| *Sminthopsis crassicaudata* | Fat-tailed Dunnart | | | | |
| *Sminthopsis macroura* | Stripe-faced Dunnart | | Vulnerable | | |
| *Sminthopsis murina* | Common Dunnart | | | | |
| *Tachyglossus aculeatus* | Short-beaked Echidna | | | | |
| *Tadarida australis* | White-striped Freetail-bat | | | | Y |
| *Trichosurus vulpecula* | Common Brushtail Possum | | | | Y |
| *Vespadelus baverstocki* | Inland Forest Bat | | | | Y |
| *Vespadelus vulturnus* | Little Forest Bat | | | | Y |
| *Wallabia bicolor* | Swamp Wallaby, Black Wallaby | | | | |
| **Birds** | | | | | |
| *Acanthiza apicalis* | Inland Thornbill | | | | |
| *Acanthiza chrysorrhoa* | Yellow-rumped Thornbill | | | | |
| *Acanthiza nana* | Little (Yellow) Thornbill | | | | |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Acanthiza pusilla* | Inland Thornbill | | | | |
| *Accipiter fasciatus* | Brown Goshawk | | | | |
| *Aegotheles cristatus* | Australian Owlet-nightjar | | | | Y |
| *Alisterus scapularis* | Australian King-parrot | | | | Y |
| *Anthochaera carunculata* | Red Wattlebird | | | | |
| *Anthochaera phrygia* | Regent Honeyeater | Critically Endangered | Critically Endangered | Endangered | |
| *Anthus novaeseelandiae* | Australasian Darter | | | | |
| *Aprosmictus erythropterus* | Red-winged Parrot | | | | Y |
| *Aquila audax* | Wedge-tailed Eagle | | | | |
| *Ardeotis australis* | Australian Bustard | | Endangered | | |
| *Artamus cyanopterus* | Dusky Woodswallow | | Vulnerable | | |
| *Artamus leucorynchus* | White-breasted Woodswallow | | | | |
| *Artamus personatus* | Masked Woodswallow | | | | |
| *Artamus superciliosus* | White-browed Woodswallow | | | | |
| *Aviceda subcristata* | Pacific Baza | | | | |
| *Barnardius barnardi* | Mallee Ringneck | | | | Y |
| *Burhinus grallarius* | Bush Stone-curlew | | Endangered | | |
| *Cacatua galerita* | Sulphur-Crested Cockatoo | | | | Y |
| *Calyptorhynchus banksia samueli* | Red-tailed Black-Cockatoo (Inland Subspecies) | | Vulnerable | | Y |
| *Calyptorhynchus funereus* | Yellow-tailed Black-Cockatoo | | | | Y |
| *Calyptorhynchus lathami* | Glossy Black Cockatoo | | Vulnerable | Vulnerable | Y |
| *Centropus phasianinus* | Pheasant Coucal | | | | |
| *Chalcites minutillus* | Little Bronze-cuckoo | | | | |
| *Chenonetta jubata* | Australian Wood Duck | | | | Y |
| *Chthonicola sagittata* | Speckled Warbler | | Vulnerable | | |
| *Cincloramphus mathewsi* | Rufous Songlark | | | | |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Climacteris picumnus victoriae* | Brown Treecreeper (Eastern Subspecies) | | Vulnerable | | Y |
| *Colluricincla harmonica* | Grey Shrike-thrush | | | | Y |
| *Coracina maxima* | Ground Cuckoo-shrike | | | | |
| *Coracina novaehollandiae* | Black-faced Cuckoo-Shrike | | | | |
| *Coracina papuensis* | White-bellied Cuckoo-Shrike | | | | |
| *Corcorax melanorhamphos* | White-winged Chough | | | | |
| *Cormobates leucophaea* | White-throated Treecreeper | | | | |
| *Corvus coronoides* | Australian Raven | | | | |
| *Corvus mellori* | Little Raven | | | | |
| *Corvus orru* | Torresian Crow | | | | |
| *Coturnix ypsilophora* | Brown Quail | | | | |
| *Cracticus nigrogularis* | Pied Butcherbird | | | | |
| *Cracticus tibicen* | Australian Magpie | | | | |
| *Cracticus torquatus* | Grey Butcherbird | | | | |
| *Dacelo novaeguineae* | Laughing Kookaburra | | | | Y |
| *Daphoenositta chrysoptera* | Varied Sittella | | Vulnerable | | |
| *Dicaeum hirundinaceum* | Mistletoebird | | | | |
| *Dicrurus bracteatus* | Spangled Drongo | | | | |
| *Dromaius novaehollandiae* | Emu | | | | |
| *Egretta novaehollandiae* | White-faced Heron | | | | |
| *Entomyzon cyanotis* | Blue-faced Honeyeater | | | | |
| *Eolophus roseicapillus* | Galah | | | | Y |
| *Eopsaltria australis* | Eastern Yellow Robin | | | | |
| *Eurostopodus mystacalis* | White-throated Nightjar | | | | |
| *Eurystomus orientalis* | Dollarbird | | | | Y |
| *Falco berigora* | Brown Falcon | | | | |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Falco hypoleucos* | Grey Falcon | | Endangered | Vulnerable | |
| *Falco longipennis* | Australian Hobby | | | | |
| *Falco subniger* | Black Falcon | | Vulnerable | | |
| *Gavicalis virescens* | Singing Honeyeater | | | | |
| *Geopelia cuneata* | Diamond Dove | | | | Y |
| *Geopelia humeralis* | Bar-shouldered Dove | | | | |
| *Geopelia striata placida* | Eastern Peaceful Dove | | | | |
| *Geophaps scripta scripta* | Squatter Pigeon (Southern) | Vulnerable | Critically Endangered | Vulnerable | |
| *Gerygone olivacea* | White-throated Gerygone | | | | |
| *Grallina cyanoleuca* | Magpie-lark | | | | |
| *Grantiella picta* | Painted Honeyeater | Vulnerable | Vulnerable | Vulnerable | |
| *Gymnorhina tibicen* | Australian Magpie | | | | |
| *Haliastur sphenurus* | Whistling Kite | | | | |
| *Hieraaetus morphnoides* | Little Eagle | | Vulnerable | | |
| *Hirundo neoxena* | Welcome Swallow | | | | |
| *Lalage sueurii* | White-winged Triller | | | | |
| *Lathamus discolor* | Swift Parrot | Critically Endangered | Endangered | Endangered | Y |
| *Lichmera indistincta* | Brown Honeyeater | | | | |
| *Lophochroa leadbeateri* | Major Mitchell's Cockatoo | | Vulnerable | Vulnerable | Y |
| *Lophoictinia isura* | Square-tailed Kite | | Vulnerable | | |
| *Malurus leucopterus* | White-winged Fairy-Wren | | | | |
| *Manorina flavigula* | Yellow-throated Miner | | | | |
| *Manorina melanocephala* | Noisy Miner | | | | |
| *Melanodryas cucullata cucullata* | Hooded Robin (South-Eastern Form) | | Vulnerable | | Y |
| *Melithreptus brevirostris* | Brown-headed Honeyeater | | | | |
| *Melithreptus gularis gularis* | Black-chinned Honeyeater (Eastern Subspecies) | | Vulnerable | | |
| *Melopsitta undulatus* | Budgerigar | | | | Y |
| *Merops ornatus* | Rainbow Bee-eater | | | | |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Microeca fascinans* | Jacky Winter | | | | |
| *Milvus migrans* | Black Kite | | | | |
| *Myiagra inquieta* | Restless Flycatcher | | | | |
| *Myiagra rubecula* | Leaden Flycatcher | | | | |
| *Neophema pulchella* | Turquoise Parrot | | Vulnerable | | Y |
| *Ninox connivens* | Barking Owl | | Vulnerable | | Y |
| *Ninox novaeseelandiae* | Southern Boobook | | | | Y |
| *Northiella haematogaster* | Blue Bonnet | | | | Y |
| *Nymphicus hollandicus* | Cockatiel | | | | Y |
| *Ocyphaps lophotes* | Crested Pigeon | | | | |
| *Oreoica gutturalis* | Crested Bellbird | | | | Y |
| *Pachycephala rufiventris* | Rufous Whistler | | | | |
| *Pardalotus striatus* | Striated Pardalote | | | | Y |
| *Parvipsitta pusilla* | Little Lorikeet | | Vulnerable | | Y |
| *Phaps chalcoptera* | Common Bronzewing | | | | |
| *Philemon citreogularis* | Little Friarbird | | | | |
| *Philemon corniculatus* | Noisy Friarbird | | | | |
| *Platycercus adscitus* | Pale-headed Rosella | | | | Y |
| *Plectorhyncha lanceolata* | Striped Honeyeater | | | | |
| *Podargus strigoides* | Tawny Frogmouth | | | | |
| *Polytelis swainsonii* | Superb Parrot | Vulnerable | Vulnerable | | Y |
| *Pomatostomus superciliosus* | White-browed Babbler | | | | |
| *Pomatostomus temporalis temporalis* | Grey-crowned Babbler (Eastern Subspecies) | | Vulnerable | | |
| *Psephotus haematonotus* | Red-Rumped Parrot | | | | Y |
| *Ptilonorhynchus maculatus* | Spotted Bowerbird | | | | |
| *Ptilotula penicillata* | White-plumed Honeyeater | | | | |
| *Rhipidura fuliginosa* | Grey Fantail | | | | |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Rhipidura leucophrys* | Willie Wagtail | | | | |
| *Scythrops novaehollandiae* | Channel-billed Cuckoo | | | | |
| *Smicrornis brevirostris* | Weebill | | | | |
| *Stagonopleura guttata* | Diamond Firetail | | Vulnerable | | |
| *Stizoptera bichenovii* | Double-barred Finch | | | | |
| *Strepera graculina* | Pied Currawong | | | | |
| *Struthidea cinerea* | Apostlebird | | | | |
| *Tachybaptus novaehollandiae* | Australasian Grebe | | | | |
| *Taeniopygia guttata* | Zebra Finch | | | | |
| *Todiramphus sanctus* | Sacred Kingfisher | | | | Y |
| *Trichoglossus chlorolepidotus* | Scaly-breasted Lorikeet | | | | Y |
| *Trichoglossus haematodus* | Rainbow Lorikeet | | | | Y |
| *Turnix varius* | Painted Button-quail | | | | |
| *Turnix velox* | Little Button-quail | | | | |
| *Tyto alba* | Barn Owl | | | | Y |
| *Tyto javanica* | Eastern Barn Owl | | | | Y |
| *pTyto novaehollandiae* | Masked Owl | | Vulnerable | | Y |
| *Vanellus miles novaehollandiae* | Masked Lapwing (Southern Subspecies) | | | | |
| **Amphibians** | | | | | |
| *Crinia sloanei* | Sloane's Froglet | | Vulnerable | | |
| *Cyclorana novaehollandiae* | New Holland Frog | | | | |
| *Cyclorana platycephala* | Water-Holding Frog | | | | |
| *Cyclorana verrucosa* | Rough Frog | | | | |
| *Limnodynastes fletcheri* | Barking Frog | | | | |
| *Limnodynastes tasmaniensis* | Spotted Grass Frog | | | | |
| *Limnodynastes terraereginae* | Northern Banjo Frog | | | | |
| *Litoria caerulea* | Green Tree Frog | | | | Y |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Litoria latopalmata* | Broad-Palmed Frog | | | | |
| *Litoria peronii* | Peron's Tree Frog | | | | Y |
| *Litoria rubella* | Desert Tree Frog | | | | Y |
| *Neobatrachus sudellae* | Sudells Burrowing Frog | | | | |
| *Platyplectrum ornatum* | Ornate Burrowing Frog | | | | |
| *Uperoleia laevigata* | Smooth Toadlet | | | | |
| *Uperoleia rugosa* | Wrinkled Toadlet | | | | |
| **Reptiles** | | | | | |
| *Acritoscincus platynotus* | Red-throated Skink | | | | |
| *Amalosia rhombifer* | Zigzag Velvet Gecko | | Endangered | | Y |
| *Amphibolurus burnsi* | Burn's Dragon | | | | |
| *Amphibolurus muricatus* | Jacky Lizard | | | | |
| *Anilios affinis* | Small-headed Blind Snake | | | | |
| *Anilios proximus* | Proximus Blind Snake | | | | |
| *Anilios unguirostris* | Claw-snouted Blind Snake | | | | |
| *Anilios wiedii* | Brown-snouted Blind Snake | | | | |
| *Anilios ligatus* | Robust Blind Snake | | | | |
| *Anomalopus brevicollis* | Short-necked Worm-Skink | | | | |
| *Anomalopus leuckartii* | Two-clawed Worm-Skink | | | | |
| *Anomalopus mackayi* | Five-clawed Worm-skink, Long-legged Worm-Skink | Vulnerable | Endangered | Endangered | |
| *Anomalopus verreauxii* | Three-clawed Worm-Skink | | | | |
| *Antaresia maculosa* | Spotted Python | | | | |
| *Aspidies melanocephalus* | Black-headed Python | | | | |
| *Aspidites ramsayi* | Woma | | Vulnerable | Near threatened | |
| *Bellatorias frerei* | Major Skink | | | | |
| *Boiga irregularis* | Brown Tree Snake | | | | |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Brachyurophis australis* | Australian Coral Snake | | | | |
| *Carlia munda* | Shaded-Litter Rainbow-skink | | | | |
| *Carlia pectoralis* | Open-Litter Rainbow-skink | | | | |
| *Carlia rubigo* | Orange-flanked Rainbow Skink | | | | |
| *Carlia schmeltzii* | Robust Rainbow Skink | | | | |
| *Carlia tetradactyla* | Southern Rainbow-skink | | | | |
| *Carlia vivax* | Lively Rainbow Skink | | | | |
| *Christinus marmoratus* | Marbled Gecko (Possible) | | | | |
| *Cryptoblepharus australis* | Inland Snake-eyed Skink | | | | |
| *Cryptoblepharus carnabyi* | Carnaby's Skink | | | | Y |
| *Cryptoblepharus metallicus* | Metallic Snake-eyed Skink | | | | |
| *Cryptoblepharus pannosus* | Ragged Snake-eyed Skink | | | | |
| *Cryptoblepharus pulcher* | Elegant Snake-eyed Skink | | | | |
| *Cryptophis boschmai* | Carpentaria Snake | | | | |
| *Cryptophis nigrescens* | Eastern Small-eyed Snake | | | | |
| *Ctenotus allotropis* | Brown-blazed Wedgesnout Ctenotus | | | | |
| *Ctenotus ingrami* | Unspotted Yellow-sided ctenotus | | | | |
| *Ctenotus regius* | Royal Ctenotus, Pale-rumped Ctenotus | | | | |
| *Ctenotus robustus* | Eastern Striped Skink | | | | |
| *Ctenotus spaldingi* | Spalding's Ctenotus | | | | |
| *Delma inornata* | Patternless Delma | | | | |
| *Delma tincta* | Excitable Delma | | | | |
| *Demansia psammophis* | Yellow-faced Whipsnake | | | | |
| *Dendrelaphis punctulata* | Green Tree Snake | | | | Y |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Denisonia devisi* | De Vis' Banded Snake, Mud adder | | | | |
| *Denisonia maculata* | Ornamental Snake | Vulnerable | | Vulnerable | |
| *Diplodactylus tessellatus* | Tessellated Gecko | | | | |
| *Diplodactylus vittatus* | Wood Gecko, Eastern Stone Gecko | | | | |
| *Diporiphora australis* | Tommy Roundhead | | | | Y |
| *Diporiphora nobbi* | Nobbi Dragon | | | | |
| *Egernia rugosa* | Yakka Skink | Vulnerable | | Vulnerable | |
| *Egernia striolata* | Tree Skink | | | | Y |
| *Eremiascincus richardsonii* | Broad-banded Sand-swimmer | | | | |
| *Furina barnardi* | Yellow-naped Snake | | | | |
| *Furina diadema* | Red-naped Snake | | | | |
| *Furina dunmalli* | Dunmall's Snake | Vulnerable | | Vulnerable | |
| *Gehyra catenata* | Chain-backed Tree Dtella | | | | |
| *Gehyra dubia* | Dubious Dtella | | | | Y |
| *Gehrya variegata* | Tree Dtella | | | | Y |
| *Gehyra versicolor* | | | | | |
| *Hemiaspis damelii* | Grey Snake | | | Endangered | |
| *Heteronotia binoei* | Bynoe's Gecko, Prickly Gecko | | | | |
| *Hoplocephalus bitorquatus* | Pale-headed Snake | | Vulnerable | | Y |
| *Lampropholis guichenoti* | Grass Skink | | | | |
| *Lerista fragilis* | Eastern Mulch-slider | | | | |
| *Lerista muelleri* | Wood Mulch Slider | | | | |
| *Lerista punctatovittata* | Eastern Robust Slider | | | | |
| *Lerista timida* | Timid Slider | | | | |
| *Lialis burtonis* | Burton's Snake-Lizard | | | | |
| *Liopholis modesta* | Eastern Ranges Rock-skink | | | | |
| *Liopholis whitii* | White's Skink | | | | |
| *Lophognathus burnsi* | Burn's Dragon | | | | |
| *Lucasium damaeum* | Beaded Gecko | | | | |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Lucasium steindachneri* | Box-patterned Gecko | | | | |
| *Lygisaurus foliorum* | Tree-Base Litter-skink | | | | |
| *Menetia greyii* | Common Dwarf Skink | | | | |
| *Morelia spilota* | Diamond Python | | | | Y |
| *Morethia boulengeri* | Boulenger's Skink | | | | |
| *Morethia taeniopleura* | Fire-Tailed Skink | | | | |
| *Nebulifera robusta* | Robust Velvet Gecko | | | | Y |
| *Oedura marmorata* | Marbled Velvet Gecko | | | | Y |
| *Oedura monilis* | Ocellated Velvet Gecko | | | | Y |
| *Paradelma orientalis* | Brigalow Scaly-foot | | | | |
| *Parasuta dwyeri* | Dwyer's Snake | | | | |
| *Parasuta spectabilis* | Spectacled Hooded Snake | | | | |
| *Pogona barbata* | Eastern Bearded Dragon | | | | Y |
| *Pseudechis australis* | King Brown Snake, Mulga Snake | | | | |
| *Pseudonaja textilis* | Eastern Brown Snake | | | | |
| *Pygopus lepidopodus* | Common Scaly-foot | | | | |
| *Pygopus schraderi* | Eastern Hooded Scaly-foot | | | | |
| *Rhynchoedura ormsbyi* | Eastern Beaked Gecko | | | | |
| *Rhynchoedura ornata* | Beaked Gecko | | | | |
| *Strophurus intermedius* | Eastern Spiny-tailed Gecko | | | | Y |
| *Strophurus williamsi* | Eastern Spiny-tailed Gecko | | | | |
| *Suta suta* | Curl Snake | | | | |
| *Tiliqua rugosa* | Shingleback Lizard | | | | |
| *Tiliqua scincoides* | Blue-Tongue | | | | |
| *Underwoodisaurus milii* | Thick-tailed Gecko, Barking Gecko (W&S) | | | | |
| *Varanus gouldii* | Sand Goanna | | | | |
| *Varanus panoptes* | Yellow-spotted Monitor | | | | |
| *Varanus tristis* | Freckled Monitor | | | | Y |

| Scientific name | Common name | Conservation status | | | Likely to use tree hollows |
|---|---|---|---|---|---|
| | | EPBC Act | NSW | QLD | |
| *Varanus varius* | Lace Monitor | | | | Y |
| *Vermicella annulata* | Bandy-Bandy | | | | |

