SARAJI EAST MINING LEASE PROJECT

Environmental Impact Statement

Appendix C-3
Central Queensland Threatened Species Habitat Descriptions

BHP

Central Queensland Threatened Species Habitat Descriptions

Citation

This report should be cited as Kerswell A, Kaveney T, Evans C and Appleby L. (2020) *Habitat descriptions for 12 threatened species, specific to central Queensland*. Report commissioned by BHP.

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Abbreviations

Abbreviation	Description
ALA	Atlas of Living Australia
DAWE	Department of Agriculture, Water and the Environment
DERM	Department of Environment and Resource Management
DEWHA	Department of Environment, Water, Heritage and the Arts
DoE	Department of Environment
DoEE	Department of Environment and Energy
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
LZ	Land zone
NC Act	*Nature Conservation Act 1992*
TSSC	Threatened Species Scientific Committee

1. Introduction

BHP have a number of coal operations across central Queensland within the Bowen Basin. In the course of undertaking works at these operations, BHP frequently encounters a number of fauna species that are protected as Matters of National Environmental Significance (MNES) under the *Environment Protection and Biodiversity Conservation Act 1999*. These species are indicative of environments within central Queensland and include:

- koala (*Phascolarctos cinereus*)
- greater glider (*Petauroides volans*)
- squatter pigeon (*Geophaps scripta scripta*)
- painted honeyeater (*Grantiella picta*)
- Australian painted snipe (*Rostratula australis*)
- ornamental snake (*Denisonia maculata*)
- yakka skink (*Egernia rugosa*)
- collared delma (*Delma torquata*)
- large-eared pied bat (*Chalinolobus dwyeri*)
- south-eastern/Corben's long-eared bat (*Nyctophilius corbeni*)
- ghost bat (*Macroderma gigas*)
- grey-headed flying fox (*Pteropus poliocephalus*)

Ecological investigations and environmental impact assessments necessary to facilitate coal operations generally involve survey for and description of these species and their associated habitats.

A wide range of literature is available on the majority of the species, including description provided in conservation guidelines and the Species Profile and Threats Database (SPRAT). However, as none of these are unique to central Queensland, the description of habitats does not necessarily capture the ecological factors and habitat variances in central Queensland environments that allow these species to persist there.

BHP has worked with a number of professional ecologists to undertake a review of the information available for these species and refine these descriptions in a way that is tailored to the specific ecology of the central Queensland region.

For the purposes of this assessment central Queensland is broadly defined to include the Briglow Belt north and south bioregions, within the state of Queensland. The majority of observational and site-specific data has been sourced from areas within the Bowen Basin region.

The specific aims of this work are to:

- Develop agreed detailed habitat descriptions for a suite of EPBC Act-listed species in central Queensland
- Use the best available regional information to update & refine SPRAT definitions

- Provide a suite of habitat definitions that can be used consistently to support ecological investigations and environmental impact assessments, thereby ensuring assessment material is standardised, consistent and scientifically robust
- Ensure habitat definitions are well supported by scientific evidence, or where this is not available, consensus opinion from species experts, thereby removing individual interpretation, opinion and inconsistency.

The following sections of this report outline the methodology undertaken to collated and refine the descriptions and profiles for each of the species assessed. The refined habitat definitions provided below include a detailed description of each species' habitat that accounts for the niche requirements of species based on the actual climatic, vegetation, hydrological and topographical features of central Queensland. The descriptions are focuses at two levels:

- Factors that influence species' utilisation and life cycle behaviours within and across the range of habitats in which a species may be encountered e.g. breeding, roosting/resting, foraging and dispersal; and
- Determining which factors are crucial for a species' to persist in an area compared to those that are less key in facilitating a species' presence at that particular site.

2. Methodology

2.1 Desktop assessment and literature review

A desktop assessment and literature review of a variety of information sources / lines of evidence was undertaken to identify species habitat requirements and attributes. The best available data was utilised, with a priority placed on scientific publications. The range of different information sources reviewed are detailed in Table 1 below and included:

- Commonwealth and State government policy guidance
- Published literature
- BHP terrestrial ecology reports
- BHP terrestrial ecology geodatabase
- Publicly available ecology survey results from other Bowen Basin projects

The nature of ecological research is such that there are gaps in knowledge for some species, especially in a central Queensland specific setting. To provide a rigorous approach to addressing these gaps, a number of assessment techniques were used including:

- Review of 'grey literature' including unpublished research studies, monitoring studies and environmental impact statements
- High level spatial analysis of BHP's ecology geodatabase and State published vegetation and habitat layers
- Expert elicitation with a number of consulting ecologists who have significant experience with these species in central Queensland (round 1 peer review), and
- Expert elicitation with research-focused ecologists (academic and consulting) who also have significant experience with these species in central Queensland (round 2 peer review).

Table 1: Overview of lines of evidence used to develop habitat descriptions

Line of evidence	Relevance to habitat definitions	Examples	Limitations of dataset
Commonwealth and State government policy guidance	Provides guidance on broad habitat requirement across species geographic range Framework that regulators use in assessments	SPRAT Conservation advice, recovery plans, referral guidelines Recent advice from QLD North Assessment Team	Data may not be specific or relevant to central QLD context Data are sometimes quite dated Some information is incomplete or inconsistent
Published literature	Provides peer reviewed scientific evidence	Ellis et al. (2002) Tree use, diet and home range of the koala (*Phascolarctos cinereus*) at Blair Athol, central Queensland. Wildlife Research 29, 303-311.	May be very site specific Limited number of publications for some species and central QLD in general

Line of evidence	Relevance to habitat definitions	Examples	Limitations of dataset
BHP terrestrial ecology reports	Habitat definitions will be provided in ecology reports Specific to central QLD context Using both impact and offset site data can provide a range of habitat condition settings	Reports from numerous project assessments, usually provided to support impact assessments	Regulators have not accepted some of these definition in previous assessments Inconsistencies in definitions between report authors
Publicly available ecology survey results from other Bowen Basin projects	Provides central QLD specific data supplementary to that held by BHP	Olive Downs Project Isaac Downs Project Fairhill Coal Project Meadowbrook Project	Regulators may have required updates to definitions during EIA process
BHP terrestrial ecology geodatabase and ALA records	Spatial analysis to inform mapped habitat areas and also analysis of location of species records	NA	Statistical analysis may not be possible depending on size of datasets, but trends should be evident
Expert elicitation from other senior consulting ecologists and researchers	Environmental scientists/researches most frequently working in the Bowen Basin to provide expert review of draft habitat definitions Expert elicitation well accepted as a robust method of filling data gaps, especially where consensus can be reached	See Section 2.4 for participants	Risk that consensus cannot be reached Experts may not hold enough data to provide confident inputs

The review of information sources was used to identify and record habitat requirements and attributes for each species. These requirements and attributes included:

- Vegetation – composition, structure, Regional Ecosystems (REs)
- Food resources
- Land forms/land zones
- Soils
- Water/hydrology needs
- Patch size
- Connectivity
- Shelter including denning or roosting resources
- Micro habitat features (fallen woody debris, leaf litter, rocky outcrops)
- Breeding resources
- Habitat condition requirements

Across all data sources, uncertainties, inconsistencies and gaps were also be noted as appropriate.

2.1.1 Spatial analysis

A high-level spatial analysis was undertaken to support the development of habitat definitions. This included:

- Reviewing species records within areas of ground-truthed species habitat to gain additional understanding as to the habitat features that are present.
- Undertaking correlative assessment to inform which land zones or vegetation community types appear to be most commonly recorded as providing habitat for threatened species.
- Determining REs that may provide habitat within the central Queensland region. In this instance, REs considered in the habitat identification guides are those within the Brigalow Belt Bioregion (north and south) that intersect the Bowen Basin.

It is important to note that these spatial data were not relied upon heavily in determining the overall habitat definitions for species, as there is inherent uncertainty in the quality and accuracy of the data, as well as potential bias in survey effort. Rather the data contributed to the overall understanding of habitat requirements for each species.

2.2 Development of draft definitions

Information gathered via the above methods was collated into a master information spreadsheet for each species, with information recorded against each of the key attributes listed above (where available). This allowed an initial assessment of common themes for species-specific requirements across data resources, highlighted any inconsistencies and identify and prioritise information relevant to central Queensland. The information was used as a holistic based of evidence upon which to build the species habitat definitions.

Using the collated information and expert opinion, ecologists experienced in undertaking assessments in central Queensland prepared draft habitat definitions for each species. These were developed according to a suite of habitat categories, as described below.

2.3 Habitat categories

Three habitat categories were used to provide a consistent framework for identifying, describing and defining species' habitats within inland areas of central Queensland – preferred, suitable and marginal habitat. These categories have been applied to each species, noting that not all species have habitat diverse enough the warrant a split across all three categories.