**Table A4**. **Weed species that may occur in the Poplar Box Grassy Woodland.**

Source: Benson et al. 2006; Wang et al. 2008; Benson 2010; Fritz 2012.

| Scientific name | Common name |
|---|---|
| *Ammi majus* | Bishop's-weed, Bullwort |
| *Andropogon gayanus* | Gamba Grass |
| *Asphodelus fistulosus* | Onion Weed, Wild Onion |
| *Avena fatua* | Black Oats |
| *Avena ludoviciana* | Ludo, Wild Oats |
| *Bidens pilosa* | Cobbler's Pegs, Farmer's Friend |
| *Bryophyllum* spp. | Mother Of Millions |
| *Carthamus lanatus* | Saffron Thistle |
| *Cenchrus ciliaris* | Buffel Grass |
| *Centaurium tenuiflorum* | |
| *Chloris gayana* | Rhodes Grass |
| *Chondrilla juncea* | Skeleton Weed |
| *Ciclospermum leptophyllum* | Marsh Parsley, Slender Celery, Fir-leaved Celery |
| *Cirsium vulgare* | Spear Thistle |
| *Convolvulus arvensis* | Field Bindweed |
| *Conyza bonariensis* | Flaxleaf Fleabane |
| *Conyza sumatrensis* | Guernsey Fleabane |
| *Cyperus flavus* | Denton's Flatsedge |
| *Echinochloa esculenta* | Japanese Barnyard Millet |
| *Echium plantagineum* | Salvation Jane |
| *Ehrharta calycina* | Perennial Veldt Grass |
| *Eleusine tristachya* | Goose Grass, Crabgrass |
| *Eragrostis cilianensis* | Stinkgrass |
| *Eragrostis curvula* | African Lovegrass |
| *Erodium cicutarium* | Common Storksbill, Common Crowfoot |
| *Euphorbia* sp. | |
| *Glandularia aristigera* | Mayne's Pest |
| *Gnaphalium pensylvanicum* | Pennsylvania Cudweed |
| *Gomphocarpus physocarpus* | Balloonplant, Balloon Cotton-bush, Bishop's Balls, Nailhead |
| *Gomphrena celosioides* | Gomphrena Weed |
| *Heliotropium amplexicaule* | Clasping Heliotrope, Blue Heliotrope, Summer Heliotrope |
| *Hordeum leporinum* | Barley Grass |
| *Hyparrhenia hirta* | Coolatai Grass |
| *Hypochaeris glabra* | Smooth Catsear |

| Scientific name | Common name |
|---|---|
| *Hypochaeris radicata* | Catsear, Flatweed |
| *Lactuca serriola* | Prickly Lettuce |
| *Leontodon rhagadioloides* | Cretan Weed |
| *Leontodon rhagadioloides* subsp. *cretica* | Cretan Weed |
| *Lepidium africanum* | |
| *Lepidium bonarise* | Cut-leaf Peppercress |
| *Lolium perenne* | Perennial Ryegrass |
| *Lolium rigidum* | Wimmera Ryegrass |
| *Lycium ferocissimum* | African Boxthorn |
| *Malva parviflora* | Small-Flowered Mallow |
| *Malvastrum americanum* | Spiked Malvastrum |
| *Medicago minima* | Woolly Burr Medic |
| *Medicago polymorpha* | Burr Medic |
| *Megathyrsus maximus* | Guinea Grass |
| *Melinis repens* | Rose Natal Grass, Natal Grass |
| *Opuntia aurantiaca* | Tiger Pear |
| *Opuntia stricta* | Spiny Pest Pear |
| *Opuntia tomentosa* | Velvety Tree Pear |
| *Oxalis corniculata* var. *corniculata* | Procumbent Yellow-sorrel, Sleeping Beauty |
| *Parthenium hysterophorus* | Parthenium Weed |
| *Paspalum didatatum* | Paspalum |
| *Paspalum dilatatum* | Dallisgrass, Dallas Grass, Sticky Heads |
| *Pavonia hastata* | |
| *Petrorhagia nanteuilii* | |
| *Phyla canescens* | Lippia |
| *Physalis lanceifolia* | |
| *Physalis longifolia* | Groundcherry, Longleaf Groundcherry, Wild Tomatillo |
| *Plantago lanceolata* | Lamb's Tongues, Plantain |
| *Polygonum arenastrum* | Wireweed |
| *Polygonum aviculare* | Prostrate Knotweed, Birdweed, Pigweed, Lowgrass |
| *Portulaca pilosa* | Kiss-Me-Quick, Hairy Pigweed |
| *Rapistrum rugosum* | Turnip Weed, Giant Mustard |
| *Salsola australis* (formerly *Salsola kali*) | Soft Roly-Poly |
| *Setaria pumila* | Yellow Foxtail, Yellow Bristle-grass, Pigeon Grass, Cattail Grass |
| *Sida rhombifolia* | Paddy's Lucerne |

| Scientific name | Common name |
|---|---|
| *Sisymbrium irio* | London Rocket |
| *Sonchus oleraceus* | Common Sowthistle |
| *Sorghum halepense* | Johnson Grass |
| *Spergularia diandra* | |
| *Spergularia rubra* | Sandspurry, Red Sand-Spurrey |
| *Stellaria pallida* | Lesser Chickweed |
| *Symphyotrichum subulatum* | Wild Aster, Bushy Starwort |
| *Themeda quadrivalvis* | Grader Grass |
| *Tribulus terrestris* | Cat’s Head |
| *Trifolium angustifolium* | Narrow-Leaved Clover |
| *Trifolium glomeratum* | Clustered Clover |
| *Vachellia farnesiana* | Sweet Acacia, Huisache, Needle Bush |
| *Verbena bonariensis* | Purpletop |
| *Verbena gaudichaudii* | |
| *Verbena litoralis* | Seashore Vervain, Brazilian Vervain |
| *Verbena officinalis* | Common Vervain, Common Verbena |
| *Verbesina encelioides* subsp. *encelioides* | |
| *Vernena aristigera* | Mayne's Pest |
| *Vulpia myuros* | Rat's Tail Fescue |
| *Xanthium strumarium* | Large Cocklebur |
| *Zinnia peruviana* | Wild Zinnia |

## APPENDIX B – DETAILED DESCRIPTION OF THREATS

This appendix provides information about the known and potential threats to the ecological community. This information helps to explain why the ecological community merits listing as threatened, supporting the assessment for listing against criteria at Appendix C. The threats outlined have corresponding conservation actions which are detailed in Section 6 of the conservation advice.

### B1. Clearance and fragmentation

In eastern Australia areas containing Poplar Box (*Eucalyptus populnea*) were predominantly the first lands settled west of the Great Dividing Range. Settlement in these regions commenced in the 1820s in New South Wales and about 1840 in Queensland. The first domestic livestock introduced were cattle, horses and later sheep. With the development of railways some land was used for growing cereal crops and for dairying. In this period of European expansion most areas of woodland were selectively cleared or were modified by grazing and burning (Weston et al. 1980). Since the early 1890s, the killing of trees on grazing lands to increase grass growth in the ground layer for livestock has been common practice, although some trees are kept for stock shelter and for timber harvesting (Back et al. 2009a; 2009b). With mechanised farming practices, broad scale clearing has greatly eroded the remaining area of Poplar Box woodland, and the rates of clearing remain appreciable at the present time, but vary year to year (DNR 2007; DECCW 2009; DSITIA 2014a, 2014b; DSITI 2015, 2016; OEH 2016). In NSW Eucalyptus populnea and other trees common to this community are declared as 'invasive native scrub' exempting them from standard clearing regulations.

Clearing has substantially decreased the extent, and increased the fragmentation, of Poplar Box Grassy Woodland and the broader landscape in which it occurs. The extent of clearance is detailed in the criteria analysis at Appendix C. Impacts from historical clearance for agricultural and pastoral activities have been compounded by rural-residential development and construction of mines and other infrastructure, including roads and railways. Clearance of hollow bearing canopy tree species such as Poplar Box, and/or grass and forb species in the understorey have direct impacts on fauna species through loss of habitat for foraging, breeding, roosting and shelter; for instance such loss can lead to the decline of microbats and arboreal mammals and birds.

The canopy of Poplar Box Grassy Woodland has been heavily cleared over much of its former range, and much of the native understorey has declined or been replaced by exotic plants. Some patches may retain some native trees; however, destruction of the ground layer effectively represents a loss of the largest component of vegetative biodiversity in the ecological community. In many cases, the loss of the understorey is effectively irreversible if remnants are converted to permanent croplands, improved pastures, mining voids and other permanently developed sites.

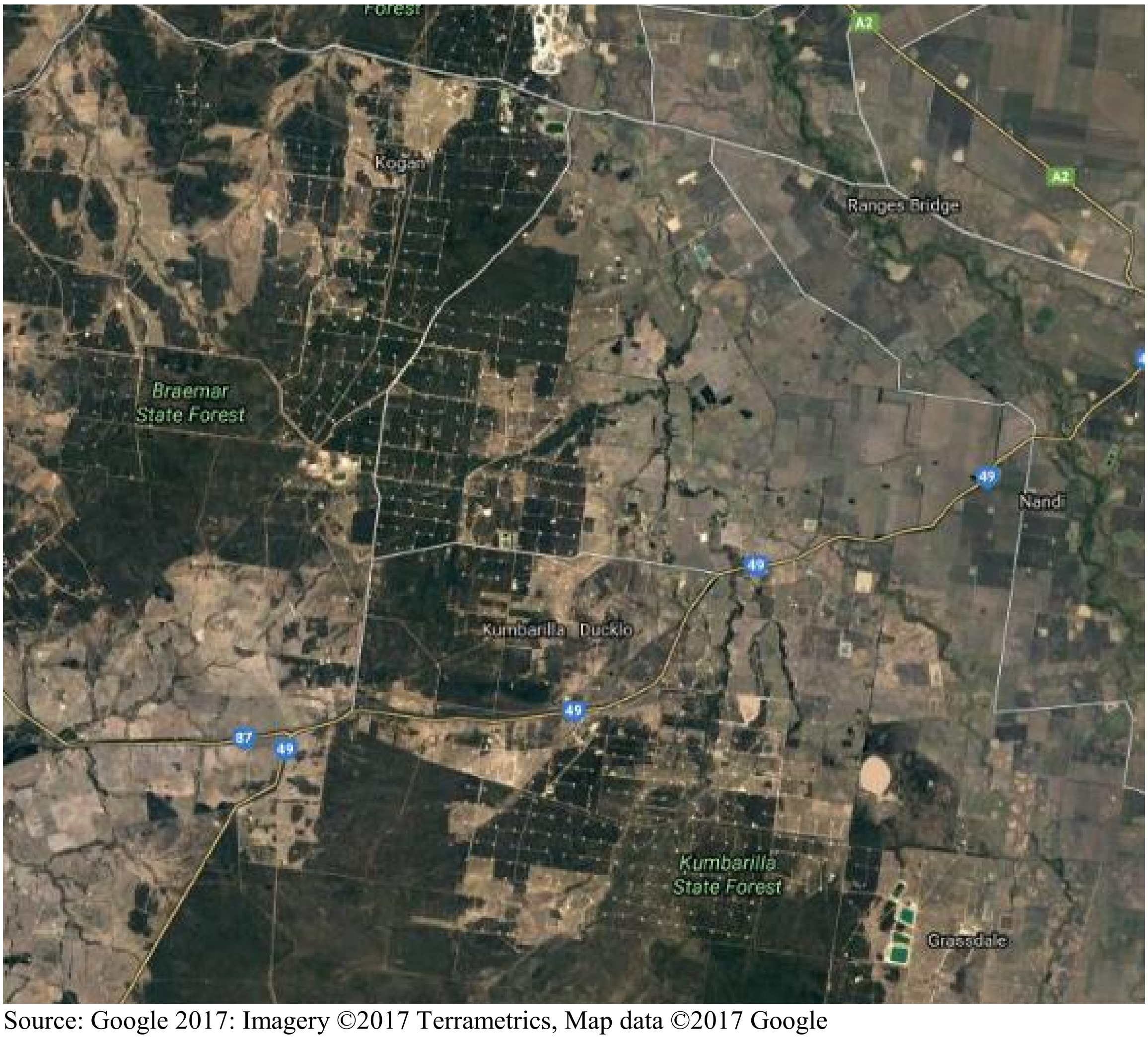
Extensive clearing and conversion to cropping, such as in the NSW Liverpool Plains and Queensland Darling Downs has resulted in smaller, fragmented stands with an increase of edge to area ratio (Benson et al. 2006; Benson 2008; Queensland Herbarium 2015). Smaller, isolated fragments are less buffered against disturbances and edge effects, such as invasion by weeds that encroach from their margins, or impacts from surrounding landscape and development activities such as spray drift and hydrological changes. As the condition of many remnants continues to decline through additional clearance of the canopy and understorey modification, the degree of fragmentation are expected to increase. The removal of standing and fallen hollow-bearing trees for timber, altered fire regimes, and grazing of domestic livestock are likely to have long-term effects on remaining tree health.

Fragmentation also leads to small, isolated populations resulting in loss of genetic variability, inbreeding and mutation. Fragmentation can reduce food availability for species, increase predator abundance, and restrict normal adaptive behaviour. Small and/or fragmented populations are also more likely to become extinct through stochastic events such as fire (Williams et al. 2012b).

B2. Mining

Significant high-quality bituminous coal (black coal) deposits, and substrates containing unconventional gas[18] (including shale and coal seam gas) underlay the Poplar Box Grassy Woodland in both NSW and Queensland, such as in the Bowen, Surat and Galilee Basins. Direct removal of coal from open-cut and subterranean mining involves land clearing. Exploration for and extraction of unconventional gas also often impacts remnant vegetation (Figure B1). Once vegetation is cleared and topsoil stripped, these areas cannot be recovered to a pre-mining state, particularly for open-cut mines. In addition to the mine site, further clearing and modification occurs in order to provide service infrastructure for mining activities (associated buildings, roads and pipelines) and the requirement of additional areas for deposition of overburden and spoil (Butt et al. 2013).

**Figure B1.** Unconventional gas wells in Braemar and Kumbarilla State Forests near Dalby, southern Queensland. The satellite image shows extensive networks of wells and roads within native vegetation remnants among a landscape that is already heavily fragmented.




Source: Google 2017: Imagery ©2017 Terrametrics, Map data ©2017 Google

Clearing and vegetation disturbance associated with access tracks and gas pipelines provide an opportunity for fast growing, colonising species, such as acacias, non-native perennial grasses and other weed species, to establish which can lead to changes in the floristic structure and composition of vegetation communities. Colonisation by these species can lead to an increase in competition for resources such as light, nutrients and space and changes to the micro-climate, e.g.

[18] Unconventional gas: natural gas (methane and other hydrocarbon gases) extracted from non-porous rock layers such as coal seams (300–1000 m below ground level) or shale formations (>1500 m below ground level). Gas is generally extracted either by removing groundwater within the coal seam formation or hydraulically fracturing (fracking) the shale formation.

through shading. In the long-term, the impact is a loss of native biodiversity and an increase in weed infestations, loss of fauna habitat value, increase in fire fuel loads and changes in the subsequent conservation management requirements of remnant vegetation (Australia Pacific LNG 2010b).

Increasing works for unconventional gas exploration and development is likely to lead to ongoing fragmentation of remnant vegetation over large areas, impacting regions where the Poplar Box Grassy Woodland occurs. Khan and Kordek (2014) noted that in the Gunnedah Basin, each coal seam gas (CSG) well has an expected 5-20 year life span, and a typical CSG to Liquefied Natural Gas (LNG) project with multiple supply wells may have a 25-35 year production time. Clearing enough space for multiple well pads, roads and pipelines in a single or large patches of native vegetation can therefore result in cumulative fragmentation (Figure B1) and produce substantial increased vehicle traffic flow in areas previously devoid of such activities. Once CSG and LNG production becomes unviable due to reduced gas flow, new wells are required to be developed to maintain gas supply.

Mining can also lead to the disruption of hydrological processes, erosion and changes to soil structure and chemistry. Underground mining and unconventional gas extraction can result in subsidence or fractures in the subsurface rocks which can be associated with cracking of valley floors, creek lines and aquifers, subsequently affecting surface and groundwater hydrology (ACARP 2001, 2002, 2003; Australia Pacific LNG 2010a, 2010b).

Likely fauna impacts from mining activities include (Australia Pacific LNG 2010a, 2010b; Cumberland Ecology 2013; Eco logical 2013):

- Removal of habitat such as mature vegetation, hollow-bearing trees and fallen logs and therefore loss of breeding, nesting, perching and foraging resources
- Disturbance to shelter including ground cover such as leaf litter for reptiles, small mammals and terrestrial dependant birds
- Disturbance to fauna movement corridors and dry season fauna refuges (e.g. riparian vegetation)
- Unearthing burrowing fauna species during construction
- Mortality - Direct mortality of native fauna may also occur from poisoning and/or drowning in saline detention ponds, and from vehicle strike (road kill)
- Trenchfall – Ground-dwelling fauna may fall into open trenches and become trapped and exposed to overheating, dehydration, predation and/or drowning. Fauna entrapment particularly within pipeline trenches has been recognised as a key environmental issue by APIA (2013), Swan and Wilson (2012) and Doody et al. (2003).

B3. Invasive weeds and pest animals

The Poplar Box Grassy Woodland has an extensive geographic range but remnants throughout this range are often in close proximity to heavily disturbed and modified land. As a result, many invasive species which threaten the ecological community include perennial species often associated with agricultural and pastoral lands.

Grassy woodlands such as the Poplar Box Grassy Woodland are distinguished from shrubby woodlands by the presence of a well-developed grass and forb layer and the lack of a dense shrub layer, although scattered or patchy shrubs may be present. Given the ecological community's open grassy structure and association with more fertile alluvial soils, understorey species in the Poplar Box Grassy Woodland can be readily impacted by a range of threats. In particular introduced pasture species that are directly planted or spread from surrounding agricultural lands or disturbed sites. These weeds can disperse into the ecological community via water, wind, livestock, machinery or other disturbance.

The most serious perennial weeds include: African lovegrass (*Eragrostis curvula*), buffel grass (*Cenchrus ciliaris*), Coolatai grass (*Hyparrhenia* hirta) and lippia (*Phyla canescens*, also present at some sites subject to occasional inundation). Serious annual and seasonal weeds include: burr medic (*Medicago polymorpha*), Cretan weed (*Leontodon rhagadioloides*), flat weed (*Hypochaeris* *radicata*), parthenium weed (*Parthenium hysterophorus*), paspalum (*Paspalum dilatatum*) and small-flowered mallow (*Malva parviflora*) (Cox et al. 2001; Wang et al. 2008; Benson et al. 2010; Welsh et al. 2014). Table A4 in Appendix A lists some weeds that may occur in the ecological community.

Several feral animal species have been recorded throughout the ecological community, for example rabbits, foxes, pigs, rats, goats, deer, mice, cats and dogs. Rabbits may selectively remove the most palatable herbs and grasses and suppress regeneration. Goats and deer damage trees, eat and trample ground layer plants and can cause erosion. Pigs do considerable damage to vegetation by digging and turning over the sod particularly during wet periods. Pigs may also selectively target native lilies and orchids which have palatable tubers, and may also consume eggs and young of ground-nesting birds. Introduced carnivores such as foxes, cats and dogs are a threat to a wide range of native fauna species that are part of the ecological community (DEWHA 2008, DoEE 2016).

B4. Inappropriate fire regimes

Prior to European settlement Indigenous use of fire is likely to have managed parts of the vegetation in the range of the Poplar Box Grassy Woodland. Fire was used in grassy woodlands for purposes such as flushing out possums and kangaroos, encouraging new growth to attract animals to hunt, and to limit tree and shrub densities (McIntyre 2011; Graham et al. 2014). Fire frequency is considered to have been a factor in maintaining an open grassy structure prior to European settlement. However, drought coupled with overgrazing and weeds has dramatically altered fuel loads and fire regimes.

Graham et al. 2015 notes that fire frequency varies greatly across the full extent of Poplar Box woodland. Estimates of fire frequency range from almost annually in the higher rainfall areas of northern Queensland, down to 1:10, 1:25 and 1:50 years in the southern NSW extent of the woodland, particularly in semi-arid regions. Different fuel loads have been attributed to high rainfall and fire frequency with native perennial grass species producing higher fuel loads than annual species, and invasive species such as buffel grass producing very high fuel loads.

Fire frequency, seasonality, height and intensity of fires can affect species dominance in the ecological community. Disruption or changes to one or more of these processes can alter the prevalence and density of flora components. For example, the grass species *Heteropogon* and *Themeda* exhibit differing protective and germination strategies. *Heteropogon's* deep seed burial mechanism can protect the species more effectively from hot fires than associated shallow seeding native species, such as *Bothriochloa* and *Dichanthium*. In addition, the germination of buried *Heteropogon* seeds can be enhanced by burnt, blackened soils absorbing greater amounts of solar radiation at a time when ambient temperatures are too low for this to occur in unburnt situations. *Themeda's* dense internally damp tussocks can more effectively insulate the species from radiant heat damage of fire than the loose tussock formation of *Heteropogon* such as in regularly burned and lightly grazed areas (Shaw 1957; Walker et al. 1981; Graham et al. 2015).

The spread of shrub species in recent decades has changed the structure of some grassy woodlands (Cunningham et al. 1992; Yates and Hobbs 1997; Graham et al. 2014). Fire frequency is considered to have been a factor in maintaining an open grassy structure before European settlement (Hodgkinson and Harrington, 1985). In the absence of fire, woody cover can increase, particularly in semi-arid areas (Hodgkinson, 1998, Hodgkinson and Harrington 1985; Yates and Hobbs 1997). In addition, impacts from drought and preferential grazing may impact on the understorey structure of grassy woodlands (Harrington 1991). However, Fensham et al. (2017) suggests that perceptions of fire-controlled dynamics which leads to woody thickening in subtropical woodlands are largely unsupported by evidence and that instead, successive recruitment and senescence of shrubs is primarily related to climate cycles i.e. rainfall patterns governing the mortality and regeneration of flora species.

Fire intensity and frequency, exacerbated by invasive ecosystem transforming species, such as buffel grass in the northern extent of the ecological community, threaten floristic diversity, particularly of native perennial grasses. Invasive grasses with high biomass, such as buffel grass and Rhodes grass (*Chloris gayana*) can cause changes in fire regimes through a positive feed-back cycle known as the 'grass-fire cycle'. This feedback cycle can also be initiated when drought followed by rain allows invasive grasses to more quickly colonise patches than native grass species (Fensham et al. 2015). Fire loads fuelled by high biomass species reduce the diversity in the understorey of grassy woodlands such as the ecological community (Fairfax and Fensham 2000). Fire-promoting grasses also have the potential to alter the nutrient cycle and carbon cycling processes within remnant grassy woodland ecosystems (Rossiter et al. 2003).

B5. Grazing

Moderate to heavy, or frequent, grazing by domestic stock along with the activities of feral pests and native herbivores can change the structure, composition and ecological function of the ecological community (Lunt 2005). Grazing impacts such as browsing, compaction of topsoil, which often prevents seeds from germinating (Cole et al. 2004), and erosion, result in the decline and disappearance of palatable plant species and make restoration of a diverse native understorey problematic (Prober et al. 2002; Prober and Thiele 2005; Martin and McIntyre 2007). Many native grass and forb species do not appear to form persistent longer-term soil seed banks, so that once plants have been eliminated from a patch of vegetation, they are unable to re-establish naturally, even if grazing pressure is removed (Cole et al. 2004). Impacts on the soil seed bank are exacerbated where ploughing or other measures remove the soil-stored seed bank or disrupt their germination potential, thus preventing the natural, unassisted regeneration of the vegetation (Lunt 2005).

The extent to which native plant species are affected by grazing depends on their palatability, growth form and regeneration capacity. For example, kangaroo grass, present in parts of the ecological community, is highly palatable and proliferates when grazing is excluded, particularly in response to summer rain, but may be eliminated under continued heavy grazing regimes. Forbs with erect growth forms are also more prone to decline under grazing than those with rosette or prostrate growth forms. Bare areas or 'scalds' created by heavy grazing also provide opportunities for the establishment of exotic plant species.

Livestock tend to concentrate around points of water availability or shelter from heat, cold and wind. For example, in the most westerly extent of the ecological community in the wheat sheep zone of south eastern Australia, watering points are often located within or adjacent to remnant vegetation, therefore concentrating nutrient deposition and stock activity in these sensitive areas. Native flora species adapted to low nitrogen and phosphorous soils can decline due to nutrient enrichment from animals or direct pasture improvement, which can also further advantage exotic plant species (Lunt 2005; Dorrough et al. 2006; Duncan et al. 2008).

B6. Dieback

Dieback is the premature, relatively rapid decline of canopy crown health of native tree species often leading to their death. Dieback affects eucalypts in ecological communities that range from forests, woodlands to scattered trees in open woodland and farmland. When affected by dieback, eucalypts such as *Eucalyptus populnea* typically have sparse foliage, often with chlorosis (yellowing), and a large proportion of dead or dying branches. It can be caused by a variety of biotic or abiotic factors, that can interact synergistically to cause decline in tree health, and that appear to be linked with land use practices (Reid and Landsberg, 1999; Jurskis, 2005; Reid et al., 2007).

Factors implicated in the dieback of *Eucalyptus populnea* include:

- Water stress, notably from drought and falling water tables, which can increase foliage nitrogen levels and increase salinity.
- Insect herbivory, notably outbreaks of insect pests in response to increased nutrient levels in the foliage and roots of food plants. Insect pests involved include lerps (Hemiptera: Psyllidae), sawfly larvae (Hymenoptera: *Perga* spp.), and Christmas and leaf beetles (Coleoptera: Scarabaeidae and Chrysomelidae).

- Vertebrate herbivores, overgrazing of patches by species such as *Phascolarctos cinereus* (koala), *Trichosurus vulpecula* (brush-tailed possum), *Cacatua galerita* (sulphur-crested cockatoo) and *Eolophus roseicapillus* (galah).
- Pathogens and parasites, including heavy infestations of mistletoes (e.g. *Amyema miquelii* and *A. pendula*); and fungal diseases of trees, cankers, foliage diseases and diseases of seedlings (Reid and Yan 2000).
- Woodland fragmentation disrupting community function, for instance through a decline in parasitoids and predator insects and birds that keep pest insect populations in check. Bird insectivores may also be displaced by *Manorina melanocephala* (noisy miners). Agricultural chemicals may contribute to a decline in arthropod predators, such as spiders.
- Tree populations with little age structure or genetic variation or low degree of regrowth levels if these are equally attractive to herbivores.

<u>B7. Chemical impacts and spraydrift</u>

The crops and pastures that surround or occur adjacent to remnant patches of the Poplar Box Grassy Woodland are also prone to significant weed invasion problems. Broad-scale applications of herbicides and pesticides are often used to control undesirable weeds on these agricultural lands.

Non-selective chemicals in the form of defoliants, herbicides and insecticides can spread to remnant vegetation via various pathways including spray drift, vapour and dust transport, leaching and runoff. These pathways can transport agricultural chemicals many kilometres given specific conditions. The movement of chemicals through spray drift is dependent on several factors including air temperature, droplet size and prevailing winds, while runoff can be either in the form of soil to which the chemical is bound, or in aqueous solution. The movement of agricultural chemicals through runoff and leaching can lead to contamination of surface and groundwater (Mawhinney 1998; Thoms et al. 1999).

Reid et al. (2007) noted that since the 1970s herbicide use has increased on the Liverpool Plains with the shift from grazing to cropping land use. The change to minimum tillage for soil conservation purposes has also contributed to the trend towards increased herbicide reliance in cropping systems. The defoliant glyphosate is widely used in all cropping systems in the region.

Broad-spectrum pesticides such as fenitrothion were periodically sprayed up to the 1990s from the air over areas affected by the Australian plague locust (*Chortoicetes terminifera*). Australian studies on the effects of sublethal fenitrothion exposure in birds have recorded potentially detrimental impacts to reproduction and feeding in a number of species. Since 2004 the Australian Plague Locust Commission (APLC) has largely replaced the aerial application of chemical pesticides with the use of a biological control agent, *Metarhizium acridum* (Green Guard). However, aerial spraying of insecticides may still pose an indirect threat to bird species, such as the plains-wanderer, which occurs in the ecological community, through impacts to food webs if spraying impacts on food abundance within the ecological community.

Groundwater recharge on the Liverpool Plains consists of localized runoff flowing onto the colluvial and alluvial fans on the mid and lower slopes surrounding the Plains, with recharge also occurring across the broad alluvial plains (Dawes et al. 2000). As the canopy trees of the Poplar Box Grassy Woodland are dependent on surface and shallow groundwater, and given the ecological community mainly occurs on alluvial soils in agricultural areas, the spread of chemicals via these various pathways can adversely impact on the integrity of the ecological community.

The scale and duration of chemical impacts from mining activities, such as coal seam gas (CSG) extraction can also be significant. The associated water produced during CSG extraction typically contains concentrations of salts, boron, fluoride and sodium and elevated pH compared with potable water (Australia Pacific LNG 2010a). These chemicals can also leach into surface and groundwater impacting on remnant vegetation.

B8. Nutrient enrichment

Nutrient enrichment of native grassy woodland remnants is highly detrimental to the many native plant species that have adapted to the poor nutrient status of most Australian soils. This can occur through intentional application of inorganic fertilisers to promote non-native pastures, incidental drift from adjacent farmland or accumulation of manure from livestock. Although eucalypts are likely to adapt to increasing nutrient loads, understorey species such as native perennial geophytes decline with an increase in soil nutrient phosphorus content (Prober and Thiele 2005; Reid et al. 2007; Duncan et al. 2008). Increased availability of soil nutrients following soil disturbance also contributes to the establishment of weeds into grassy systems.

As a result of these practices, good quality patches of grassy vegetation have become increasingly restricted to small remnants in areas marginal for agriculture. Smaller woodlands are further prone to increased soil nutrient load as a consequence of livestock sheltering as well as drift from surrounding agricultural land. In a study by Duncan et al. (2008), it was noted that small remnants patches (<3ha) were accumulation zones for nutrients, with levels comparable or higher than adjacent crop lands. In the semi-arid crop lands, current trends in intensification of cropping are also likely to increase the nutrient threat to larger remnants. Re-establishing natural soil nutrient status is identified as a major inhibitor to restoring grassy ecosystems (Prober et al. 2005) and areas where exotic pasture species have been sown and maintained through elevated soil nutrient levels are difficult to restore to their natural state.

B9. Salinity

Salinisation or dry land salinity can be dependent on the specific geomorphology and topography of a site (House of Representatives Standing Committee on Science and Innovation 2004). As a consequence of the lateral flow of subsurface seepage, dissolved salts move from hill-slopes to valley floors. As the Poplar Box Grassy Woodland is often located in low lying sites such as alluvial plains and terraces adjacent to watercourses, salinisation can be a problem. Salinity affects both the understorey and overstorey species in remnant native woodlands. Causes include historic land use practices, and the destruction of perennial vegetation through clearance resulting in increased recharge and/or a rise in groundwater. Dry land salinity occurs most significantly in components of the ecological community that correspond within NSW mapping unit Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion (PCT101).

B10. Climate change

Climate change poses a serious long-term threat to terrestrial and aquatic ecosystems with the potential to change ecology of these environments through changes to species composition and function (Dunlop et al. 2012). The increasingly fragmented nature of the Poplar Box Grassy Woodland greatly increases its vulnerability to the effects of a changing climate, for example by limiting movement of native species.

A number of studies have made climate predictions relevant to regions where the Poplar Box Grassy woodland ecological community occurs, to some extent. By 2050, the ecological community generally is predicted to experience a general warming in all seasons, reduced winter and spring rainfall, and increased summer rainfall (DECCW 2010a; Dunlop et al. 2012; Hueston et al. 2012). DECCW (2010a; 2010b) projected climate change effects to 2050 for the New England, North West and Western regions of NSW. Daily maximum temperatures are projected to increase by an average of 1–3°C, with the greatest increases during autumn, winter and spring (2–3°C). Evaportation is predicted to increase and result in generally drier conditions throughout the year. The frequency of very high or extreme fire-risk days could also increase. The fire season is likely to be extended as a result of higher temperatures and evaporation, however more research is needed to assess how projected climate changes may impact on fire frequency and intensity.