Preferred habitats are those that are most important to the species and contain the features that are crucial for the species' persistence in an area. It includes habitats in which key activities are undertaken e.g. breeding, roosting and/or where high quality/species limiting foraging resources are found. If the species is present in a region, individuals will usually be found in preferred habitat.

Suitable habitat provides resources for the species but is not crucial for its persistence in an area. Individuals may be found in suitable habitat but are not likely to be undertaking key activities such as breeding or roosting. Foraging resources may be lower quality or used opportunistically (rather than being depended upon). If the species is present in a region, individuals may be found in suitable habitat but this habitat type may also remain unoccupied.

Marginal habitat provides limited resources for the species and is not crucial for its persistence in an area. Individuals may be occasionally found in marginal habitat but will not be undertaking key activities such as breeding, roosting or extensive foraging. If the species present in a region, individuals would be found in marginal habitat only rarely and this habitat type is likely to be unoccupied most of the time.

Preferred habitat is defined for all species. For some species, only suitable or marginal habitat is defined (i.e. only two habitat categories preferred and suitable or preferred and marginal). For species with definitions preferred and suitable habitat, those areas categorised as suitable comprise a range of resources and may vary in quality and usage across a region. Areas that do not meet the definition of preferred or suitable would not be used by the species and therefore 'marginal habitat' is not considered to be a relevant habitat category. For species with definitions preferred and marginal habitat, those areas categorised as preferred comprise the majority of habitat for the species and are crucial for persistence. There may be areas that are used on rare occasions but only contain limited resources and these are considered marginal. There are unlikely to be areas that are provide suitable habitat resources that are not considered crucial and therefore 'suitable habitat' is not considered to be a relevant habitat category these some species.

2.4 Expert elicitation and review

To provide scientific rigour and a level of robustness to the habitat descriptions, draft species-specific definitions were reviewed and refined in collaboration with key personnel with significant experience in collecting data, analysing and reporting on these species (see Table 2).

Emphasis was placed on senior/principal consulting ecologists who regularly work within central Queensland as well as academic researchers, as they possess detailed working knowledge of these species. The process for expert elicitation included providing species profiles to experts for review and seeking their input across the following questions:

- What information in the draft definition (preferred/suitable/marginal) do you support and why?
- What information in the draft definition (preferred/suitable/marginal) do you not support and why?
- Do you have additional suggestion to improve the draft definition?
- For species where only two habitats types are defined (e.g. preferred and suitable or marginal), do you think the third habitat type should be included? If not, why? If so, why and please provide a suggested definition.
- Are there other resources, particularly published literature or outcomes of research, relevant to this species in central Queensland that are not referenced in the current work?

Given the importance of this step, the full results of the reviews along with details of each reviewer's credentials is provided in an accompanying expert elicitation report, available on request.

Table 2: Professional ecologists involved in expert elicitation and review process

Name	Current position	Years' experience in central QLD	Species definitions reviewed
Steve Wilson	Fauna Consultant; Information Officer at the Queensland Museum	35 years	Ornamental snake, Collared delma, Yakka Skink
Dr Alistair Melzer	Adjunct Research Fellow, Central Queensland University	30+ years	Koala, Greater glider
Dr Penn Lloyd	Principal Ecologist, Biodiversity Assessment & Management Pty Ltd (BAAM)	27 years	Squatter pigeon, Ornamental snake, Australasian painted snipe
Craig Eddie	Principal Ecologist, BOOBOOK Ecological Consulting	25+ years	Koala, Greater glider, Squatter pigeon, Ornamental snake, Yakka skink, Australian painted snipe, Painted honeyeater, Collared delma, Large-eared Pied bat, Corben's (south-eastern) long-eared bat
Andrew Veary	Director, Footprints Environmental Consultants	25 years	Ornamental Snake
Lindsay Agnew	Principal Biologist and Director, Austecology	24+ years	Koala, Greater glider, Squatter pigeon, Ornamental snake, Australasian painted snipe
Greg Ford	Principal Ecologist, Balance! Environmental	20+ years	Large-eared Pied bat, Corben's (south-eastern) long-eared bat, Ghost bat, Grey-headed Flying-fox
Dr David Watson	Professor of Ecology, Charles Sturt University	20+ years	Painted honeyeater
Dr Stephen Debus	Independent Ecological Consultant, Adjunct Lecturer University of New England	20 years	Australian Painted Snipe, Squatter Pigeon, Painted Honeyeater
Dr Kevin Wormington	Senior Ecologist, Kleinfelder	18 years	Koala, Greater glider
Brad Dreis	Principal Ecologist, E2M	18 years	Koala, Greater glider, Squatter pigeon Ornamental snake, Australasian painted snipe, Painted honeyeater
Liz Fisher	Principal Ecologist / Ecology Team Lead, AECOM	12 years	Koala, Greater glider, Squatter pigeon, Ornamental snake, Yakka skink, Painted honeyeater
Berlinda Ezzy & Andrew Jensen	Associate Ecologist, EMM Consulting	10+ years	Painted honeyeater, Grey-headed Flying-fox
Loren Appleby	Senior Ecologist, Eco Logical Australia	7 years	All species

2.5 Definition refinement and finalisation

Following the results of expert elicitation and review from independent expert ecologists, the habitat definitions were refined where necessary and based on the consensus view of relevant reviewers. These are the definitions presented in the species profile sections below[1].

[1] Draft definitions that were reviewed by species experts listed in Table 2 are provided in the expert elicitation report.

3. Koala (*Phascolarctos cinereus*)

3.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable (as the combined populations of Queensland, New South Wales and the Australian Capital Territory)

Nature Conservation Act 1992: Vulnerable

3.2 Ecology and distribution

The koala (*Phascolarctos cinereus*) is an arboreal marsupial, with a stocky body, large rounded ears, sharp claws and variable but predominantly grey-coloured fur (see Figure 3-1). In the north of their distribution, koalas tend to have shorter, silver-grey fur, whereas those in the south have longer, thicker, brown-grey fur.[2]

Koalas display sexual dimorphism (males generally are larger than females), with male koalas weighing approximately 9 kg and females up to 7 kg in Queensland.[3] There is also a latitudinal cline in morphology with a trend of increasing body mass from northern Queensland to Victoria[4], although there is also some regional variation in central Queensland.[5]

Figure 3-1: Koala (*Phascolarctos cinereus*) (Steve Wilson 2020)

3.2.1 Known distribution

The koala is distributed along the east coast of Australia extending from Queensland to Victoria and into South Australia (see Figure 3-2). In Queensland, the koala's distribution extends across several

[2] Martin & Handasyde 1999

[3] Menkhorst and Knight 2001; Melzer 1995

[4] Briscoe et al. 2014

[5] Melzer 1995

bioregions, encompassing a great diversity of habitats, and they have been recorded in many biogeographic regions including the Einasleigh Uplands, Wet Tropics, Desert Uplands, Central Mackay Coast, Mitchell Grass Downs, Mulga Lands, Brigalow Belt, South Eastern Queensland and Channel Country.[3] Typically, koalas occupy wet forests along the coast, sub-humid woodlands in southern and central regions, and eucalypt woodlands along watercourses in semi-arid environments of western regions.[6]

in Queensland, koala densities are greatest in the southeast region. Over the remainder of the species range within Queensland, the population densities are low to very low, with a few localised exceptions where numbers are relatively high and densities in central Queensland are typically low relative to those in the southeast. Abundance is strongly influenced by heat wave and drought severity and duration.[7] Consequently, some otherwise suitable koala habitat may be vacant for a number of years or decades before being recolonised.[8]

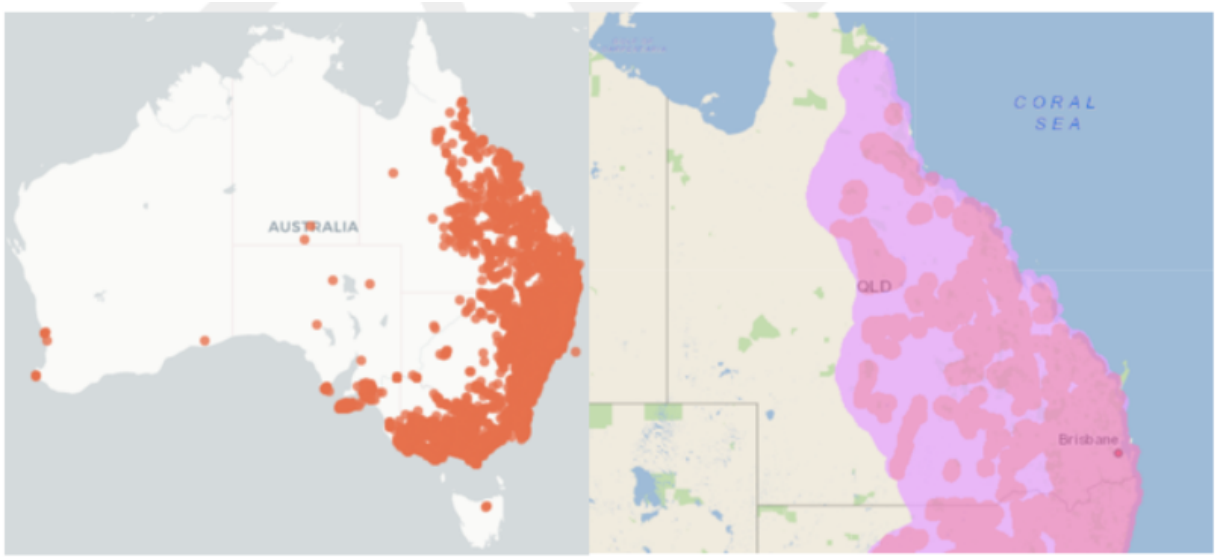

Figure 3-2: Distribution range of the koala (ALA 2020; DoE 2020; noting that records in central and western Australia are likely to be captive animals or spurious records)