Regional climate modelling also has been undertaken by CSIRO (Ekstrom et al. 2015). Their report for the Central Slopes region covers the bulk of the ecological community's extent from Roma, Queensland in the north to Orange, NSW in the south and from the ranges west to Walgett, NSW. They provided short-term projections to 2030 and longer-term projections to 2090 for low and high emissions scenarios. Their basic predictions are that:

- temperatures will increase [by 0.6-1.5°C in the short-term across all emission scenarios, and in the long-term by between 0.6-1.8°C under a low emission scenario (RCP2.6) and 3.0-5.4°C under a high emission scenario (RPC8.5)];
- hotter days will become more frequent [for instance, the number of days above 35°C in Dubbo is projected to double by 2090 under a medium emission scenario (RCP4.5)];
- evaporation will increase; and
- rainfall will be lower at least during winter to spring though changes in other seasons are unclear in the model.

Recent analysis by the CSIRO and Bureau of Meteorology (2016) shows that the duration, frequency and intensity of extreme heat events have increased across large parts of Australia, and are projected to continue to increase into the future. Over much of the region where the ecological community occurs, hasher fire weather, increased intensity of extreme rainfall events, and an increase in the proportion of time spent in drought under a high emission scenario is also projected (Ekstrom et al. 2015).

These predicted changes to climate are likely to impact upon the ecological community and result in issues such as:

- loss of resilience to degradation and fragmentation;
- structural and compositional changes of the herbaceous ground layer:
  - changed $C_3$/$C_4$ ratios e.g. summer-growing or $C_4$ grasses, such as kangaroo grass, redgrass or the weed African lovegrass (*Eragrostis curvula*), are likely to replace the winter-growing or year-long green or $C_3$ grasses, such as speargrasses and wallaby grasses in the ecological community's southern extent;
  - replacement of perennial grasses with annual species;
  - reduced pasture production and increasing grazing pressure from livestock, eastern grey kangaroos and other macropods and exotic herbivores.
- predominance of exotic plant species and reduced native forb diversity;
- altered fire frequency, increased intensity and spread;
- high rainfall areas under increased pressure for cropping; and
- cascading changes in ecological interactions.

Climate change could also exacerbate existing threats such as habitat loss, altered fire regimes, altered hydrological regimes, dieback and the spread of invasive species. This could put increasing pressure on the ecological community as a whole and alter the survival rates of constituent species. It is also likely to interact with other threats, such as changed fire regimes and weed invasion. The long generation time and limited dispersal ability of some key species, such as Poplar Box is likely to limit adaptation through range shift. Cool seasonal species such as $C_3$ grass species, are likely to contract further south than their current range.

The impacts of threats on the Poplar Box Grassy Woodland are analyses in detail against the listing criteria in Appendix C.

**Appendix C – Eligibility for listing against the EPBC Act criteria**

This appendix presents a detailed assessment of whether and how the Poplar Box Grassy Woodland on Alluvial Plains ecological community meets each of the six listing criteria. It forms the listing advice from the Threatened Species Scientific Committee to the Minister.

Criterion 1 – Decline in geographic distribution

| Criterion 1. Decline in geographic distribution | | | |
|---|---|---|---|
| **Category** | **Critically Endangered** | **Endangered** | **Vulnerable** |
| Its decline in geographic distribution is **either**: | very severe | **severe** | substantial |
| **a)** Decline relative to the longer-term (beyond 50 years ago e.g. since 1750); **or**, | ≥90% | **≥70%** | ≥50% |
| **b)** Decline relative to the shorter-term (past 50 years). | ≥80% | ≥50% | ≥30% |

**Eligible under Criterion 1(a) for listing as Endangered**

**Evidence:**

Prior to European settlement the Poplar Box Grassy Woodland was part of an extensive range of intergrading grassy woodland and grassland ecosystems that extended throughout eastern Australia inland between the Great Dividing Range and the arid zones. Many of these areas and ecosystems have been heavily modified for agricultural, pastoral, urban and mining activities. Changes in structure, composition and function have occurred to the ecological community through clearance of overstorey and understorey species and from intensive long-term grazing, pasture development and cropping.

Published estimates of the pre-1750 extent, current distribution and decline are incomplete for some areas of Poplar Box Grassy Woodland. However, there are available data for most areas and these demonstrate severe declines across the Poplar Box Grassy Woodland's range. The pre-1750 extent of the ecological community in Queensland has been estimated to have been about 2.5 million ha but has declined to an estimated 566 700 ha (a decline of about 77%) (Table C1). In Queensland, it is also apparent that clearing of native remnant vegetation, including the ecological community is continuing for certain activities, including: high-value agriculture, extractive industries and grazing (DNRM 2013; 2014).

**Table C1**. Estimates of extent and decline for key NSW (PCT) and Queensland (RE) mapping units that primarily correspond to the Poplar Box Grassy Woodland.

| Map Unit | Pre-1750 extent (ha) | Current extent (ha) | Decline (%) |
|---|---|---|---|
| **Queensland** | | | |
| RE 11.3.2[19] | 1 926 400 | 506 200 | 74 |
| RE 11.3.17 | 259 700 | 34 500 | 87 |
| RE 11.4.7[20] | 209 400 | 19 200 | 91 |
| RE 11.4.12 | 66 900 | 7 400 | 89 |
| RE 12.3.10 | 20 500 | 400 | 98 |
| Sub total in QLD | 2 490 900 | 566 700 | 77 |
| **NSW** | | | |
| PCT56 (RVC 22) [21] | 450 000 | 100 000 | 78 |
| PCT87 (RVC 76) | 600 000 | 200 000 | 67 |
| PCT101 (RVC 80) | 20 000 | 5 000 | 75 |
| PCT244 (RVC 22) | 1 500 000 | 400 000 | 73 |
| Sub total in NSW | 2 570 000 | 705 000 | 73 |
| | | | |
| Total | 5 060 900 | 1 271 700 | 75 |

Source: Benson 2006; Benson et al 2010; OEH 2017; Accad et al 2019.

The pre-1750 extent of the Poplar Box Grassy Woodland in NSW was estimated to be about 2.57 million hectares by Benson et al. (2006, 2010). Estimates indicate that the ecological community has declined in NSW to the present extent of approximately 705 000 ha.

The data from Benson et al. (2006, 2010) were combined with the Queensland data when deriving estimates of total decline across the whole of the ecological community (Table C1). The estimates for decline in Table C1 do not take into consideration the condition of remnants. Although the majority of decline in extent has mainly occurred due to historical clearance and weed invasion, expanding agricultural, pastoral and mining activities continue to reduce the extent in both NSW and Queensland (Benson 2006; Australia Pacific 2010b; Benson et al. 2010; Cumberland Ecology 2013; Accad et al 2017; OEH 2017; Accad et al 2019).

The pre-1750 extent of the ecological community across its entire range is estimated to be 5.06 million hectares and the current extent is estimated to be 1.27 million hectares. These estimates account for most known patches of the ecological community and are considered indicative of total decline. It is likely that the extent of the Poplar Box Grassy Woodland that remain in good condition and which meet the condition thresholds (see section 3.2.2) is substantially lower than indicated in Table C1. The Committee judges that it is likely that the ecological community has undergone a decline in extent across its entire distribution of at least 75%.

The ecological community has undergone a **severe decline** in its geographic extent and is therefore eligible to be listed as **Endangered** under this criterion.

[19] In the Queensland Regional Ecosystem notation (e.g. RE11.3.2) the first number denotes the bioregion, the second number the land zone and the third number the vegetation type. Land Zone 3 - Recent Quaternary alluvial systems. Alluvium is sediment mass deposited from channelled stream flow or over-bank stream flow.

[20] Land Zone 4 - Paleogene-early Quaternary clay plains. Originates from ancient alluvial deposits and aeolian clays (parna). Elevated above Land Zone 3.

[21] RVC - Regional Vegetation Community; PCT – Plant Community Type.

Criterion 2 – Limited geographic distribution coupled with demonstrable threat

| Criterion 2 - Limited geographic distribution coupled with demonstrable threat | | | |
|---|---|---|---|
| Its geographic distribution is: | **Very restricted** | **Restricted** | **Limited** |
| 2.1. Extent of occurrence (EOO) | < 100 $km^2$<br>= <10,000 ha | <1,000 $km^2$<br>= <100,000 ha | <10,000 $km^2$<br>= <1,000,000 ha |
| 2.2. Area of occupancy (AOO) | < 10 $km^2$<br>= <1,000 ha | <100 $km^2$<br>= <10,000 ha | <1,000 $km^2$<br>= <100,000 ha |
| 2.3. Patch size # | < 0.1 $km^2$<br>= <10 ha | < 1 $km^2$<br>= <100 ha | - |
| **AND** the nature of its distribution makes it likely that the action of a threatening process could cause it to be lost in: | | | |
| the Immediate future<br>[within10 years, or 3 generations of any long-lived or key species, whichever is the longer, up to a maximum of 60 years.] | Critically endangered | Endangered | Vulnerable |
| the Near future<br>[within 20 years, or 5 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years.] | Endangered | Endangered | Vulnerable |
| The Medium term future<br>[within 50 years, or 10 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years.] | Vulnerable | Vulnerable | Vulnerable |

# A number of patch size measures may be applied here, depending on what data are available.
1) The mean or the median patch area. In cases where the ecological community is highly fragmented and the patch data distribution is skewed towards mostly small patches, the median would be a more appropriate measure. Otherwise, the smaller of the mean or median should be referred to.
2) The proportion of patches that fall within each size class.
3) Changes in patch size and distribution between the modelled pre-1750 and currently mapped occurrences.

Criterion 2 aims to identify ecological communities that are geographically restricted to some extent and due to that, demonstrable threats could lead to loss of the ecological community. It is recognised that an ecological community with a distribution that is limited, either naturally or that has become so through landscape modification, has an inherently higher risk of extinction if it continues to be subject to ongoing threats that may cause it to be lost in the future. That there are demonstrable and ongoing threats to the Poplar Box Grassy Woodland on Alluvial Plains ecological community has been detailed in *Appendix B – Description of threats*.

The indicative measures that apply to this criterion are:

- extent of occurrence, an estimate of the total geographic range over which the ecological community occurs;
- area of occupancy, an estimate of the area actually occupied by the ecological community, which generally equates with its present extent;
- patch size and size distribution, an indicator of the degree of fragmentation of the ecological community and the vulnerability of small patches to particular threats; and
- an assessment of timeframes over which threats could result in loss of the ecological community.

The generational length of Poplar Box is quite long and likely requires up to 20 years for effective seedset to enable generation. However, this species can also sucker after disturbance which may also allow for more rapid regeneration than other canopy species.

**Insufficient information available for listing under Criterion 2**

**Evidence:**

Extent of occurrence

The Poplar Box Grassy Woodland occurs widely from central Queensland to southern NSW. The extent of occurrence of the ecological community would exceed its pre-1750 extent of about 5.06 million ha (Table C1) which exceeds the threshold for being considered limited.

Area of occupancy

The Poplar Box Grassy Woodland is estimated to occupy a total area of approximately 1.27 million ha (Table C1). The estimated area of occupancy of the ecological community therefore greatly exceeds the threshold for being considered limited.

Patch size distribution

Patch size data for the ecological community are available for Queensland (Accad and Neldner 2015) and the northern to central extent of NSW (OEH 2017). These data cover much of the extent of the Poplar Box Grassy Woodland and may be indicative of the patch size distribution for the ecological community as a whole given similar threats across Queensland and NSW.

Data collated for five regional ecosystems across Queensland showed that the median patch size in Queensland was 7.5 ha (Table C2), and that 58% of patches were less than 10 ha in size while 93% were under 100 ha (Table C3).

**Table C2**. Patch size distribution for Queensland Regional Ecosystems that correspond to the Poplar Box Grassy Woodland.

| Regional Ecosystem | Patch no. ≤ 10 ha | Patch no. >10 - ≤100 ha | Patch no. >100 ha - <1000 ha | Patch no. ≥1000 ha | Total no. of patches | Median patch (ha) |
|---|---|---|---|---|---|---|
| **RE 11.3.2** | 1 431 | 929 | 211 | 11 | 2 582 | 7.9 |
| **RE 11.3.17** | 263 | 171 | 19 | 0 | 453 | 7.5 |
| **RE 11.4.7** | 432 | 200 | 29 | 0 | 661 | 6.3 |
| **RE 11.4.12** | 155 | 82 | 10 | 0 | 247 | 8.1 |
| **RE 12.3.10** | 30 | 6 | 1 | 0 | 37 | 2.6 |
| **Total** | 2 311 | 1 388 | 270 | 11 | 3 980 | **7.5** |

**Table C3**. Indicative patch size distribution for the Poplar Box Grassy Woodland ecological community in Queensland.

| Thresholds | | Size range (ha) | No. patches | % patches | Cumulative % |
|---|---|---|---|---|---|
| Restricted | Very Restricted | ≤ 10 | 2311 | 58 | 93 |
| | | > 10 - ≤100 | 1388 | 35 | |
| | | > 100 - <1000 | 270 | 6.8 | |
| | | ≥ 1000 | 11 | >0.3 | |
| | | **Total** | **3980** | **100** | |

Source: Accad and Neldner 2015.

Available data on current patch size is limited to the four key NSW Plant Community Types (PCT) in two NSW mapping regions: Central West Lachlan, and Border River Gwydir Namoi. These regions, however, account for the main distribution of Poplar Box Grassy Woodland within NSW but there are no reliable data for the other mapping regions in NSW. The data for the two regions indicate a similar pattern of fragmentation to that which occurs in Queensland. Data collated for the four PCTs showed that the median patch size in NSW was smaller than for Queensland, at 1.4 ha (Table C4), with 89% of patches being less than 10 ha in size and 99% of patches under 100 ha (Table C5).

**Table C4.** Patch size distribution for CentralWest Lachlan and Border River Gwydir Namoi mapping regions (in NSW) that correspond to the Poplar Box Grassy Woodland.

| Regional Ecosystem | Patch no. ≤ 10 ha | Patch no. >10 - ≤100 ha | Patch no. >100 ha - <1000 ha | Patch no. ≥1000 ha | Total no. of patches | Median patch (ha) |
|---|---|---|---|---|---|---|
| **PCT56** | 16 864 | 2 170 | 127 | 0 | 19 161 | 1.5 |
| **PCT87** | 3 001 | 119 | 1 | 0 | 3 121 | 1.6 |
| **PCT101** | 5 671 | 377 | 7 | 0 | 6 055 | 0.9 |
| **PCT244** | 24 176 | 3 141 | 219 | 2 | 27 538 | 1.3 |
| **Total** | 49 712 | 5 807 | 354 | 2 | 55 895 | **1.4** |

Source: OEH 2017.

**Table C5**. Indicative patch size distribution for the Poplar Box Grassy Woodland ecological community in NSW for CentralWest Lachlan and Border River Gwydir Namoi mapping regions.

| **Thresholds** | | **Size range (ha)** | **No. patches** | **% patches** | **Cumulative %** |
|---|---|---|---|---|---|
| Restricted | Very Restricted | ≤ 10 | 49 712 | 89.0 | 99.4 |
| | | > 10 - ≤100 | 5 807 | 10.4 | |
| | | > 100 - <1000 | 354 | 0.6 | |
| | | ≥ 1000 | 2 | <0.1 | |
| | | **Total** | **55 875** | **100** | |

Source: OEH 2017.

**Table C6.** Indicative patch size distribution for the Poplar Box Grassy Woodland ecological community in NSW and Queensland

| **Thresholds** | | **Size range (ha)** | **No. patches** | **% patches** | **Cumulative %** |
|---|---|---|---|---|---|
| Restricted | Very Restricted | ≤ 10 | 52 023 | 87.0 | 99.0 |
| | | > 10 - ≤100 | 7 195 | 12.0 | |
| | | > 100 - <1000 | 624 | 1.0 | |
| | | ≥ 1000 | 13 | <0.1 | |
| | | **Total** | **59 855** | **100** | |

Source: Accad and Neldner 2015; OEH 2017.

Overall, when the data for Queensland was grouped with the available information for NSW, the large majority of patches are under ten hectares in size, indicating a fragmented distribution. This may be a consequence of natural patchiness of the landforms on which the ecological community occurs, as well as disturbances associated with human impacts (and is considered further under Criterion 4). Nevertheless, data on current patch sizes is lacking across the full distribution.

Conclusion

There are ongoing threats and evidence that clearing is not only ongoing but has increased most recently in Queensland at least (see Criterion 5). However, the ecological community is widely distributed, the area of occupancy is not limited (over a million hectares remain) and there are some large remnants persisting. Notably there are also some data gaps, particularly in regard to quantification of patch sizes across NSW. Listing under this criteria rests on rapid rates of decline and threats operating within the ecological community's geographic distribution. While there are a large number of threats operating throughout the range of the Poplar Box Grassy Woodland, and loss of the ecological community may occur over a short timeframe in some areas, based on available information, this is not apparent across its entire geographic distribution. This criterion considers fragmentation across the entire extent of the ecological community. However, the impacts of localised and more recent declines are properly considered under Criterion 5. In conclusion, there is **insufficient information to properly determine eligibility** of the ecological community for listing under any category of criterion 2.