3.2.2 Biology and reproduction

The koala is an arboreal folivore, feeding primarily during dawn, dusk or during the night. Its staple diet is comprised of foliage of *Eucalyptus* spp.; however, it may also consume foliage of other genera, and will even consume bark, termite mounds and soil from time to time.[9,10,2] Although koalas will

[6] Melzer et al. 2014

[7] Gordon et al. 1988

[8] Melzer pers. obs., Gordon et al. (2006)

[9] Crowther et al. 2013

[10] Moore and Foley 2000

occasionally drink free water when it is available, the vast majority of their water intake comes from the water within the leaves that they eat.[11]

Female koalas can potentially produce one offspring each year with births occurring between October and May. Offspring stay in the pouch for 6 to 8 months and remain dependent on the mother, riding on its back, until 12 months of age. The generation length of koalas is estimated to be between 6 to 8 years.[3] Adult females may live for more than 15 years and adult males for more than 12 years, although this may be lower in central Queensland.[2]

3.3 General habitat requirements

Koalas utilise their habitat in complex ways to meet their physiological demands, as described below[12]. Whilst the specifics of habitat utilisation vary across the species distribution as the environment, landscape and habitat structure change, the key elements are:

- Presence of one or more palatable tree species (not always as the dominant species) occurring in a landscape that provides reliable leaf moisture
- Complexity of habitat structure allowing koalas to avoid predators, and/or mitigate the stresses of high temperature or high humidity
- A landscape of sufficient extent to allow a widespread population to persist and interact.

Additionally, the general manner in which koalas use habitat includes:

- Selecting trees at night for feeding and socialising
- Selecting a different, but overlapping set of trees by day for sheltering and avoiding predation
- Additional daytime habitat usage, which may involve the use of shrubs, vine thickets, tree hollows, stream banks and hollow logs, especially in more western locations.

In Queensland, a koala habitat landscape usually includes multiple vegetation communities (REs) and the pattern of habitat usage by the species changes with season. Typically, a koala home range will encompass a range of vegetation communities and landform elements, with koalas in central Queensland moving around considerably. Sustainable koala habitat is founded on the food tree species having access to groundwater throughout the year somewhere within the resident koalas' range, and this must be sufficient to maintain leaf moisture content at a level to sustain the koala. The groundwater may be sub-surface stream aquifers, but also cracked rock aquifers, with the latter being critical in central Queensland where they provide drought refuges. The vegetation dependent on these aquifers are groundwater dependent ecosystems and to some extent these have been mapped by Queensland Government Wetlands Group.[13]

[11] Clifton et al. 2007

[12] A. Melzer pers comm. 2020

[13] https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/groundwater-dependent/

3.4 Central Queensland habitat definition

Preferred koala habitat in central Queensland is defined as:

- Contiguous remnant *Eucalyptus* open forest to woodlands on alluvial and/or cracked rock groundwater where palatable food tree species occur frequently (and are usually dominant)
- This specifically includes stream fringing open forest, open forest or woodland on alluvial terraces where *Eucalyptus tereticornis/camaldulensis* are dominant or common subdominant elements. Other important food species on the alluvial terraces can include E*. coolibah, E. crebra, E. melanophloia* and *E. popunea*.

Preferred habitat areas located where aquifers persist through most drought cycles, substrates have high fertility and food tree species occur at relatively high frequencies have the potential to support moderate to high density koala populations. Preferred habitat areas represented as *Eucalyptus crebra/drepanophylla* tall woodland on hills and ranges with aquifers that persist in most drought cycles (commonly cracked rock aquifers) have the potential to support a low to moderate density koala population e.g. Clarke-Connors Ranges, Minerva Hills.

Suitable koala habitat that provides food resources or aids to movement for the species in central Queensland is defined as:

- Remnant and regrowth *Eucalyptus* open forest to woodlands with more variable aquifers (often seasonal) and that have connectivity to other areas of suitable or preferred habitat.

Marginal koala habitat in central Queensland is defined as:

- All other fragmented and sparsely distributed woodlands and open woodlands, shrub lands and forests, with some food trees and which experience significant seasonal water deficits and/or are subject to periodic high intensity fires.

An example marginal habitat type is *Acacia harpophylla* open forest with isolated *Eucalyptus tereticornis/camaldulensis, E. coolabah and/or E. populnea*. These areas have the potential to support only very low density koala populations.

NOTE: A landscape across which koalas move, but does not contain palatable tree species, and/or a persistent freshwater aquifer sufficient to maintain leaf moisture at levels sufficient to sustain a resident koala population and/or a habitat structure that provides refuge from predators or the capacity to avoid heat stress, is not considered to provide habitat values for the species.

3.5 Habitat identification guidance

Table 3 provides specific information about key attributes of koala habitat requirements, and where these data can be obtained. Collectively these data enable koala habitat to be classified as preferred, suitable or marginal as described above.

Table 3: Koala habitat identification

Attribute	Description	Verification area
Vegetation composition	High abundance eucalypt trees present in vegetation patch (food resource abundance), relative to other	Desktop and field

Attribute	Description	Verification area
	analogous central Queensland locations; community may not be diverse	
Vegetation structure	Open forests, woodlands, open woodlands including remnant and regrowth, with structural complexity to allow shelter from heat by day (may include mid-story or scattered acacias or dry rainforest elements)	Field
Regional ecosystem associations that may comprise preferred, suitable and/or marginal habitat	Preferred: 11.3.2, 11.3.2a, 11.3.2b, 11.3.4, 11.3.4a, 11.3.25, 11.3.27 Suitable: 11.3.3, 11.3.6, 11.3.7, 11.3.9, 11.3.10, 11.3.14, 11.3.15, 11.3.17, 11.3.18, 11.3.26, 11.3.28, 11.3.29, 11.3.30, 11.3.35, 11.3.36, 11.3.37, 11.3.39, 11.4.2, 11.4.7, 11.4.10, 11.4.12, 11.4.13, 11.5.1, 11.5.1a, 11.5.2, 11.5.3, 11.5.3b, 11.5.5, 11.5.5a, 11.5.5c, 11.5.7, 11.5.8, 11.5.9, 11.5.9b, 11.5.9c, 11.5.9d, 11.5.12, 11.5.13, 11.5.17, 11.5.20, 11.7.1, 11.7.4, 11.7.6, 11.7.7, 11.8.1, 11.8.2, 11.8.4, 11.8.5, 11.8.5a, 11.9.1, 11.9.2, 11.9.7, 11.9.7a, 11.9.9, 11.9.10, 11.9.13, 11.10.1, 11.10.1a, 11.10.1d, 11.10.2, 11.10.2a, 11.10.4, 11.10.5, 11.10.7, 11.10.7a, 11.10.11, 11.10.11a, 11.10.12, 11.10.13a, 11.11.1, 11.11.3, 11.11.3c, 11.11.6, 11.11.9, 11.11.10, 11.11.10a, 11.11.11, 11.11.15, 11.11.15a, 11.11.16, 11.11.19, 11.12.1, 11.12.1a, 11.12.1b, 11.12.2, 11.12.3, 11.12.5, 11.12.6 and 11.12.7 Marginal: 11.3.19, 11.5.4, 11.5.4a, 11.7.2, 11.7.3, 11.7.5, 11.10.3, 11.10.6, 11.10.9, 11.10.13, 11.11.2	Desktop and field (with field validation essential to determine relative dominance of *Eucalyptus* at a local scale)
Food resources	Known food trees in CQ include (but are not limited to): *E. camaldulensis*, *E. tereticornis*, *E. populnea, E. orgadophila*, *E. melanophloia*, *E. crebra*, *E. moluccana*, *E. coolabah*, *E. brownii*, *E. cambageana*, *E. thozetiana*, *E. exserta*, *E. chloroclada*, *E. major*, *E. grisea*, *E. longirostrata*, *E. melliodora*.	Field
Landforms/land zones	Found across multiple landforms and land zones[14].	Desktop
Soils	Landscapes/soils of relatively high fertility where there is reliable groundwater.	Desktop
Water (for drinking)	Distribution associated with water availability in terms of leaf moisture i.e. groundwater depended ecosystems (as this is the primary source of water for the species in central Queensland). [15]	Desktop and field
Hydrological needs	Relationship between leaf water concentration and occurrence of koala[16], including both drainage lines (alluvial aquifers) and suurounding landscapes with more variable aquifers (seasonal water availability). Rock	Desktop and field