Criterion 3 – Loss or decline of functionally important species

| Criterion 3 - Loss or decline of functionally important species | | | |
|---|---|---|---|
| **Category** | **Critically Endangered** | **Endangered** | **Vulnerable** |
| For a population of a native species likely to play a major role in the community, there is a: | very severe decline | severe decline | substantial decline |
| Estimated decline over the last 10 years or three generations, whichever is longer of: | at least 80% | at least 50% | at least 20% |
| to the extent that restoration of the community is not likely to be possible in: | the immediate future | the near future | the medium-term future |
| *restoration* of the ecological community as a whole is *unlikely* in | 10 years, or 3 generations of any long-lived or key species, whichever is the longer, up to a maximum of 60 years. | 20 years, or 5 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years. | 50 years, or 10 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years. |

**Insufficient information available for listing under Criterion 3.**

**Evidence:**

There are few detailed studies on functional species in the Poplar Box Grassy Woodland. However, *Eucalyptus populnea* being the dominant species of the canopy cover of the ecological community has a key functional role in determining vegetation structure and influencing hydrological inputs for groundwater, surface water flow and salinity. The canopy further alters microclimate, affecting light transmission, temperature and humidity, as well as mitigating the erosional effects of wind and rainfall.

Poplar Box trees are also important as they provide food and habitat for fauna in the ecological community, for example, for nectarvores when the trees flower during summer. However, the ability of the trees to provide resources and habitat is diminished if they are in poor condition, or in a state of young regrowth. A large variety of native fauna species are dependent on tree hollows for shelter and nesting, including parrots, owls, possums, gliders and bats. The proportion of trees with hollows increases with tree diameter (Gibbons and Lindenmayer 2002; Manning et al. 2004). The formation of large hollows in the trunk can take many decades. Gibbons and Lindenmayer (2002) noted that hollows suitable for fauna species may not form in some eucalypts until after at least 120 years, with larger hollows taking more than 200 years to develop. Therefore, lost large hollows may not be replaced for very long periods. Mature trees with hollows are limited in many of the rural lands of Queensland, where widespread clearing has removed much of the mature vegetation and habitat features.

The Poplar Box Grassy Woodland is characterised by subtle variations in understorey species composition across its full extent due to the wide-ranging climate, soil types and landscape positions. A consequence of the variable nature of the ecological community is that no individual understorey species has an apparent functional importance across the entire range of the Poplar Box Grassy Woodland.

Fragmentation of the ecological community has reduced its ability to support a natural and complete assemblage of fauna, particularly those with small home ranges. The loss of woodland birds is a major cause of eucalypt dieback in eastern Australia by insect attack. In some locations a healthy bird community has been observed to remove 50–70% of foliage feeding insects, thus playing an important role in maintaining the health of the tree layer (Ford 1989; Barrett 2000).

The loss of bird and mammal species from the ecological community is also likely to have a negative effect on ecological function, through the reduction of pollination, seed dispersal and soil engineering (Eldridge and James 2009; Fleming et al. 2013). Additionally fundamental changes in nutrient inputs and hydrology associated with land clearing for agriculture and pastoral activities cause physical, chemical and biological changes to woodland soils, driving reductions in the abundance and quality of soil, groundcover density and type, and litter dwelling invertebrates, which are a major food source for many woodland birds (Hannah et al. 2007; Ford 2011; Ingwersen and Tsaros 2011; Maron et al. 2011; Watson 2011). However, there are no data on impacts from loss of fauna specific to Poplar Box Grassy Woodland.

Whilst threats are likely to have broadly impacted functionally important species, such as Poplar Box trees and woodland bird species, particularly insectivores and terrestrial granivores, specific data related to the impacts due to decline of such species in this ecological community are not available. As such there is **insufficient information to determine the eligibility** of the ecological community for listing under any category of Criterion 3.

Criterion 4 – Reduction in community integrity

| Criterion 4 - Reduction in community integrity | | | |
|---|---|---|---|
| **Category** | **Critically Endangered** | **Endangered** | **Vulnerable** |
| The reduction in its integrity across most of its geographic distribution is: | very severe | **severe** | substantial |
| as indicated by degradation of the community or its habitat, or disruption of important community processes, that is: | | | |

Note: Reference should also be made to the indicative restoration timeframes as outlined under Criterion 3, above.

**Eligible under Criterion 4 for listing as Endangered**

**Evidence:**

Criterion 1 considers how much of the ecological community has been lost outright. Criterion 4 considers that areas of the ecological community that remain are subject to progressive degradation and loss of flora and fauna diversity and ecological integrity, notably as a consequence of the increased fragmentation and isolation of remnants, weed invasion and inappropriate land management (e.g. grazing and fire) regimes. Other threats, such as rural tree dieback and the potential impacts from climate change may also contribute to loss of integrity over time.

Many of the threats and disturbances acting on the Poplar Box Grassy Woodland are common to other grassy woodland systems in the intensive land use zone of eastern Australia. It is assumed the nature of impacts are similar across woodland types.

*Reduction in integrity through fragmentation*

Reliable data on patch size distribution of the Poplar Box Grassy Woodland in Queensland shows that the ecological community was naturally fragmented, in line with the alluvial landscape associated with the ecological community (Table C7). However, clearance has reduced connectivity and decreased the overall number and size of patches. In addition, patches originally would have been contiguous with other woodland and grasslands that also were present across alluvial plains and lowlands but are now also heavily cleared in the areas where the ecological community occurs.

**Table C7**. Patch size distribution of the Poplar Box Grassy Woodland ecological community in Queensland for the modelled pre-1750 extent and remnant vegetation in 2013.

| | ≤ 10 ha | >10 - 100 ha | >100 - 1000 ha | >1000 ha | Total | Median |
|---|---|---|---|---|---|---|
| *Number of patches* | | | | | | |
| **Pre-1750** | 5312 | 3472 | 953 | 84 | 9821 | 8.38 |
| **2013** | 2278 | 1415 | 289 | 11 | 3982 | 7.53 |
| **Reduction (%)** | 57 | 59 | 70 | 87 | 59 | |

Source: Accad and Neldner (2015). Data collated for five Regional Ecosystems in Queensland that correspond to the Poplar Box Grassy Woodland ecological community: 11.3.2, 11.3.17, 11.4.7, 11.4.12 and 12.3.10.

The main difference between the pre-1750 distribution and the 2013 extent is that there are fewer patches overall in 2013, particularly of less large and very large patches over 100 hectares in area. These very large patches have declined by 87% overall. There were 2.5 times as many patches pre-1750 than existed at 2013. It is presumed that the fewer patches in 2013 are also more isolated, being spaced further apart. This is in line with the study of eucalypt woodlands as bird habitat in central Queensland by Hannah et al. (2007), who noted that:

*"analysis of Landsat imagery taken in 1984 and 1999* [showed that] *the amount of woodland within 10 km of each woodland fragment site had fallen from 68% in 1984 to 34% in 1999 (and that within 1 km of these sites had fallen from 67% to 31%).”*

The pattern of decline in Poplar Box Grassy Woodland is not distributed evenly across the landscape, as shown by decline within each local government area in Queensland (Table C8). Local government areas in the northern and western edge of the ecological community’s northern range in Queensland had relatively lower levels of decline. High levels of decline (70% or more) were evident in the central and southern LGAs, that often coincide with prime, very productive agricultural lands (e.g. Darling Downs), hence the extensive nature of their clearing.

**Table C8.** Extent and decline of Poplar Box Grassy Woodland within local government areas (LGAs) that occur in Queensland. LGAs are sorted in order of decline for Poplar Box.

| Local Government Area | Pre-1750 extent (ha) | 2013 extent (ha) | 2015 extent (ha) | 2017 extent (ha) | Total decline of native vegetation (%) | Total decline of the ecological community (%) |
|---|---|---|---|---|---|---|
| Somerset Regional | 1 144 | 2 | 2 | 2 | 64.4 | 99.8 |
| Lockyer Valley Regional | 2 582 | 8 | 8 | 8 | 59.7 | 99.7 |
| Ipswich City | 945 | 21 | 21 | 21 | 78.6 | 97.8 |
| North Burnett Regional | 53 156 | 1 567 | 1 567 | 1 539 | 57.4 | 97.1 |
| Southern Downs Regional | 12 259 | 518 | 514 | 514 | 64.0 | 95.8 |
| Gympie Regional | 859 | 47 | 47 | 47 | 58.1 | 94.5 |
| Gladstone Regional | 6 754 | 396 | 396 | 396 | 44.6 | 94.1 |
| Rockhampton Regional | 38 410 | 2 471 | 2 468 | 2 453 | 68.3 | 93.6 |
| Scenic Rim Regional | 284 | 19 | 19 | 19 | 70.8 | 93.3 |
| Livingstone Shire | 1 476 | 97 | 96 | 96 | 38.1 | 93.5 |
| Toowoomba Regional | 119 610 | 8 544 | 8 537 | 8 448 | 74.0 | 92.9 |
| Western Downs Regional | 382 351 | 41 069 | 40 880 | 40 547 | 70.2 | 89.4 |
| South Burnett Regional | 3 869 | 432 | 432 | 432 | 74.6 | 88.8 |
| Goondiwindi Regional | 175 187 | 20 327 | 20 080 | 19 847 | 75.3 | 88.7 |
| Balonne Shire | 213 261 | 29 872 | 29 656 | 29 235 | 77.9 | 86.3 |
| Banana Shire | 184 523 | 29 187 | 29 109 | 28 954 | 65.3 | 84.3 |
| Barcaldine Regional | 131 109 | 30 689 | 30 486 | 30 131 | 31.1 | 77.0 |
| Maranoa Regional | 433 576 | 106 370 | 105 885 | 105 437 | 63.6 | 75.7 |
| Central Highlands Regional | 342 966 | 100 485 | 100 403 | 99 980 | 57.5 | 70.8 |
| Isaac Regional | 182 879 | 78 597 | 78 099 | 77 296 | 53.1 | 57.7 |
| Murweh Shire | 114 886 | 65 087 | 64 995 | 64 496 | 3.1 | 43.9 |
| Mackay Regional | 438 | 272 | 272 | 272 | 39.3 | 37.9 |
| Blackall Tambo Regional | 44 014 | 28 368 | 28 291 | 28 120 | 33.6 | 36.1 |
| Whitsunday Regional | 42 197 | 27 535 | 27 250 | 26 934 | 26.5 | 36.2 |
| Woorabinda Aboriginal | 2 209 | 1 495 | 1 495 | 1 495 | 44.9 | 32.3 |
| Charters Towers Regional | 40 487 | 30 062 | 30 062 | 30 062 | 6.3 | 25.7 |

Source: Accad et al 2019. Data were collated for five Regional Ecosystems that have Poplar Box as a dominant component: RE11.3.2, 11.3.17, 11.4.7, 11.4.12 and 12.3.10.

Equivalent data are not available for occurrences in NSW. However, Reid et al. (2007) noted that woodland fragmentation is greatest in the most intensively developed agricultural areas, in line with the Queensland observations of Table C8. An example is the highly fragmented nature of remnant vegetation on the NSW Liverpool Plains, a region of very fertile soil and highly productive agricultural activity where Poplar Box Grassy Woodland also occur.

Queensland Statewide Landcover and Trees Study data (Tables C10 and C11, Criterion 5) show evidence of ongoing and increased woody vegetation clearance particularly through pasture development and cropping (Accad et al. 2017). As remnant patches become more isolated and surrounded by a matrix of modified land uses, the remnants become more susceptible to disturbances, for instance weed invasion and spray drift. Their habitat value also declines if the remnants become too small and isolated to support a diversity of flora and fauna. Increased separation of patches is likely to limit regeneration and colonisation opportunities as many understorey plants have restricted seed dispersal or seed longevity, while many fauna (e.g. ground-dwelling reptiles) have limited ability to move among sites if they are too distant and separated by large expanses of unfavourable habitat.

*Reduction in integrity through altered management regimes (grazing and fire)*

Prior to European settlement, grazing of the Poplar Box Grassy Woodland would have naturally occurred by soft-footed native herbivores such as kangaroos, wallabies and bettongs. These species browse in a different manner to domestic stock, so they do not have the same impact on the understorey of the ecological community.

Grazing by domestic stock (sheep and cattle) is more likely to occur in the open woodland patches of the ecological community and near to watering points. Many patches of the ecological community occur on or adjacent to agricultural land where stock may seek shelter from adverse weather under the canopy trees. Their presence leads to trampling of vegetation, direct but selective removal of vegetation through browsing (e.g. of the more palatable species) and soil compaction. Damage caused by grazing tends to increase with grazing intensity. Heavy, persistent grazing can suppress the growth of many native plants. Soil compaction is a common impact of stock grazing, and medium to fine-textured moist soils such as clays and loams (i.e. those that support the ecological community) are particularly susceptible to compaction by stock. Soil compaction can reduce water infiltration which in turn can affect germination and growth of seedlings. Fauna that generally depend on understory vegetation for foraging and nesting are negatively affected by livestock grazing, whereas species that forage predominantly in the canopy are likely to be less affected (Martin and McIntyre 2007).

A few studies have examined the impacts of grazing specific to Poplar Box Grassy Woodland. Hinchcliffe (2004) noted that overgrazing impacted on ecosystem services by disrupting water and nutrient cycling in Poplar Box woodland. Tunstall et al. (1981) noted that grazing in Poplar Box remnants reduced overall herbage biomass. Grazing can keep patches relatively shrub-free but under heavier regimes can also increase the amount of bare areas (scalds). Fritz (2012) observed that, while patch grazing affected some floristic components, it did not influence overall species richness or tree condition in the Poplar Box remnants she studied in southern Queensland. The main difference was a decline in the composition of lightly grazed relative to ungrazed sites, possibly due to loss of thick grass tussock species under low levels of grazing, which then promoted recruitment of inter-tussock species. Lunt (2005) has noted that heavy grazing of many perennial dominated systems, such as the ecological community, can eventually lead to the composition of the understorey being replaced by exotic annuals or other less palatable weeds.

Grass is the main fuel component for fire in the Poplar Box Grassy Woodland and the amount available is determined by what grass species are present, hydrological regimes and shrub density. The dynamics of woody plant populations in woodlands are greatly influenced by grass fires. With the reduction in fire frequency related to excessive grazing pressures following European settlement in the 19$^{th}$ and mid 20$^{th}$ century, there has been a rapid increase in the density of unpalatable native shrubs (woody regrowth) within the range of the ecological community (Noble et al. 2007). Any potential grass fuel, particularly palatable perennial grasses, was largely consumed by large populations of domestic, and later feral herbivores, e.g. rabbits (*Oryctolagus cuniculus*) and goats (*Capra hircus*). With the development of permanent water supplies, rapidly increasing numbers of native herbivores such as *Osphranter rufus* (red kangaroo), *Macropus giganteus* (eastern grey) and *Macropus fuliginosus* (western grey kangaroos), all contributed to the total grazing pressure within native grassy woodlands (Noble et al. 2007).

Native tussock grasses, such as *Enteropogon acicularis* (curly windmill grass) and *Themeda triandra* (kangaroo grass) are well adapted to regular burns and light grazing. Dense tussocks can also tolerate heat damage from fires. However, perennial grasses have high mortality rates with increasing grazing pressure and these effects can be exacerbated during droughts. In NSW, shrubby regrowth particularly affects the Western Plains and Cobar Peneplain Bioregion, although other inland areas are also affected. Most regrowth is of non-palatable shrubs such as *Senna*, *Eremophila* and *Dodonaea* species. Shrubs are less able to carry fire within the landscape that, along with shading and competitive impacts, therefore can further suppress the growth and regeneration of native grasses and forbs.

The potential fire frequency (based on average rates of fuel accumulation) varies between 5 and 20 years for woodlands such as the Poplar Box Grassy Woodland. However, if shrub density increases, the fire interval may become much greater ranging from 50 to 100 years.

*Reduction in integrity through weed invasion*

The Poplar Box Grassy Woodland has an extensive geographic range with many remnants now surrounded by a modified landscape of crops, pastures and developed or disturbed sites. As a result, patches of the ecological community are now exposed to, and threatened by, a wide range of invasive plants. Some of these are noted to be serious environmental weeds that impact on a range of vegetation types, not just the Poplar Box Grassy Woodland. For instance, Parthenium Weed (*Parthenium hysterophorus*), African Boxthorn (*Lycium ferocissimum*) and Prickly Pear (*Opuntia* spp. and related genera) are all identified as Weeds of National Significance for their known detrimental impacts upon the environment and productivity.

The presence of any high impact weeds in remnants indicates a strong potential for further degradation if weeds are not appropriately managed to curb their future expansion. However, the effective long-term management of weeds is usually resource intensive and needs considerable commitment and effort. Given that many of the weeds now present in the ecological community are highly invasive and problematic to manage, along with the threat from the establishment and spread of new weed species, weeds are highly likely to continue to contribute to the reduction in integrity of the ecological community well into the future.

Benson et al. (2006; 2010) noted that the NSW components of the Poplar Box Grassy Woodland generally exhibit a moderate weediness cover, as follows:

- PCT56 - 5 to 15%;
- PCT87 - 15 to 30%;
- PCT101 - 15 to 30%; and
- PCT244 - 15 to 30%.

It is presumed that the degree of weed infestation is probably worse for the ecological community in Queensland, given the nature of the weeds and landscape change that occur there. Some of the key weeds known to impact on the ecological community are outlined below.

*Buffel Grass (Cenchrus ciliaris)*

Buffel Grass is a species native to Africa and southern Asia that was promoted as a pasture species suitable for the rangelands of northern and inland Australia. Its drought tolerance and ease of establishment resulted in the grass being widely planted (Franks 2002). Agronomists even recommended that it be sown underneath Poplar Box trees to improve the establishment and yield of this pasture species in semi-arid areas (Christie 1975).

Buffel Grass is now recognised as a serious environmental weed that adversely impacts upon native biodiversity (Marshall et al. 2012). It is known to invade remnants of Poplar Box and increased cover of buffel grass in these woodlands is associated with a significant decline in plant species diversity (Franks 2002). Cover of buffel grass may also influence the habitat preferences of ground reptile species in Poplar Box woodland (Eyre et al. 2009). In the arid zone of central Australia, the presence of Buffel Grass and its displacement of native grasses has also been shown to influence the composition of native ground-dwelling bird and ant guilds (Smyth et al. 2009). Despite this, it is still promoted and planted as pasture grass.

*Coolatai grass (Hyparrhenia hirta)*

Coolatai Grass is a drought, fire and herbicide tolerant tussock grass that grows up to 1.5 m in height. It is able to rapidly colonise disturbed sites, but can also invade adjacent undisturbed native vegetation where it can form dense swards that smother most native plants. Being drought tolerant, Coolatai Grass has the ability to rapidly respond to rain, producing new culms from the tussock base and flowering in a matter of weeks. It is well adapted to fire, with tussocks surviving hot burns. Since its introduction as a pasture species in the 1930s to 1960s it has spread extensively across northern and central NSW and into parts of southern Queensland. Although it is mostly in the southern winter rainfall zones of the Poplar Box Grassy Woodland, Coolatai grass has the potential to also spread into the northern extent of the ecological community.

Studies in northern NSW have shown that Coolatai Grass infestations have reduced the number of native plant, invertebrate and frog species in threatened White Box, Yellow Box and Blakeley's Red Gum Grassy Woodlands. Coolatai Grass poses a huge risk to the biodiversity of the fragmented areas of native ecosystems remaining across NSW and Queensland as it easily invades even undisturbed ecosystems (McArdle et al. 2004; DPI 2015a). It is highly likely that these impacts demonstrated in box gum grassy woodlands would also apply to other, adjacent grassy woodland systems such as the Poplar Box Grassy Woodland.

*Lippia (Phyla canescens)*

Lippia is a prostrate perennial broadleaf herb that spreads both vegetatively or by seed and has the ability to form extensive mats over the ground surface. Seed can remain viable for up to 10 years and seed banks under infestations can contain up to 10 000 seeds per square metre. Seeds and fragments can be spread by vehicles, machinery and animals but also in response to flood events where it can quickly re-establish after floodwaters subside. Spread of lippia also appears to be accelerated by persistent heavy grazing (NSW Scientific Committee 2009, Galea et al. 2014). It is a major threat to drainage areas, floodplains and pastoral areas along the inland river systems of NSW and Queensland. It is estimated 5.3 million hectares of floodplain grazing country in the Murray–Darling Basin are affected by Lippia and it has the potential to continue spreading into other inland river and floodplain systems (DPI 2015b).

In central NSW, Lippia poses a major threat along the Lachlan River and floodplain systems west of Forbes, where the Poplar Box Grassy Woodland occurs. It is also known to invade remnants of Poplar Box in Queensland (Galea et al. 2014). Lippia causes major environmental impacts in several ways (Leigh and Walton 2004). Where Lippia occurs on floodplain or riparian soils, the deep root systems of lippia does not bind the soil but causes them to crack and dry out, unlike the extensive, fine root systems of native perennial plants. Flood and heavy rainfall events can more easily erode the soils beneath the Lippia mats. Lippia can completely dominate the ground layer, if left unchecked, and in so doing reduces the diversity and cover of native plants, especially perennial grasses (Leigh and Walton 2004). It is one of the few serious weeds that can displace native plants without prior disturbance to enable its establishment. The dense nature of its ground cover and the soil drying effect of its deep root system can prevent native eucalypt seedlings from establishing, (Leigh and Walton 2004).

*African Boxthorn (Lycium ferocissimum)*

African Boxthorn, a weed of national significance, is a perennial shrub that can grow up to 5m in height. It has an extensive, deep, branched taproot, spiky branches and fleshy fruits that can be widely dispersed by birds. African Boxthorn occurs widely across southern Australia, extending into central and northern NSW and southern Queensland. African Boxthorn grows on all soil types but establishes best on lighter soils, such as alluvial soils associated with the Poplar Box Grassy

Woodland ecological community. It can form dense, spiky thickets which can outcompete grassy ecosystems such as the Poplar Box Grassy Woodland. The species also provides protective and breeding habitat for other invasive species, such as rabbits and foxes (DPI 2015c). Highly invasive woody weeds, such as African Boxthorn can alter an ecological community's structure from a predominantly grassy ground layer to a shrubby understorey.

*Other weeds*

While there are many other weeds known to occur in Poplar Box Grassy Woodland, their specific impacts to the ecological community are less well studied. However, they contribute to the overall detrimental impacts of weeds generally upon the ecological community. Additional weeds of note include Prickly Pear (*Opuntia* spp.), Mother of Millions (*Bryophyllum delagoense*), African Lovegrass (*Eragrostis curvula*), Burr Medic (*Medicago polymorpha*), Cretan Weed (*Leontodon rhagadioloides*), Flat Weed (*Hypochaeris radicata*), Parthenium Weed (*Parthenium hysterophorus*), Paspalum (*Paspalum dilatatum*) and Small-flowered Mallow (*Malva parviflora*). Gamba Grass (*Andropogon gayanus*) is also an emerging threat in the northern range of the ecological community (see Table A4 in Appendix A for a more complete list).

*Reduction in integrity through dieback*

Dieback (canopy decline) in Queensland has been noted in a large range of tree species in surveys conducted during the early 1980s and late 1990s (Wylie et al. 1993; Fensham and Holman 1999; Reid et al. 2007). Dieback was especially common in 20 Queensland shires including parts of the Darling Downs where the ecological community is known to occur. Dieback was more pronounced on smaller properties that were more intensively managed and had a greater proportion of their area cleared (Wylie et al. 1993). Although long or reccurring droughts induce severe water stress that can lead to tree death, a study by Reid et al. (2007) found that multiple causes can act simultaneously leading to dieback of Poplar Box.

In NSW, dieback is particularly common for inland box woodland communities. Dieback has intensified on many parts of the Liverpool Plains, with Poplar Box and *Eucalyptus camaldulensis* (river red gum) being two of the most affected species. Banks (2006) found that 43% of Poplar Box and 12% of river red gum trees surveyed were moderately to severely dieback-affected. Tree decline has also been noted since 1990 in the Gunnedah and Narrabri areas. Poplar Box dieback is widespread in the lower Macquarie Valley (Hassall and Associates 1996), as well as the Gwydir and Namoi Valleys.

The decline in tree and crown health of Poplar Box in the Namoi region was unusually severe in the 1990s and contrasted with the health of other trees in the same or nearby landscapes. The tree health survey of 40 sites in the middle Upper Namoi catchment in 1999 showed that Poplar Box on the flood plains, Liverpool Plains and Gunnedah region were most affected by dieback (Reid et al. 2007). The study found that individual and cumulative impacts from multiple causes, particularly falling shallow water tables (especially during drought), insecticide drift damage, along with defoliant and herbicide drift contributed to the severe decline of Poplar Box. Reid et al. (2007) also noted that in the Namoi Valley "dieback was found to be more severe on the floodplain in landscapes where farming, particularly irrigated cropping and fallows, and woodland fragmentation were extensive." Reduced tree health leads to a decline in mature tree vigour and lack of natural recruitment results in canopy cover loss in remnant patches as senescent trees of low vigour are not replaced (Reid and Landsberg 1999; Batterham 2008).

*Reduction in integrity due to change in community structure and composition (including loss of fauna)*

Reduction in extent and further fragmentation of the ecological community reduces its capacity to support a variety of faunal assemblages, removing the ecological services provided by these animal species. For example, the simplification of the bird assemblage can increase the risk to the community of *Eucalyptus* dieback associated with defoliation by insects, while other services such as pollination and seed dispersal may also be compromised (Maron and Lill 2005; Briggs et al.

2007; Hannah et al. 2007; Reid et al. 2007; Ford 2011; Ingwersen and Tzaros 2011). Among the worst affected group of woodland birds are the ground-foragers, (particularly those species that feed on insects) such as *Pomatostomus temporalis temporalis* (greycrowned babbler).

Extensive clearing of eucalypt woodlands on the most fertile and productive soils, such as valley floors, floodplains and lower slopes, and degradation of the remaining habitat through intensified agriculture has undoubtedly changed soil and ground litter properties, resulting in reduced food resources available to ground-feeding birds. The loss of eucalypts from lowland areas, especially those renowned for nectar and foliage insect resources has impacted on populations of nectar feeders such as *Anthochaera phrygia* (regent honeyeater) and *Lathamus discolor* (swift parrot). The conversion of structurally complex and floristically diverse grassy woodlands such as the ecological community, into highly simplified monocultures dominated by exotic annuals has also affected species such as *Stagonopleura guttata* (diamond firetail) and *Climacteris picumnus* (brown treecreeper) (Ingwersen and Tzaros 2011).

Vegetation structure is also of overriding importance to the maintenance of fauna populations. The age and size of trees is important in terms of their ability to provide food and shelter requirements. Several arboreal mammals and bird species are dependent on tree hollows for shelter and nesting, including parrots, owls, possums, gliders and bats. If old growth trees are lost from woodlands, some animals may become locally extinct and may only recolonise areas once vegetation patches reach maturity and are within the dispersal range of the animal (Benson 1999). In the agricultural landscape large eucalypts often remain as isolated individuals (paddock trees or small stands). These trees suffer increased mortality related to dieback causes, such as water stress, recurring insect attack and occasional lightning strike.

Mature trees with hollows are limited in many of the rural lands of Queensland, where widespread clearing has removed much of the mature vegetation. Hollows suitable for use by many fauna species may not form until eucalypts are at least 120 years old, with large hollows rare in trees under 220 years old (Gibbons and Lindenmayer 2002). Therefore, lost hollows may not be replaced for very long periods. Even single or widely scattered mature hollow-bearing trees can be important habitat, such as for hollow-roosting bats. Rayner et al. (2014), noted that Poplar Box had one of the highest probabilities of containing large hollows at relatively small limb sizes. The study suggested that large-scale removal of Poplar Box trees with a diameter at breast height greater than 20 cm would remove a large proportion of hollows from the landscape. The loss of large hollow-bearing Poplar Box trees, contributes to a loss of fauna and to a severe reduction in ecological function within the ecological community.

Some ground-dwelling native animals such as *Vombatus ursinus* (bare nosed wombat) and *Tachyglossus aculeatus* (short-beaked echidna); as well as bettong and bandicoot species found (or formerly present) in the ecological community play an important ecological role in maintaining soil processes. In other locations in NSW it has been observed that soil disturbances created by these animals can provide benefits by assisting soil aeration, nutrient cycling and water infiltration, as well as the spread and establishment of seedlings (Martin 2003). The loss of digging ‘ecological engineers’ is likely to cause a reduction in the ecological function (and disrupt the regeneration) of the ecological community (Eldridge and James (2009). In addition, with other modifications and ongoing threats to the ecological community, where soil disturbance occurs, rather than assisting recruitment of native flora, it can encourage weed invasion.

Although shrubs naturally occur in the ecological community, they can shift from a typically sparse presence to dense localised cover, particularly in semi-arid areas. The increased shade from denser shrub canopies and greater competition for water and nutrients discourages the growth and spread of grass and forb species in the Poplar Box Grassy Woodland. Encroachment can eventually result in structural transitions from a grassy woodland to shrubby woodland. Shrub encroachment into the ecological community may be a response to naturally or artificially induced processes such as fluctuating hydrology, altered nutrients, loss of apex predators or altered fire regimes.

Pasture improvement techniques, such as fertiliser addition, can influence the composition of the vegetation and lead to a progressive loss of native flora species. Australian soils are generally poor in nitrogen and phosphorus, to which native flora species have adapted. Consequently, some species will decline under increased soil fertility conditions. These impacts are exacerbated if fertiliser addition is accompanied by oversowing exotic pasture species. Pasture species and/or weeds, such as buffel grass, may have a competitive advantage over native species under conditions of improved soil fertility, displacing native perennial species.

*Conclusion*

Substantial clearing, severe fragmentation, weed invasion, inappropriate fire and grazing, pasture improvement and other threats causing changes to vegetation structure and loss of faunal components have severely reduced the integrity of the ecological community. The very long lag time to recover vegetation structure, with adequate representation of large old trees, limits the likelihood of recovery in the near future. The intractability of other problems, such as the regional loss of fauna, and the nature of existing land and water use in the ecological community's extent further reduces the potential for recovery.

The reduction in integrity experienced by the ecological community across most of its geographic distribution is **severe**, as indicated by **severe** degradation of the community and its habitat. Therefore, the ecological community is **eligible** for listing as **endangered** under this criterion.

Criterion 5 – Rate of continuing detrimental change

| Criterion 5 - Rate of continuing detrimental change | | | |
|---|---|---|---|
| **Category** | **Critically Endangered** | **Endangered** | **Vulnerable** |
| Its rate of continuing detrimental change is: as indicated by a) degradation of the community or its habitat, or disruption of important community processes, that is: or b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is: | very severe | severe | **substantial** |
| 5.1 An observed, estimated, inferred or suspected *detrimental change* over the *immediate*# past or projected for the *immediate* future of at least: | 80% | 50% | 30% |

# The immediate timeframe refers to10 years, or 3 generations of any long-lived or key species believed to play a major role in sustaining the community, whichever is the longer, up to a maximum of 60 years.

**Eligible under Criterion 5 for listing as Vulnerable**

**Evidence:**

There is ongoing vegetation clearance of the ecological community. Reliable data on clearing and change in the extent of the ecological community are available for Queensland since 1997 (Table C9) but not NSW.

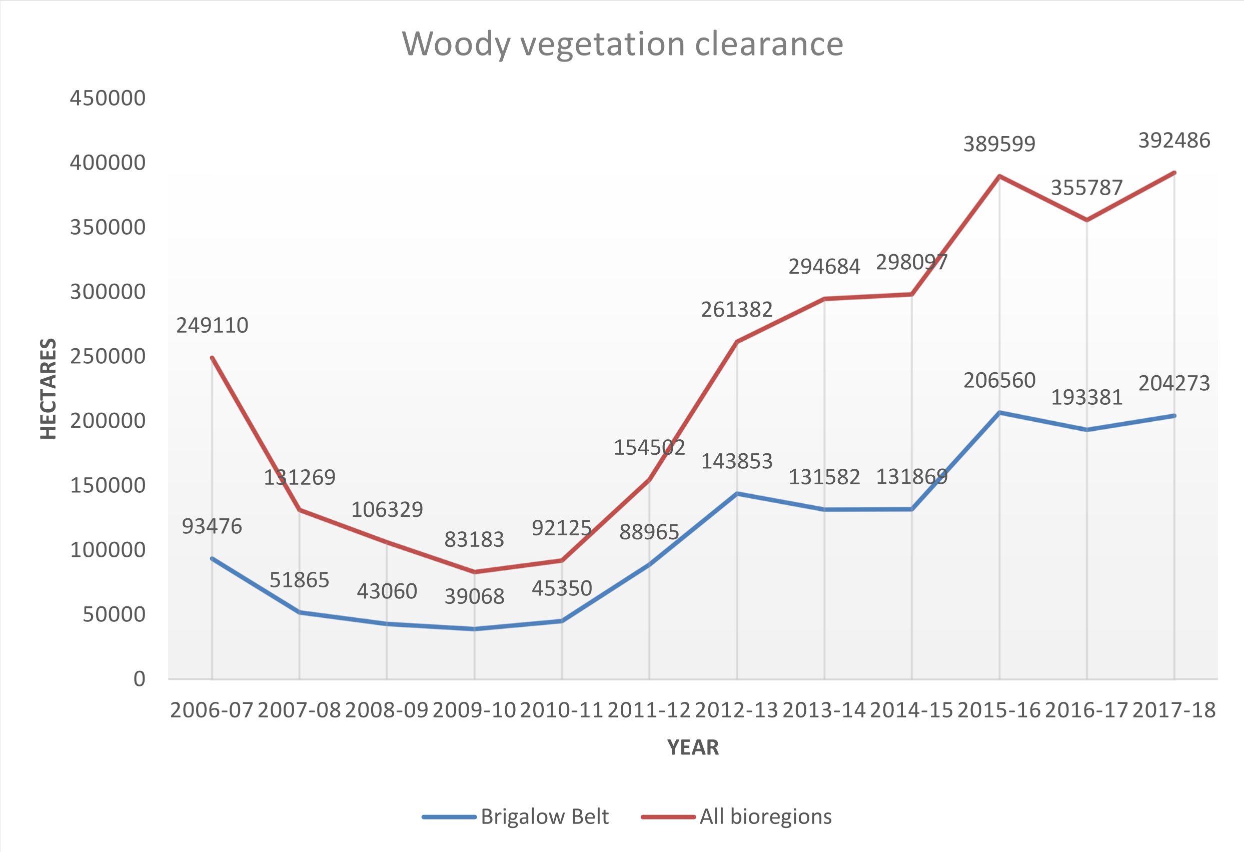
**Table C9.** Estimates of decline in Queensland regional ecosystems dominated by Poplar Box from 1997 – 2017. Data were collated for the five regional ecosystems that correspond to the Poplar Box Grassy Woodland.

| Year | Extent (ha) | Period - % change / 2 yrs | Area of change (ha) |
|---|---|---|---|
| 1997 | 672 947 | | |
| 1999 | 625 140 | 1997-1999 – 7.10% | 47 807 |
| 2001 | 594 223 | 1999-2001 – 4.95% | 30 917 |
| 2003 | 585 070 | 2001-2003 – 1.54% | 9 153 |
| 2005 | 577 372 | 2003-2005 – 1.31% | 7 689 |
| 2006b | 575 054 | 2005-2006b – 0.40% | 2 318 |
| 2009 | 572 425 | 2006b-2009 – 0.46% | 2 629 |
| 2011 | 571 271 | 2009-2011 – 0.20% | 1 154 |
| 2013 | 569 139 | 2011-2013 – 0.20% | 1 132 |
| 2015 | 566 680 | 2013-2015 – 0.43% | 2 459 |
| 2017 | 562 439 | 2015-2017 – 0.75% | 4 241 |

Source: Wilson et al 2002; Accad et al 2019.