[14] Melzer et al. 2014

[15] Melzer et al. 2014

[16] Adams-Hosking et al. 2012

Attribute	Description	Verification area
	aquifers in basalt and discharge zones around sandstone escarpments are key refugia, as are long-term persistent waterholes.[17]	
Patch size	Preferred habitat patches should be larger than 50-100 ha in size unless they are part of a cluster of highly connected patches.[18]	Desktop
Connectivity	Clusters of patches should be separated by less than 100-200 m.	Desktop
Shelter/denning/roosting	Shelter trees are likely to be selected based on height, canopy cover and elevation. There is no identified sub-set of forest and woodland trees known to be shelter trees.[19]	Field
Micro habitat features	N/A	N/A
Breeding resources	It is not possible to separate foraging and breeding habitat requirements with current available information and they are likely to share the same characteristics.	Field
Habitat condition	Assessment of habitat quality for koalas is usually based on the identification of local preferences for food tree species and quantification of the availability of those species. This includes an assessment of canopy connectivity.	Field

3.6 References

Adams-Hosking, C., McAlpine, C., Rhodes, J. R., Grantham, H. S., & Moss, P. T. 2012. Modelling changes in the distribution of the critical food resources of a specialist folivore in response to climate change. Diversity and Distributions, 18(9), 847–860

ALA 2020. *Phascolarctos cinereus: Koala* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:e9d6fbbd-1505-4073-990a-dc66c930dad6

Briscoe, N.J., Krockenberger, A, Handasyde, K. A. and Kearney, M.R., (2014) Bergmann meets Scholander: Geographical variation in body size and insulation in the koala is related to climate. *Journal of Biogeography*, 42: 791-802.

Clifton, I.D., Ellis, W. A. H., Melzer, A. and Tucker, G. (2007) Water turnover and the northern range of the koala (*Phascolarctos cinereus*). *Australian Mammalogy* 29 85 – 88.

Commonwealth of Australia 2014. *EPBC Act Referral Guidelines for the vulnerable koala (combined populations of Queensland, New South Wales and the Australian Capital Territory*.

[17] A. Melzer pers comm. 2020

[18] McAlpine et al. 2007

[19] Crowther et al. 2013

Crowther, M., D. Lunney, J. Lemon, E. Stalenberg, R. Wheeler, G. Madani, K. Ross & M. Ellis 2013. *Climate-mediated habitat selection in an arboreal folivore*. Ecography. 36:001-008.

Department of the Environment (DoE) 2020. *Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Gordon, G., Brown, A.S. and Pulsford, T., (1988), A koala (*Phascolarctos cinereus* Goldfuss) population crash during drought and heatwave conditions in south-western Queensland. *Australian Journal of Ecology*, 13: 451-461.

Gordon, G., Hrdina, F., and Patterson, R., (2006) Decline in the distribution of the Koala Phascolarctos cinereus in Queensland. *Australian Zoologist*:33(3): 345-358

Martin, R.W., Handasyde, K.A. and Krockenberger, A. 2008. Koala. In: Van Dyck, S. and Strahan, R. (eds) The Mammals of Australia. Third Edition. Reed New Holland, Sydney. Pp. 198-201.

McAlpine, C.A., Rhodes, J. R, Peterson, A., Possingham, H., Callaghan, J and Lunney, D. 2007. *Planning Guidelines for Koala conservation and Recovery: A guide to best planning practice.* University of Queensland, Brisbane

Melzer, A, Cristescu, R, Ellis, W, Fitzgibbon, S and Manno, G. 2014. *The habitat and diet of Koalas (Phascolarctos cinereus) in Queensland*. Australian Mammalogy 36(2): 189-199.

Melzer, A.M. (1995) *Aspects of the ecology of the koala Phascolarctos cinereus (Goldfuss, 1817) in the sub-humid woodlands of Central Queensland.* PhD Thesis, University of Queensland, Brisbane, Qld.

Menkhorst and Knight (2001) *A field Guide to the Mammals of Australia*. CSIRO Publishing, Australia.

Moore, B.D. & Foley, W.J. 2000. *A review of feeding and diet selection in koalas (*Phascolarctos cinereus*)*. Australian Journal of Zoology. 48:317-333.

Phillips, S.S. 2000. *Population trends and the koala conservation debate*. Conservation Biology. 14:650-659.

Threatened Species Scientific Committee (TSSC) 2012. *Listing advice for Phascolarctos cinereus (Koala)*.

4. Greater glider (*Petauroides volans*)

4.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

4.2 Ecology and distribution

The greater glider has a head and body length of 35 – 46 cm and a tail ranging from 45 – 60 cm in length, making it the largest gliding possum in Australia. The greater glider has a short snout and large fury ears. There are two distinct colour forms of the greater glider that co-occur; in the dark form the upper fur is almost charcoal, while in the pale form the upper fur is light grey to white.

Figure 4-1: Greater glider (*Petauroides volans*) (Steve Wilson 2019)

4.2.1 Known distribution

The greater glider has an extensive latitudinal distribution, extending from the Windsor Tableland in north Queensland to central Victoria (Wombat State Forest). The westerly distribution is constrained, reflecting the habitat requirements for a relatively wet open forest/woodland and susceptibility to fire (see Error! Reference source not found.). Two isolated populations also occur within Gregory Range west of Townsville and in the Einasleigh Uplands. Their distribution covers an elevational range from sea level to 1200 m above sea level.[Error! Bookmark not defined.]

Although the extent of the species occurrence has unlikely changed significantly since European settlement, their area of occupancy has decreased considerably; predominantly as a result of land clearing and fires, both of which result in the loss of hollow bearing trees. They are largely restricted to eucalypt forests and woodlands where their distribution is often patchy.[Error! Bookmark not defined.]

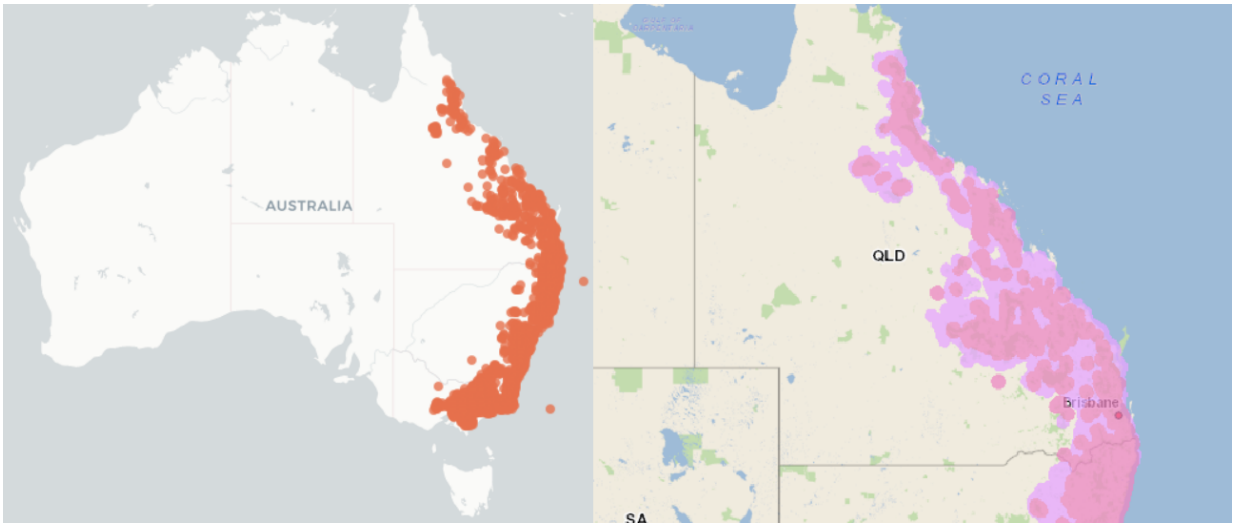

Figure 4-2: Distribution range of the greater glider (ALA 2020; DoE 2020)

4.2.2 Biology and reproduction

The greater glider is primarily a folivore, consuming eucalypt leaves and occasionally flowers.[Error! Bookmark not defined.] The species typically selects younger leaves within larger trees for feeding, favouring species that have higher levels of nutrients.[20,21] Examples of key eucalypt species that are used across the species' geographic range from Victoria to Queensland include: *Eucalyptus radiata, E. viminalis, E. acmenoides, E. fastigata, E. globoidea, E. moluccana, E. regnans,* and *E. tereticornis*. The greater glider has also been observed consuming non-eucalypt species on rare occasions including *Acacia* and *Amyemai* species.[22]

Females reach sexual maturity at age 2 and give birth to a single young between March and June. The generation length of the greater glider is estimated to be between 7 to 8 years and longevity is around 15 years.[Error! Bookmark not defined.]

4.3 General habitat requirements

Greater gliders inhabit eucalypt forests and woodlands; typically, moist, montane eucalypt forests that contain taller, older trees with abundant hollows.[Error! Bookmark not defined.] Their habitat consists of a range of eucalypt communities with these varying throughout their range.

In a study conducted in a large tract of forest in the dry inland of southern Queensland the species was commonly foraging on *Eucalyptus moluccana, E. fibrosa* and *Corymbia citriodora,* preferring trees in 30-70 cm dbh classes and as mature and over mature according to growth-stage charateristics.[Error! Bookmark not defined.,Error! Bookmark not defined.]

[20] Smith et al. 2007

[21] Smith & Smith 2018

[22] Harris & Maloney 2010

Occupancy modelling has indicated that the degree of site occupancy is associated with vegetation lushness and terrain wetness.[23] This is likely due to their water intake being primarily sourced from the foliage that they consume and explains their preference for moist forests.[Error! Bookmark not defined.] Importantly, the lushness/wetness of vegetation must be considered relative to the vegetation present in the region and it is not appropriate to compare the this habitat attribute across the species' range (i.e. the wet temperate forests of Victoria cannot be compared with the inland riparian forests and woodlands of central Queensland).

Greater gliders shelter within tree hollows during the day and due to their size, larger tree hollows are required (80 mm, with internal hollow measurements reaching 250 x 250 mm).[24] In one southern Queensland study, large (dbh >50 cm) were primarily used as den trees [Error! Bookmark not defined.]. Research in southern Queensland has demonstrated that the numbers of greater gliders (and other gliders and possums) peak at 6 hollows/ha in tall forests (>25 m) and at 4 hollows/ha in shorter forests[25].

Greater gliders have small home ranges; typically, between 1-4 ha, but can be larger (up to 16 ha) in lower productivity forest and open woodland (Smith et al. 2007; TSSC 2016).[Error! Bookmark not defined.,Error! Bookmark not defined.] This may be limited both by the presence of hollows and also the generalist diet, which means individuals generally do not need to travel within suitable habitats far to find foraging resources.

The species is sensitive to fragmentation and fire, including strategic or 'controlled' burns. It does not disperse easily across non-native vegetation.[Error! Bookmark not defined.] To maintain viable populations, they appear to require large areas of continuous habitat (estimated in one study to be at least 160 km^2 in Queensland).[Error! Bookmark not defined.]

4.4 Central Queensland habitat definition

Preferred greater glider habitat in central Queensland is defined as:

- Remnant, connected eucalypt woodlands containing more than 2 hollow bearing trees/ha, with hollows medium-large in size (>10 cm entrance), usually on fertile, wetter soils of riparian zones.
- In central Queensland, preferred foraging and den trees include *E. camaldulensis, E. tereticornis, E. fibrosa* and *Corymbia citriodora.* The species has also been observed in *Angophora floribunda, Eucalyptus cambageana, E. coolabah, E. crebra, E. laevopinea, E. moluccana, E. orgadophila, E. populnea, E. melanophloia* and *C. tessellaris* in which it may use for foraging and/or denning.

Suitable greater glider habitat in central Queensland is defined as:

- Remnant eucalypt woodlands connected to areas of roosting habitat that does not contain more than 2 hollow bearing trees/ha, medium-large in size (>10 cm entrance). Generally within ~ 120m of breeding / denning habitat, reflecting the home range of the species.

[23] Lumsden et al. 2013

[24] Eyre 2006

[25] Wormington 2003

Marginal greater glider habitat in central Queensland is defined as:

- Remnant or high value regrowth vegetation[26] adjacent to preferred greater glider habitat where hollows are smaller and/or less frequent. Isolated patches of marginal habitat >100 m from adjacent habitat do not provide habitat for the species due to gliding capabilities.
- Remnant or high value regrowth vegetation on low fertility and low moisture soils, regardless of hollow densities.

4.5 Habitat identification guidance

Error! Reference source not found. provides specific information about key attributes of greater glider habitat requirements, and where these data can be obtained. Collectively these data enable greater glider habitat to be classified as preferred or marginal as described above. It is important to note that much of the knowledge for this species has been gathered from other geographic regions (e.g. Victoria, south-east Queensland) and the level of uncertainty about its requirements in central Queensland is higher than for populations in better studied areas, indicating a need for further study of local populations.

Table 4: Greater glider habitat identification

Attribute	Description	Verification area
Vegetation composition	Forests and woodlands dominated by Eucalyptus species.	Desktop and field
Vegetation structure	Eucalypt forests and woodlands, highly associated with tall (min 16 m), old-growth hollow-bearing trees.[27] This association may be less strong in central and far north Queensland. In drier climates, a home ranges are larger and hollows for dens are required throughout this area.	Field
Regional ecosystem associations that may comprise preferred or marginal habitat	Eucalypt and/or *Corymbia citriodora* dominant forest and woodland REs that have potential to form hollows of sufficient size and abundance, including the following REs: 11.3.2, 11.3.2b, 11.3.3, 11.3.4, 11.3.6, 11.3.9, 11.3.10, 11.3.14, 11.3.15, 11.3.17, 11.3.18, 11.3.25, 11.3.26, 11.3.29, 11.3.30, 11.3.35, 11.3.36, 11.3.37, 11.3.39, 11.4.2, 11.4.7, 11.4.10, 11.4.12, 11.4.13, 11.5.1, 11.5.1a, 11.5.2, 11.5.3, 11.5.3b, 11.5.4, 11.5.4a, 11.5.5, 11.5.5a, 11.5.5c, 11.5.7, 11.5.9, 11.5.9b, 11.5.9c, 11.5.9d, 11.5.13, 11.5.17, 11.5.20, 11.7.6, 11.7.7, 11.8.1, 11.8.2, 11.9.1, 11.9.2, 11.9.7, 11.9.7a, 11.9.9, 11.9.10, 11.9.13, 11.10.1, 11.10.1d, 11.10.2, 11.10.2a, 11.10.7, 11.10.7a, 11.10.11, 11.10.11a, 11.10.12, 11.10.13, 11.10.13a, 11.11.1, 11.11.3, 11.11.3c, 11.11.10, 11.11.10a, 11.11.15, 11.11.15a, 11.11.16, 11.11.19, 11.12.1, 11.12.1a, 11.12.2, 11.12.3, 11.12.6 and 11.12.7	Desktop and field (with field validation essential to determine relative dominance of *Eucalyptus* at a local scale)

[26] For high value regrowth to be considered marginal habitat, it needs to include scattered large Eucalypt trees as Smith et al. (2007) did not observe any gliders foraging in non-myrtaceous species or myrtaceous trees <20 cm dbh

[27] TSSC 2016

Attribute	Description	Verification area
	With the following likely to be considered preferred in CQ: REs 11.3.4, 11.3.4, 11.3.25, 11.8.1, 11.8.2, 11.10.1, 11.10.2, 11.10.4, 11.10.5, 11.11.1 & 11.11.3	
Food resources	Primarily eucalypt leaves and occasionally flowers. Selects younger leaves within larger trees, with key species including *E. moluccana, E. tereticornis*. *E. fibrosa* and *C. citriodora* [28] and *Angophora floribunda*, *Eucalyptus coolabah, E. laevopinea,* and *E. crebra* (C. Eddie pers comm.)	Field
Landforms/land zones	N/A	N/A
Soils	Low soil moisture impacts food quality (species water intake reliant on that contained in foliage).[29] High soil moisture includes heavier clays.	Desktop
Water (for drinking)	Species water intake reliant on that contained in foliage. Gliders do not drink free-standing water.	Desktop
Hydrological needs	Landscape position where trees have access to groundwater or surface water. Degree of site occupancy can be associated with vegetation lushness and terrain wetness relative to the local environment.[30]	Desktop and field
Patch size	Require tracts of contiguous habitat with surveys in south-east Queensland identifying 160 km^2 as the smallest forested patch the species has been observed in.[31] Within central Queensland, the species has been recorded in smaller patches.	Desktop
Connectivity	There is some argument about the distance greater gliders can glide. Recent research indicates glide distances of <50 m are feasible, but depend on the height of launch and ultimate glide angle.[Error! Bookmark not defined.] They are considered to disperse poorly across vegetation that is non-native or low vegetation. [32]	Desktop
Shelter/denning/roosting	Require at least 2–4 live den trees for every 2 ha of suitable forest habitat[33] or utilises 4-20 live den trees across their home range in dry inland environments. Large (dbh >50 cm) and old living trees primarily used as den trees. [34]	Field

[28] Smith et al. 2007

[29] Smith & Smith 2018

[30] Lumsden et al. 2013

[31] Eyre 2006

[32] Smith et al. 2007

[33] Eyre 2002

[34] Smith et al. 2007

Attribute	Description	Verification area
Micro habitat features	Hollow entrance of a minimum of 80 mm, with internal hollow measurements reaching 250 x 250 mm. [35]	Field
Breeding resources	Associated with shelter resources and micro habitat features.	Field
Habitat condition	N/A	N/A

4.6 References

ALA 2020. *Petauroides Volans: Greater glider* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:7e891f26-c72e-4b29-98db-1cd10c4eaa6d

Department of the Environment 2020. *Petauroides volans* in Species Profile and Threats Database, Department of the Environment, Canberra.