The available data shows a substantial decline in the relative extent of the ecological community during 1997 to 2005, equivalent to about 14.2% per decade. Decline was most evident during the first part of this period, in the late 1990s. That clearing occurred prior to the regulation of both broad scale vegetation clearing and the clearing of high value regrowth, introduced in 2006 and 2009 respectively (Maron et al. 2015). From 2005 to 2011, the degree of clearing of the ecological community declined, to be equivalent to about 1% per decade, and reflects the beneficial impact of effective regulation of native vegetation clearing (Figure C1).

**Figure C1.** Woody vegetation clearance for all Queensland bioregions and the Brigalow Belt bioregion 2006–2018.



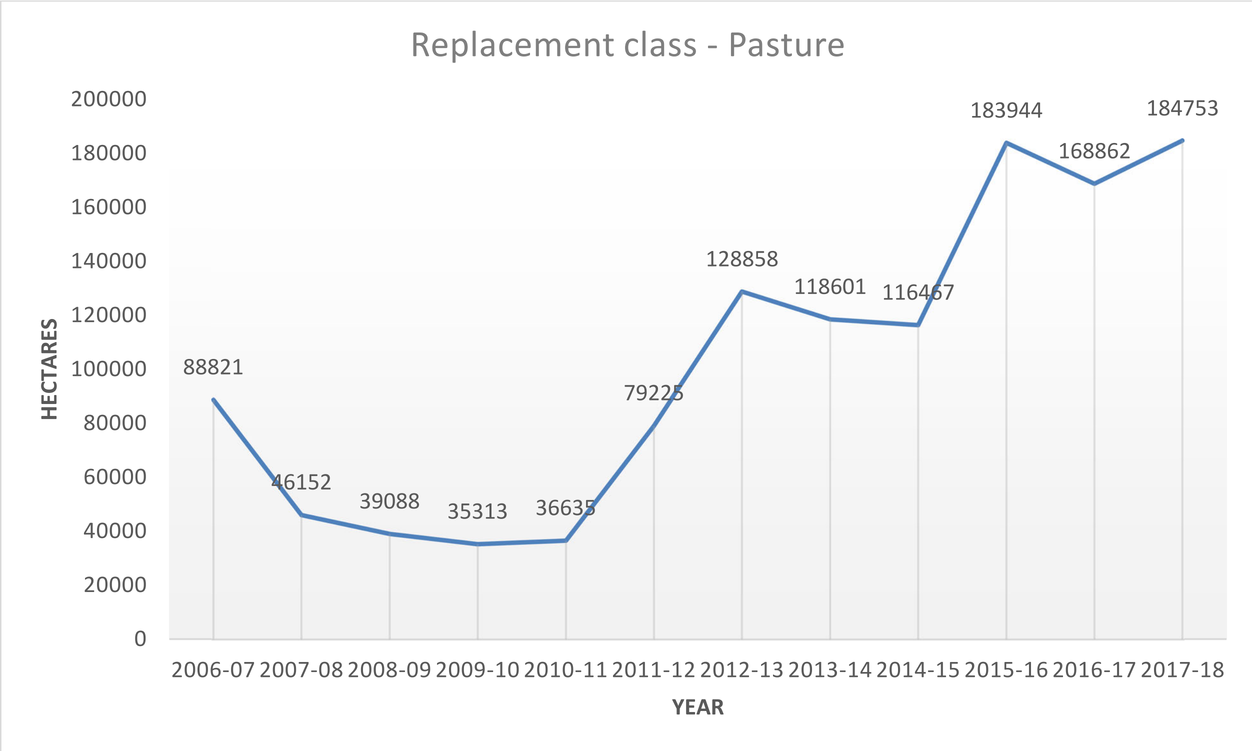

Source: DSITI 2018.

Vegetation management regulations in Queensland were considerably weakened from 2012/13. Native vegetation clearing across Queensland increased from 2013, at triple the clearing rate for some regions (Maron et al. 2015). The clearing rates of the Poplar Box Grassy Woodland specifically impacted by reversing the changes in Queensland vegetation management laws in May 2018 are yet to be confirmed and are likely to become more evident in subsequent assessment of data.

The Queensland Statewide Landcover and Trees Study (SLATS) Report 2016–17 and 2017–2018 (2018) notes an increased trend for landcover change due to a number of farming related activities. The dominant replacement land cover class for all Queensland bioregions for 2017–18 was pasture (93% of total statewide woody vegetation clearing). The figure for woody vegetation loss due to pasture development in the Brigalow Belt bioregion for the 2017-18 period was 184 753ha/year (47.1% of total statewide woody vegetation clearing), an increase of 57% from the 2011–12 figure of 79 225 ha/year and an increase of 36% from the 2013-14 figure of 118 601 ha/year (Figure C2).

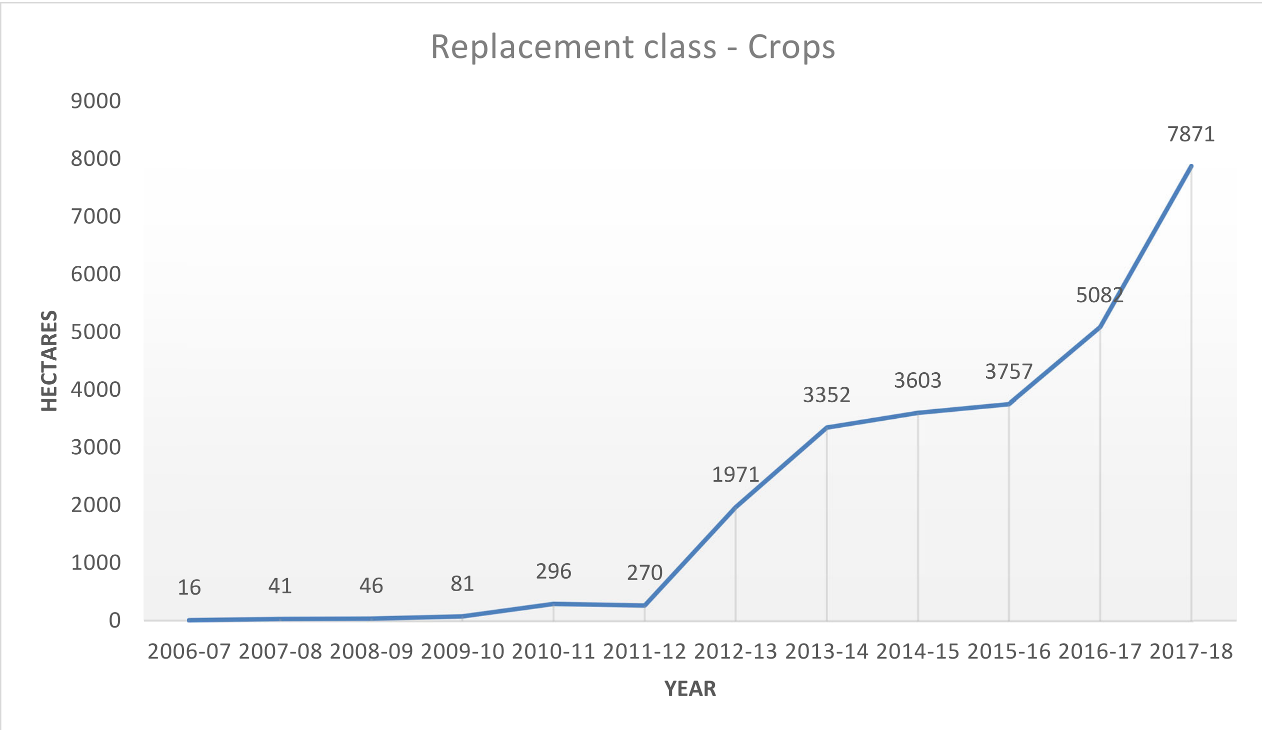
Woody vegetation loss due to crop development in the Brigalow Belt bioregion for the 2017-18 period was 7 871 ha/year, an increase of 96% from the 2011–12 figure of 296 ha/year and an increase of 57% from the 2013-14 figure of 3 352 ha/year for the bioregion (Figure C3). Within the Queensland Brigalow Belt, where much of the Poplar Box Grassy Woodland occurs, woody vegetation clearance during the 2017-18 period (7 871 ha/year) accounted for 85% of the total clearing within Queensland for conversion to crops.

**Figure C2.** Woody vegetation clearance in the Brigalow Belt bioregion of Queensland due to pasture[22] development 2006–2018.




Source: DSITI 2018.

**Figure C3.** Woody vegetation clearance in the Brigalow Belt bioregion of Queensland due to crop development 2006–2018.



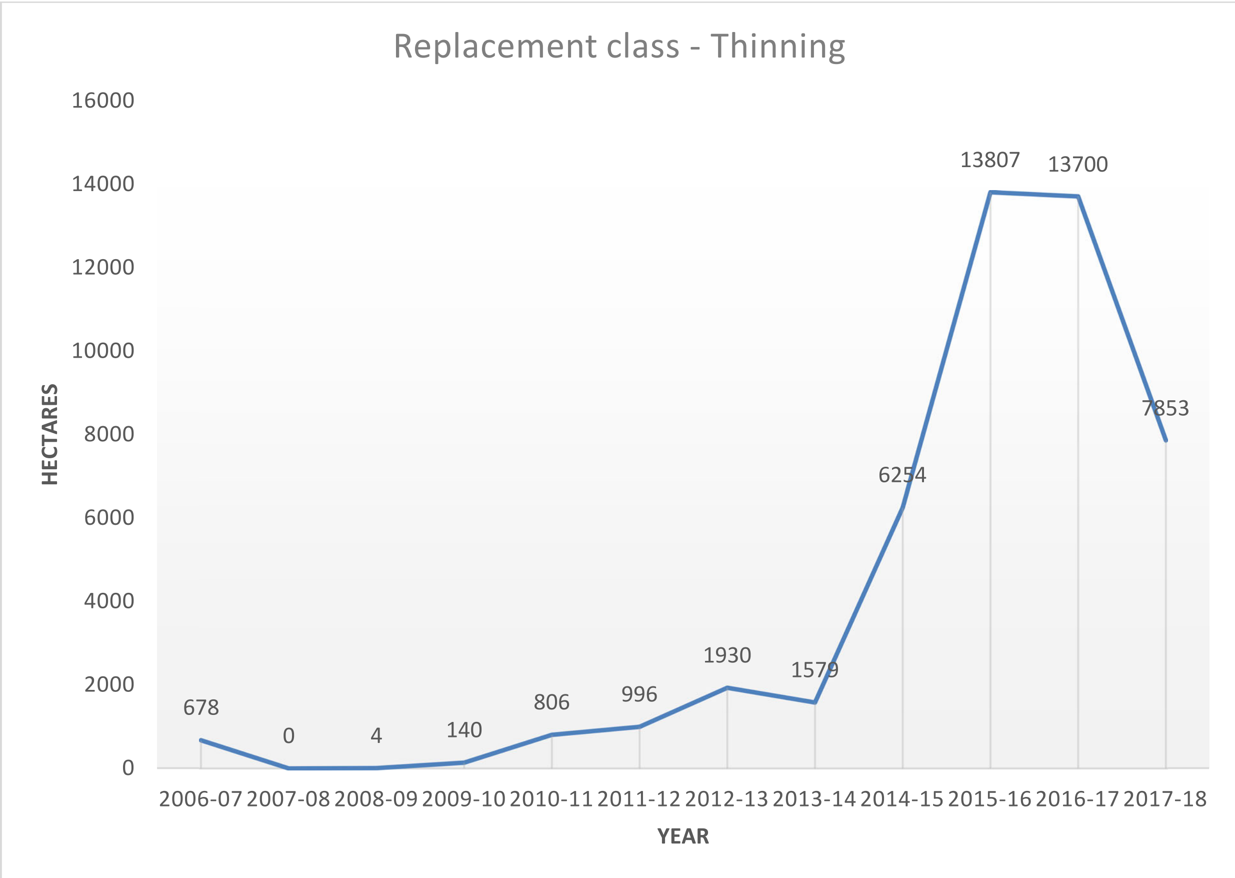

Source: DSITI 2018.

[22] SLATS defines pasture as grazing and other general land management practices (e.g. this class includes clearing for internal property tracks, fence lines or fire breaks). Areas mapped as thinning are also included in this class.

The Queensland (SLATS) Report (2018) notes that in 2017–18, the biogeographic region with the highest woody vegetation clearing rate was the Brigalow Belt with more than 204 000 ha/year. This represented a 36% increase from the woody vegetation clearing rate of 131 582 ha/year in 2013-14, and a 57% increase from the woody vegetation clearing rate of 88 965 ha/year in 2011-12. Thinning of woody vegetation is included as part of the SLATS pasture definition.

In the Brigalow Belt, the figure for woody vegetation loss due to thinning[23] for the 2017-18 period had reduced to 7 853 ha/year (4% of total woody vegetation clearing[24] within the Brigalow Belt). However, during the 2016–17 period thinning was 13 700 ha/year (3.9% of total statewide woody vegetation clearing, more than double for the 2011–12 figure of 6 254 ha/year and more than eight times the 2013–14 figure of 1 579 ha/year (Figure C4).

**Figure C4.** Woody vegetation clearance in the Brigalow Belt bioregion of Queensland due to thinning 2006–2018.




Source: DSITI 2018.

Apart from direct clearance due to conversion for high value farming activities such as cropping, activities such as thinning and pasture development can also impact on native vegetation biodiversity. The Queensland (SLATS) Report (2018) noted that by the 2017-18 period 41% of woody vegetation had been cleared one or more times since 1988. These activities contribute to the continued reduction of biodiversity within one or more structural layers of native vegetation.

What is clear is that the ecological community occurs in a region that presently faces heavy development pressures for mining, coal-seam gas and high value farming activities (see Appendix B

[23] 'Thinning' refers to the partial removal of woody vegetation but does not necessarily align with the QLD *Vegetation Management Act 1999* definition of thinning. For example, the Statewide Landcover and Trees Study has mapped areas of partial removal of trees or shrubs where machinery has been used.

[24] Woody vegetation clearing refers to the anthropogenic (i.e. human) removal or destruction of woody vegetation. SLATS maps woody vegetation clearing in the National Vegetation Information System (NVIS) structural formation classes of 'open woodland'/'open shrubland' to 'closed forest'/'closed shrubland'.

Key threats) and that such developments are likely to result in further detrimental impact to the ecological community.

Apart from direct impacts from clearance activities for mining, ongoing impacts during development, operation and post operation can be numerous and compounding at a local and landscape scale. For example, unconventional gas infrastructure development results in the fragmentation of vegetated landscapes (Figure C1). Williams et al. (2012b) noted that wells for coal seam gas extraction may be 200–750 m apart in a grid pattern, depending on the nature of the coal seam. Eco Logical Australia (2012) calculated that an ‘average’ Coal Seam Gas footprint in eastern Australia constituted approximately 160 km of road and about 60 individual fragments (or ‘islands)’ (parcels of land encompassed by road) for every 100 km² developed (see Table C10). Although the overall proportion of vegetation loss in an unconventional gas development is about 2%, the increase in fragmentation and subsequent reduction in patch size of remnant vegetation (or loss of ‘intactness’ in the landscape) can result in: increased edge effects over a large area of the landscape, with numerous service roads providing a vector for weed invasion well into formerly intact patches e.g. buffel grass (Fensham et al. 2015); restriction on the mobility of many species, particularly for smaller fauna species that are ground-dwelling (Williams et al. 2012a; 2012b); and direct vehicle impact to these and other fauna species.