Eyre, T. J. 2002. *Habitat preferences and management of large gliding possums in southern Queensland*. Ph.D. thesis, Southern Cross University, Lismore.

Eyre, T. J. 2006. *Regional habitat selection of large gliding possums at forest stand and landscape scales in southern Queensland, Australia I. Greater Glider (Petauroides volans).* Forest Ecology and Management 235(1):270-282

Harris, J. M., & Maloney, K. S. 2010. *Petauroides volans (Diprotodontia: Pseudocheiridae).* Mammalian Species, 42(1), 207–219.

Lumsden, L.F., Nelson, J.L., Todd, C.R., Scroggie, M.P., McNabb, E.G., Raadik, T.A., Smith, S.J., Acevedo, S., Cheers, G., Jemison, M.L. & Nicol, M.D. 2013. *A New Strategic Approach to Biodiversity Management – Research Component*. Arthur Rylah Institute for Environmental Research. Unpublished Client Report for the Department of Environment and Primary Industries, Heidelberg, Victoria.

Threatened Species Scientific Committee (TSSC) 2016. *Conservation Advice Petauroides volans greater glider.* Canberra: Department of the Environment.

Smith, G.C, Mathieson, M., and Hogan, L. 2007. *Home range and habitat use of a low-density population of greater gliders, Petauroides volans (Pseudocheiridae: Marsupialia), in a hollow-limiting environment*. Wildlife Research, 2007, 34, 472–483

Smith, P., & Smith, J. (2018). *Decline of the greater glider* (Petauroides volans) *in the lower Blue Mountains, New South Wales.* Australian Journal of Zoology, 66(2), 103–114.

Worminton, K. (2003). The habitat requirements of arboreal marsupials in the dry sclerophyll forests of south-east Queensland, Australia. PhD Thesis.

[35] Smith et al. 2007

5. Squatter pigeon (southern; *Geophaps scripta scripta*)

5.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

5.2 Ecology and distribution

The squatter pigeon (southern) (*Geophaps scripta scripta*) is a medium-sized ground-dwelling bird that is approximately 30 cm in length and weighs 190 – 250 g. It is predominantly grey-brown grading to blue-grey on the lower breast and belly; with bold black and white stripes around the face and throat. It has a black bill and faded purple legs and feet (see Figure 5-1). Juveniles have duller colouring and less distinctive black and white facial stripes. The southern subspecies is slightly larger than the northern subspecies and has blue-grey skin around the eyes instead of yellowy-orange to orange-red skin.[36]

Figure 5-1: Squatter pigeon (*Geophaps scripta scripta*) (Loren Appleby 2020)

5.2.1 Known distribution

The squatter pigeon is distributed along the inland slopes of the Great Dividing Range; extending from the Burdekin-Lynd Divide in central Queensland to the south in New South Wales (north of 29° S) (see Figure 5-2). This distribution has reduced significantly since the 1870's, with the species historically being abundant and widespread within NSW. The squatter pigeon is now rarely sighted in NSW.[36,37]

Large areas of squatter pigeon's original habitat in Queensland has been replaced by improved pasture for cattle-grazing; reducing the abundance of food and native plants. Within their current range, they

[36] Higgins & Davies 1996

[37] Cooper et al. 2014

occupy open-forests, open-woodlands and scrub including sparse regrowth and partly modified vegetation.[38]

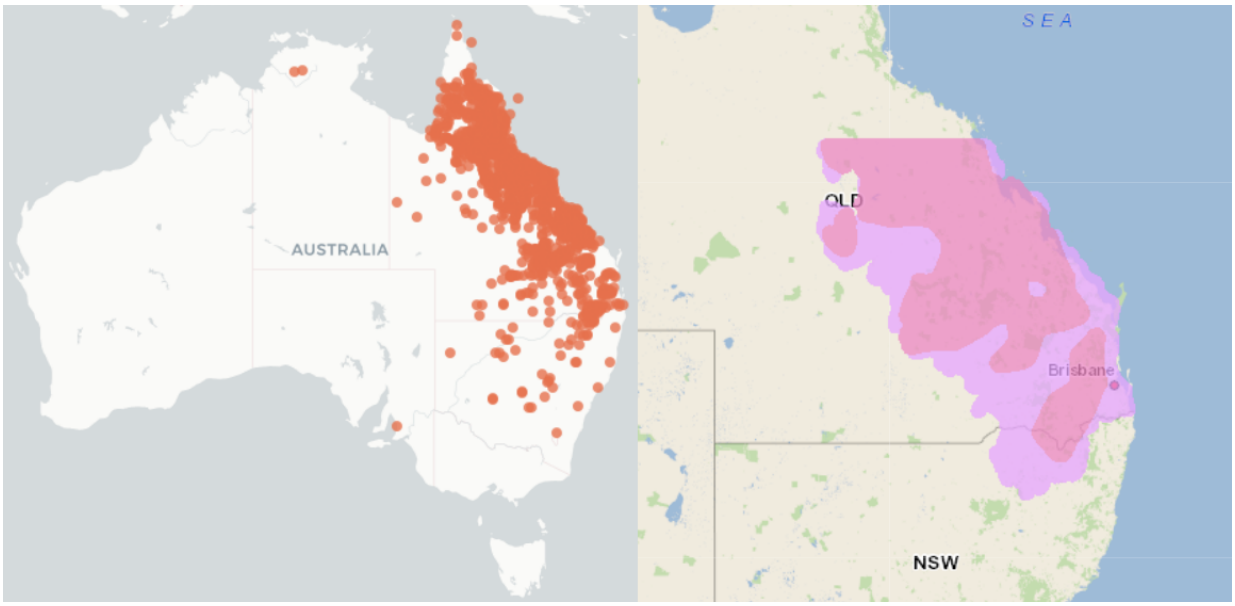

Figure 5-2: Distribution range of the squatter pigeon (ALA 2020; DoE 2020). Note – the ALA records include both subspecies and records from the NT and SA are doubtful/erroneous.

5.2.2 Biology and reproduction

The squatter pigeon primarily forages on seeds which have fallen to the ground from nearby vegetation including grasses, herbs and shrubs. It is also observed foraging around stockyards consuming seeds and ticks from livestock droppings. The species requires access to waterbodies for drinking and these can be natural or artificial as long as there is bare ground at the water's edge. The squatter pigeon will access suitable waterbodies on a daily basis. Squatter pigeons can be found in pairs or in groups that can contain greater than 20 individuals. [38, 39]

The life cycle of the squatter pigeon is poorly understood but they have been observed breeding from one year of age. The generation length is estimated to be 5 years and breeding typically coincides with optimal conditions (food availability), although can occur throughout the year. In Queensland, peak breeding season most likely occurs during the dry season (April to October) when seeds on the ground are abundant. They breed in solitary pairs and can produce two broods of young per season.[39]

Squatter pigeons scrape a depression into the ground beneath tussock grass, a bush or a fallen log to create a nest. Females typically lay two eggs which are incubated for 17 days and once hatched, chicks remain within the nest for 2-3 weeks and continue to be dependent upon their parents for around 4 weeks once leaving the nest.[39,40]

[38] TSSC 2015

[39] DoE 2020

[40] EPA 2006

5.3 General habitat requirements

Squatter pigeons generally inhabit the grassy understory of eucalypt woodland and can be found on tropical savanna and in open grassy areas including regrowth and modified areas such as paddocks and other non-native grasslands.[38,41] Their habitat is typically:[39]

- Comprised of an overstorey dominated by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* species;
- Within 3 km of a waterbody;
- On low, gently sloping, flat to undulating plains and foothills; and
- On well-draining, gravelly, sandy or loamy soils.

An overstorey is required within squatter pigeon habitat as they roost in low trees overnight and prefer to undertake daytime behaviours (foraging, dust bathing, breeding) under a canopy of trees.[39] However, they are also observed foraging in more modified landscapes including burnt areas, roadsides, stockyards and around rural homes.[38,41]

5.4 Central Queensland habitat definition

All squatter pigeon habitat is located on low, gently sloping, flat to undulating plains, foothills and plateaus.

Preferred squatter pigeon habitat in central Queensland is defined as:

- Remnant or regrowth grassy open forest to woodland dominated by *Eucalyptus, Corymbia, Callitris* or *Acacia* with patchy, relatively sparse ground cover vegetation (33 %) and sparse shrub layer on well-draining sandy, loamy or gravelly soils within 1 km of a suitable permanent[42] waterbody.
- Preferred habitat may be located on land zones 3, 5, 7, 8, 9 and 10.

Preferred habitat does not include areas dominated by introduced pasture grasses, in particular *Cenchrus ciliaris*, nor heavily grazed areas[43] but these areas may be included in suitable and marginal habitat as defined below.

Suitable squatter pigeon habitat in central Queensland is defined as:

- Remnant or regrowth grassy open forest to woodland dominated by *Eucalyptus, Corymbia, Callitris* or *Acacia* with patchy, relatively sparse ground cover vegetation (<33 %) on well-draining sandy, loamy or gravelly soils between 1 and 3 km of a suitable permanent or seasonal[44] waterbody; and
- Non-remnant areas within 100 m of preferred habitat.

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[41] Campbell & Woods 2013

[42] Includes mapped wetlands and ≥3rd order streams.

[43] Reis 2012

[44] Includes 1st and 2nd order streams.

- Suitable habitat may be located on land zones 3, 5, 7, 8, 9 and 10.

Marginal squatter pigeon habitat in central Queensland is defined as:

- Non-remnant areas, regrowth and remnant woodland or forest areas more than 3 km from a permanent or seasonal waterbody that facilities the movement of the species between patches of preferred or suitable habitat.

5.5 Habitat identification guidance

Table 5 provides specific information about key attributes of squatter pigeon habitat requirements, and where these data can be obtained. Collectively these data enable squatter pigeon habitat to be classified as preferred, suitable or marginal as described above.

Table 5: Squatter pigeon habitat identification

Attribute	Description	Verification area
Vegetation composition	Mostly dominated in the overstorey by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* species.[45]	Desktop and field
Vegetation structure	Open forests to sparse, open woodlands, woodlands and scrub[45] Open and short grass cover. Less commonly found in dense grass cover. [45] Ground cover rarely exceeds 33%.[45]	Field
Regional ecosystem associations that may comprise preferred, suitable or marginal habitat	11.3.10, 11.3.14, 11.3.17, 11.3.18, 11.3.2, 11.3.2a, 11.3.2b, 11.3.2c, 11.3.25, 11.3.26, 11.3.27, 11.3.29, 11.3.3, 11.3.30, 11.3.35, 11.3.36, 11.3.37, 11.3.38, 11.3.39, 11.3.4, 11.3.4a, 11.3.6, 11.3.7, 11.3.9, 11.5.1, 11.5.1a, 11.5.11, 11.5.12, 11.5.13, 11.5.17, 11.5.2, 11.5.20, 11.5.3, 11.5.4, 11.5.5, 11.5.8, 11.5.9, 11.7.2, 11.7.3, 11.7.4, 11.7.5, 11.7.6, 11.7.7, 11.9.10, 11.9.7, 11.10.1, 11.10.13, 11.10.4, 11.10.6, 11.10.7, 11.10.9, 11.10.11, 11.10.12 11.3.19, 11.3.22, 11.4.2, 11.4.12, 11.8.2, 11.8.4, 11.8.5, 11.9.2, 11.9.9, 11.10.3, 11.10.13, 11.10.14 & 11.11.1	Desktop and field
Food resources	Predominantly seeds of legumes in the family Fabaceae (45% of food volume) including those of exotic pasture plants such as *Stylosanthes* spp., and native grasses in the family Poaceae[46]	Field
Landforms/land zones	Predominantly land zones 3, 5, 7, 8, 9 and 10.	Desktop
Soils	Well-draining, gravelly, sandy, loamy, clay and clay-loam soils.[47]	Desktop

[45] TSSC 2015.

[46] Higgins and Davies 1996

[47] Squatter Pigeon Workshop 2011.

Attribute	Description	Verification area
Water (for drinking)	Drinks water daily. Permanent or seasonal rivers, creeks, lakes, ponds and waterholes, and artificial dams where there is gently sloping, bare ground on which to approach and stand at the water's edge.[47] Known to utilise stock yard troughs as a drinking resource	Desktop and field
Hydrological needs	Nearly always found within 3 km of water bodies such as rivers, creeks and waterholes.[45]	Desktop and field
Patch size	N/A	N/A
Connectivity	N/A	N/A
Shelter/denning/roosting	Not applicable as habitat is identified as breeding or foraging.	N/A
Micro habitat features	Prefers to forage and dust-bathe on bare ground under an open canopy of trees.[47] Favour ground surface consisting of bare patches of gravelly or dusty soil and areas lightly covered in leaf litter and coarse, woody debris.[47] Commonly forage along the sides of roads or along dusty tracks. The subspecies is also commonly seen foraging in and around stockyards. [45]	Field
Breeding resources	Nests in shallow depressions in the ground and requires well-draining soils.[47] There are gaps in the knowledge of the characteristics of breeding habitat and nesting has been recorded in a variety of habitat and across land zones. There is general consensus that nesting occurs close to water (within 1 km).	Field
Habitat condition	Remnant, regrowth or partly modified vegetation communities. Also found on tracks and roadsides. [45]	Field

5.6 References

ALA 2020. *Geophaps scripta scripta: Squatter pigeon* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:76f9c0ac-bec9-4846-8a63-bc2c92495907

Campbell, I. & Woods, S. 2013. Wildlife of Australia. Princeton: Princeton University Press, Project MUSE.

Cooper, R.M., McAllan, I.A.W. & Curtis, B.R. 2014. *The Atlas of the Birds of NSW and the ACT*. Mini-Publishing, Gordon, New South Wales.

Department of the Environment (DoE) 2020. *Geophaps scripta scripta* in Species Profile and Threats Database, Department of the Environment, Canberra.

Environmental Protection Agency (EPA) 2006. *EPA 2006 Database*. Environmental Protection Agency, Brisbane. www.epa.qld.gov.au.

Garnett, S., Szabo, J. & Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing, Melbourne.

Higgins, P.J. & Davies, S.J.J.F. 1996. *Handbook of Australian, New Zealand, and Antarctic Birds*. Vol. 3. Snipe to Pigeons. Oxford University Press, Melbourne.

Reis, T. 2012. *Squatter Pigeon (Southern Subspecies)*. Pp. 254-255 *in* Curtis, L.K., Dennis, A.J., McDonald, K.R., Kyne, P.M. and Debus, S.J.S. eds. *Queensland's Threatened Animals*. Collingwood, Victoria: CSIRO Publishing.

Threatened Species Scientific Committee (TSSC) 2015. *Conservation Advice Geophaps scripta scripta squatter pigeon (southern).* Canberra: Department of the Environment.

6. Painted honeyeater (*Grantiella picta*)

6.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

6.2 Ecology and distribution

The painted honeyeater has white underparts, black upperparts and black spots on its flanks. It has yellow edges on its flight and tail feathers, black legs and a deep pink bill (see Figure 6-1). Females are browner on their back, have fewer spots and are smaller than males. Compared to other honeyeaters, this species is the only yellow-winged species with entirely white underparts.[48]

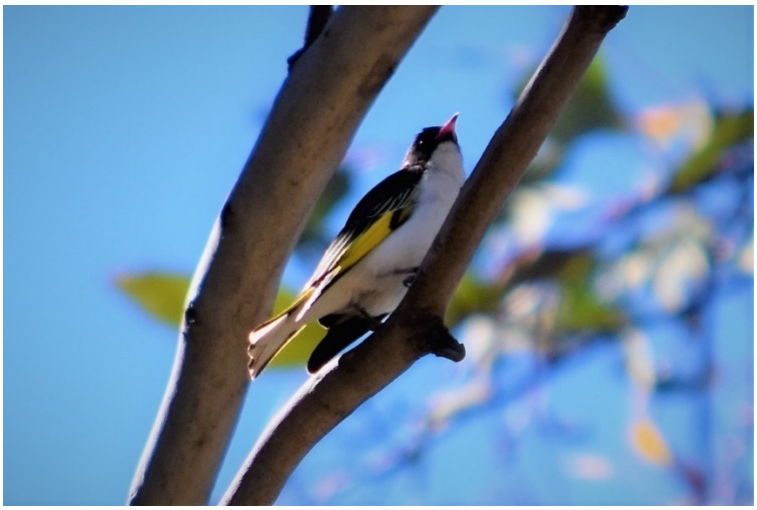

Figure 6-1: Painted honeyeater (*Grantiella picta*) (Tomas Kelly 2019)