**Table C10.** Area and extent of unconventional gas development near Dalby and Tipton QLD.

| Impact | Dalby QLD | Tipton QLD |
|---|---|---|
| Total mine area (ha) | 3 658 | 8 494 |
| Number of wells | 90 | 140 |
| Density of wells (wells/km²) | 2.5 | 1.6 |
| Total area of wells (ha) | 66.2 | 64.5 |
| Total length of service roads (km) | 104.8 | 179.3 |
| Total area of service roads (ha) | 62.5 | 107.2 |
| Number of fragments isolated by roads | 76 | 101 |
| Average fragment size (ha) | 46.4 | 82.4 |

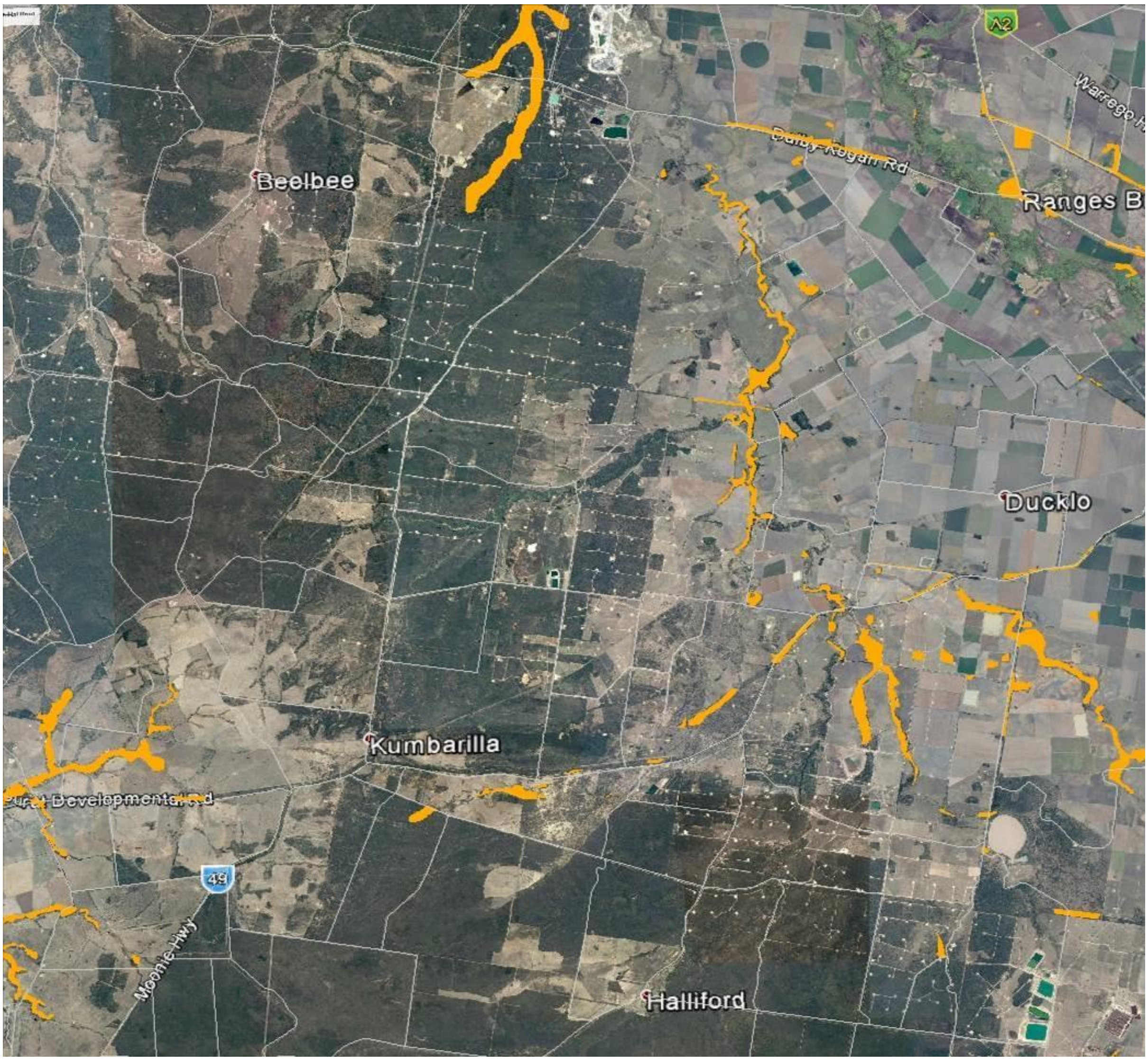
Source: Eco Logical Australia 2012; 2013.

During the period 2011 to 2015, 505 gas wells were approved for development within Queensland state forests containing remnant vegetation. With CSG development in Australia, clearance for the average CSG well pad is 1.2 – 2.0 ha with an average density of approximately 1.1 pads and 1.6 km of service roads (0.64–0.96 ha) per km² (1 km²=100 ha) (Eco Logical Australia 2012, 2013; Williams et al. 2012a; 2012b). The Braemar and Kumbarilla State Forests currently have many unconventional gas wells and service roads in place (Table C10; Figure C5). Although unconventional gas service road use data is limited for the Poplar Box Grassy Woodland, Eco Logical Australia (2013) noted a US study that estimated 4 300 to 6 600 vehicle visits, occurred at a well pad, and was associated with site clearing and construction, drilling, hydraulic fracturing, flowback water removal and completion. Given remnant patches of Poplar Box Grassy Woodland are located in or adjacent to many development fields, particularly near Dalby (Figure C1), direct and associated impacts from road usage is likely to be significant.

Many unconventional gas wells and roads have been developed in the Western Downs Regional local government area (LGA) near Dalby, Queensland. Gas developments in this LGA are similar to other areas outside the region. Private and public land in the Queensland Western Downs Regional LGA has already been cleared of native vegetation by about 70% with approximately 89% of the ecological community having been cleared as at 2013 (Table C8). Fragmentation and edge effects from intensive mining development significantly impact the remaining, often linear, patches of the ecological community. Given wells have a limited lifespan of between 5–20 years before new wells and roads are required to be developed, the likely rate of continuing detrimental change through fragmentation and edge effects will lead to further degradation of the community and detrimental change projected for the immediate future and is likely to be substantial to severe.

No data on the recent extent of clearing are available for the NSW occurrences of the Poplar Box Grassy Woodland. However, similar threats occur in NSW as in Queensland, for instance, Williams et al. (2012b) noted similar impacts to vegetation in the Pilliga state forest in NSW, which contains patches of the ecological community.

**Figure C5.** Regional Ecosystems containing Poplar Box Grassy Woodland on Alluvial Plains and unconventional gas development near the Braemar and Kumbarilla State Forests (yellow polygons/data groups for relevant Regional Ecosystems in Table C1).




There is evidence of substantial ongoing clearing of the Poplar Box Grassy Woodland over the previous two decades for significant areas of the ecological community, especially in Queensland, though there are gaps in such information for NSW. Nevertheless, the nature of development pressures facing the region where the ecological community occurs indicates a likelihood of longer-term, landscape-level impacts directly on the ecological community, and also through the surrounding region. Therefore the Committee recommends the ecological community meets this criterion as **vulnerable** for listing under Criterion 5.

Criterion 6 – Quantitative analysis showing probability of extinction

| Criterion 6 - Quantitative analysis showing probability of extinction | | | |
|---|---|---|---|
| **Category** | **Critically Endangered** | **Endangered** | **Vulnerable** |
| A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its geographic distribution, is: | at least 50% in the immediate future. | at least 20% in the near future. | at least 10% in the medium-term future. |

**Not eligible for listing under Criterion 6.**

*There are no quantitative data available to assess this ecological community under this criterion. Therefore, it is **not eligible** for listing under this criterion.*

## Appendix D – Additional information about the ecological community

### D1. Similar and intergrading ecological communities

The Poplar Box Grassy Woodland is a relatively distinctive woodland that co-occurs with other woodland to open forest vegetation associations within a matrix of remnant native vegetation in the temperate and semi-arid zones of NSW and Queensland. The Poplar Box Grassy Woodland is mainly distinguished from similar threatened woodland types by the dominant presence of *Eucalyptus populnea* in the tree canopy and from native grasslands by the presence of a tree canopy. Other Poplar Box Woodlands may overlap with the national ecological community; for example, PCT105 (Poplar Box grassy woodland on flats mainly in the Cobar Peneplain Bioregion and Murray Darling Depression Bioregion) and PCT207 (Poplar Box grassy low woodland of drainage lines and depressions of the semi-arid (hot) and arid zone climate zones). However, these are considered to be distinct from the national ecological community as they have fewer understorey species in common, occur in a lower rainfall zone or occur too high in the landscape which is not consistent with the majority of the ecological community.

Woodlands dominated by Poplar Box also occur in bioregions to the west of the Darling Riverine Plains and Brigalow Belt South bioregions. These are excluded from the national ecological community on the basis that they contain different biota associated with different soils, landscape or climate. Further inland, towards the Mulga lands, in Queensland for example, the landscape becomes progressively arid and the biota changes particularly the diversity of woodland ground layer plant species becoming increasingly depauperate.

Throughout the range the ecological community grades into various floodplain woodlands dominated by other tree canopy species. Differences in the tree canopy species are determined by flood levels and landscape position. For instance, woodlands dominated by *Eucalyptus camaldulensis* (River Red Gum) are closely associated with the banks of channels, streams, drainage lines and associated floodplains that are inundated more often than Poplar Box Grassy Woodland. Woodlands dominated by *Callitris glaucophylla* (White Cypress Pine) occupy sites on higher ground with loamy or sandy soils. The national ecological community may also grade into native grasslands, for example, in the Liverpool Plains where there are heavier, cracking clay soils.

Many other tree species are known to co-occur with Poplar Box in the canopy layer of the Poplar Box Grassy Woodland. However, the ecological community is not considered present if one or a combination of the following species constitute more than 50% of the total tree crown cover:

- *Acacia aneura* (Mulga)
- *Acacia harpophylla* (Brigalow)
- *Allocasuarina luehmannii* (Buloke)
- *Callitris glaucophylla* (White Cypress Pine)
- *Casuarina cristata* (Belah)

Other eucalypt species also in this category include *Eucalyptus moluccana* (Grey Box), *E. microcarpa* (Grey Box, Western Grey Box), *E. woollsiana* (Grey Box, Narrow Leaved Grey Box), *E albens* (White Box), *E. Coolibah* (Coolibah), *E. largiflorens* (Black Box) and *E. melliodora* (Yellow Box).

Other intergrading nationally listed woodland and grassland ecological communities include:

- Brigalow (*Acacia harpophylla* dominant and co-dominant) is associated with a wide range of landscapes including river and creek flats, but mainly on old loamy and sandy plains, basalt plains and hills, or hills and lowlands on metamorphic or granitic rocks. Brigalow is usually either dominant in the canopy or co-dominant with other species such as *Casuarina cristata* (Belah), other species of *Acacia*, and occasionally with species of *Eucalyptus*. The structure of the vegetation ranges from open forest to open woodland but unlike the Poplar Box Grassy Woodland, a prominent shrub layer is usually present.

- Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions is associated with the floodplains and drainage areas. It is found on the grey, self-mulching clays of periodically waterlogged floodplains, swamp margins, ephemeral wetlands, stream levees, drainage depressions and areas of lower floodplain that remain inundated for longer periods in addition to higher floodplain areas. Although this ecological community has a very similar structure to Poplar Box Grassy woodland, its canopy is dominated by *Eucalyptus Coolibah* (Coolibah) or with *E. largiflorens* (Black Box). Coolibah is known to hybridise with a range of other eucalypt species, including Black Box and Poplar Box.
- Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia can occur in central to southern NSW on low relief landscapes such as undulating plains, drainage depressions and flats with alluvial and colluvial soils but is not generally associated with floodplains. Grey Box Grassy Woodlands are distinguished by the dominant presence of grey box in the canopy and an understorey with a moderately dense (up to 30%) shrub layer.
- Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin and the Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland usually occurs on flat ground or gently undulating rises. These natural grasslands are distinguished in having the tree layer sparse or absent due to the deep cracking or self-mulching soils, fire regimes, frost and soil chemistry (particularly low sodicity). Elements of the ground layer (forbs and grasses) are common to both the grassland and Poplar Box Grassy Woodland.
- Weeping Myall Woodlands occur on flat areas, shallow depressions or gilgais on raised (relictual) alluvial plains. These areas are not associated with active drainage channels and are rarely flooded. This ecological community can exist naturally either as a shrubby or a grassy woodland but is distinguished by the dominance of *Acacia pendula* (weeping myall) in the canopy.
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland are characterised by a species-rich understorey of native tussock grasses, herbs and scattered shrubs, and the dominance, or prior dominance, of *Eucalyptus albens* (white box), *Eucalyptus melliodora* (yellow box) or *Eucalyptus blakelyi* (Blakely's red gum) trees. The main distribution of this woodland generally occurs further east and south of the Poplar Box Grassy Woodland, but there are some areas where the two ecological communities may occur nearby.

There may be occasions where an area of grassy woodland may meet the description of Poplar Box Grassy Woodland and one of the other national ecological communities noted above. Where this is the case, the area in question is considered to contain both ecological communities. Examples where this may occur include: an area where Poplar Box and a tree canopy species diagnostic for another listed ecological community are co-dominant (e.g. *E. populnea / E. microcarpa* co-dominated woodland); and situations where a larger patch may be dominated by Poplar Box overall but the patch contains small area(s) locally dominated by another tree species, for instance *E. microcarpa* (grey box) or *E. albens* (white box).

### D2. Indigenous cultural values and knowledge of the ecological community

#### *Indigenous knowledge*

The Indigenous people of NSW and Queensland understood and managed their natural landscapes for millennia. They established diverse and dynamic cultures and used a wide variety of plant and animal resources for food and materials. Some Indigenous plant resources were documented by Williams and Sides (2008).

Although there is little information specific to the Poplar Box Grassy Woodland, knowledge exists about the Indigenous uses of various plant and animal species that occur in the ecological community. The key Indigenous uses of plants present in the ecological community are summarised in Table D2.

Key animal resources likely to occur in the ecological community that were used for food, hides and other resources include kangaroos, wallabies, wombats, possums and various woodland birds.

**Table D2.** Known Indigenous uses of plant species that occur in the Poplar Box Grassy Woodland on Alluvial Plains ecological community

| Plant name | Indigenous use |
|---|---|
| *Acacia pendula* (weeping Myall, boree) | Food – seeds ground to make flour<br>Tools – boomerangs, digging sticks, waddies (clubs) |
| *Acacia stenophylla* (river cooba, river myall) | Food – seeds ground to make flour and baked as bread<br>Tools – boomerangs; ash mixed with pituri bark to make fish poison |
| *Allocasuarina luehmannii* (buloke) | Food – attracts many animals including possums and cockatoos<br>Tools – boomerangs and clubs<br>Medicine tree |
| *Amyema* spp., notably *Amyema cambagei* (needle-leaved mistletoe), *Amyema congener* (erect mistletoe), *Amyema gibberula* (hakea mistletoe), *Amyema miraculosa* (fleshy mistletoe), *Amyema quandang* (grey mistletoe) | Food – flowering parts<br>Medicine – bruised leaves soaked in water to treat fevers |
| *Atalaya hemiglauca* (cattle bush) | Tools - spear shafts |
| *Brachychiton populneus* (kurrajong) | Food - seeds high in protein, fat, zinc and magnesium. Used to make coffee-like drink by grinding and adding to hot water. Young stems, leaves and roots eaten raw.<br>Tools - fibres for fishing lines, dilly bags and nets; resin used to making tools<br>Medicine tree |
| *Bulbine bulbosa* (bulbine lily, native onion) | Food – bulbs roasted. |
| *Callitris glaucophylla* (White Cypress Pine) | Food – attracts birds such as pink cockatoo and galahs nest in hollows; young and eggs<br>Tools – resin for glue; bark and roots for splints; bark used for carrying fire<br>Medicine - treatment for colds |
| *Carissa ovata* (currant bush) (NSW) | Food - berries |
| *Carissa spinarum* (currant bush) (QLD) | Food - berries |
| *Chenopodium curvispicatum* (cottony saltbush) | Food - berries |
| *Chloris truncata* (windmill grass) | Food – seeds used for flour |
| *Daucus glochidiatus* (Australian carrot) | Food - tubers |
| *Dianella longifolia* (flax-lily) | Food – berries<br>Tools – leaves used for weaving baskets |
| *Dianella revoluta* (black-antler flax-lily) | Food - berries |
| *Dodonaea viscosa* (broad leaf hopbush) | Tools - clubs |

| Plant name | Indigenous use |
|---|---|
| *Duma florulenta* (lignum) | Food – young shoots eaten; attracts birds such as ibis, grey teal (duck), pink-eared duck; bird eggs |
| *Enchylaena tomentosa* (barrier saltbush, ruby saltbush) | Food – berries<br>Tools - dye |
| *Eremophila bignoniiflora* (dogwood) | Medicine – leaves crushed for a laxative and to help with digestion and constipation |
| *Eremophila longifolia* (berrigan) | Food – nectar from flowers, fruit<br>Medicine – used to treat skin problems and stomach ulcers |
| *Eucalyptus albens* (white box) | Food – source of bird eggs<br>Tools – bark for bowls and canoes. Resin for sealing containers<br>Medicine tree |
| *Eucalyptus Coolibah* (Coolibah) | Tools - fish poison |
| *Eucalyptus melliodora* (yellow box) | Tools<br>Medicine tree |
| *Eucalyptus populnea* (Poplar Box, bimble box) | Food – attracts birds and bats; bird eggs.<br>Tools – bark used for coolamons and large canoes. Resin to seal containers and canoes. |
| *Geijera parviflora* (wilga) | Food – shelter tree for animals; flowers attract native bees which produce sweet but strong smelling honey.<br>Tools – boomerangs, leaves used to sleep on, bark and roots used to make splints. |
| *Lomandra filiformis* (wattle mat-rush) | Food – seeds and young leaves eaten like celery; indicates burrowing mammals such as bilbies<br>Tools – leaves made into string, rope and used for weaving baskets and jewellery<br>Medicine – roots used for bites and stings |
| *Marsilea drummondii* (common nardoo) | Food – seeds ground to make flour |
| *Pittosporum angustifolium* (weeping pittosporum) | Tools – stone axe handles and shields.<br>Medicine – dried seeds ground into powder for aphrodisiac use; leaves, twigs and seeds boiled as a tea for internal pains and cramps |
| *Rhagodia spinescens* (berry saltbush) | Food – berries indicate birds likely to be nearby<br>Tools - dye |
| *Santalum acuminatum* (quandong) | Food – fruit<br>Tools – seed used as toy and ornaments<br>Medicine tree |
| *Solanum esuriale* (potato bush) | Food – fruit after treatment to remove toxins |

Scar tree near Jondaryan Queensland. (Photo credit: Anthony Hoffman)

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