6.2.1 Known distribution

The painted honeyeater has a sparse distribution from south-eastern Australia to north-western Queensland and eastern Northern Territory (Figure 6-2). The species is most prevalent on the inland slopes of the Great Dividing Range between the Grampians, Victoria and Roma, Queensland.[48] The species migrates between the north and south of its distribution to coincide with the fruiting of mistletoe and breeding. During non-breeding season, the painted honeyeater often moves to semi-arid regions including central and western Queensland, and north-eastern South Australia.[49]

The population of painted honeyeaters is currently declining; largely a result of land clearing and degradation. Much of the current habitat only occurs on private land and is either being cleared or degraded by cattle grazing. Grazing causes uneven age structure of mistletoe host trees, leading to future collapses of mistletoe resources; which the species relies upon for food. Breeding within southern

[48] Higgins et al. 2001

[49] DoE 2015

and central Queensland is minimal and the species is rarely seen in north-west Queensland. It is predicted that the species will likely become extinct from the northern reaches of its distribution.[49]

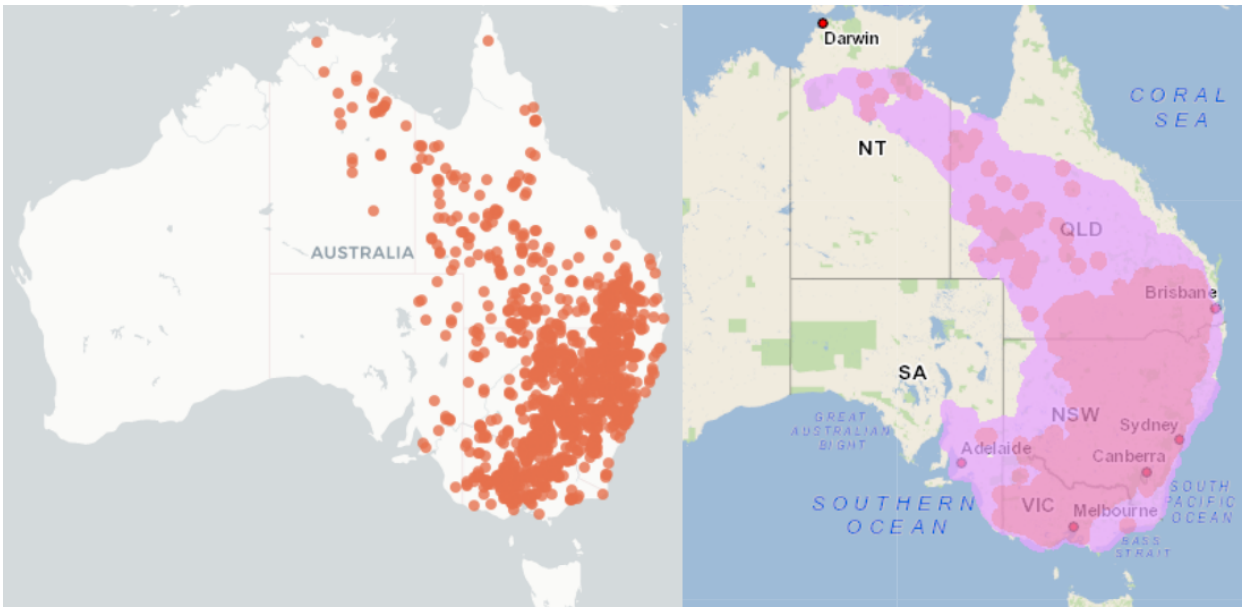

Figure 6-2: Distribution range of the painted honeyeater (ALA 2020; DoE 2020)

6.2.2 Biology and reproduction

The painted honeyeater has a specialised diet consisting mainly of mistletoe fruits and nectar. It also consumes nectar from other plants (eucalypts, non-eucalypt shrubs such as *Eremophila*, and possibly banksias) and arthropods. Arthropods are a significant food source for nestlings and also for adults during non-breeding season when flowering mistletoe is less prevalent.[48,49]

Painted honeyeaters usually occur as individuals or in pairs, but rarely flocks. They breed between October and March when mistletoe fruits are most abundant. Cup nests are built within the outer foliage of trees between 3 and 20 m above the ground. Nests are built using spiders' webs, rootlets and other plant fibres. The species typically lays 2-3 eggs and both the male and female share incubation, brooding and feeding responsibilities. The success rate of nesting is relatively low, at approximately 43%.[49]

The species can live up to 10 years and has an estimated generation length of 5.8 years.[50]

6.3 General habitat requirements

The painted honeyeater inhabits mistletoe species occurring within eucalypt forests and woodlands, riparian woodlands (*Eucalyptus* spp. such as river red gum *E. camaldulensis*), box-ironbark-yellow gum woodlands, acacia-dominated woodlands (brigalow *A. harpophylla*, weeping myall *A. pendula*, and mulga *A. aneura*), paperbarks, casuarinas and *Callitris*, as well as trees within modified landscapes such as farmland and gardens. The Weeping Myall Woodlands threatened ecological community (TEC)

[50] Garnett et al. 2011

provides important habitat for the species. Woodlands with more abundant mature trees contain greater levels of mistletoe and hence the painted honeyeater prefers these habitats.[49,51]

The species occurs more frequently within large patches of remnant vegetation that have been subject to less fragmentation and have a higher percentage of canopy cover.[52] However, they are also observed within narrow strips of vegetation; in which it also breeds if there is adequate mistletoe.[49]

6.4 Central Queensland habitat definition

Preferred painted honeyeater habitat in central Queensland is defined as:

- Acacia-dominated woodlands, primarily *Acacia pendula*, *Acacia harpophylla* and *Acacia homalophylla*, infected with the grey mistletoe (*Amyema quandang*). These features are required to establish breeding territories, which are generally located south of Roma (approx. latitude 26°S).

Suitable painted honeyeater habitat in central Queensland is defined as:

- Eucalypt and Acacia-dominated forest/woodlands[53] (remnant and regrowth), with moderate to high abundance of mistletoes provide foraging resources (fruit & nectar) across the species' migratory range

It is important to note that preferred and suitable habitats are not limited by minimum patch size or width i.e. in the Brigalow Belt South bioregion, the painted honeyeater is frequently observed in narrow (<30 m wide) shade lines, roadside strips and other corridors with high densities of mistletoe as well as in small remnants/regrowth patches even if <0.5 ha. Landscape configuration of vegetation appears to be important (C. Eddie, pers. comm.), e.g. a highly cleared landscape can still provide habitat for the species providing there is a network of vegetated corridors and small patches of vegetation which support high densities of mistletoe.

Marginal painted honeyeater habitat in central Queensland is defined as:

- Remnant and regrowth forest/woodlands with a low to infrequent mistletoe.

6.5 Habitat identification guidance

Table 6 provides specific information about key attributes of painted honeyeater habitat requirements, and where these data can be obtained. Collectively these data enable painted honeyeater habitat to be classified as preferred or marginal as described above.

[51] Rowland 2012

[52] Oliver et al. 2003

[53] Mistletoe host trees within these vegetation communities will vary based on the site by may include *Acacia pendula* (weeping myall), *A. aneura* (mulga), *A. cambagei*, *A. omalophylla*, *A. melvillei*, *A. decora*, *A. stenophylla, Eucalyptus camaldulensis* (river red gum), *E. tereticornis* (forest blue gum), *Casuarina cunninghamiana* (river oak), *C. cristata* (belah), *Allocasuarina luehmannii* (bulloak), *Eucalyptus coolabah* (coolibah) and *Acacia harpophylla* (brigalow)

Table 6: Painted honeyeater habitat identification

Attribute	Description	Verification area
Vegetation composition	Eucalypt and Acacia forests/woodlands with mistletoe host trees containing mistletoe.[54]	Desktop and field
Vegetation structure	Open forests to woodlands, open woodlands and shrublands. In central QLD, the species is often observed in shade-lines, roadside corridors, remnant edges and regrowth patches, which tend to host a higher density of mistletoes often than found within large remnants. Abundance of suitable mistletoes is considered likely the most important aspect of vegetation structure.	Field
Regional ecosystem associations that may comprise preferred or marginal habitat	11.3.1, 11.3.1b, 11.3.2b, 11.3.3, 11.3.4, 11.3.5, 11.3.16, 11.3.25, 11.3.25b, 11.3.25c, 11.3.25e, 11.3.27i, 11.3.28, 11.4.3, 11.4.7, 11.4.8, 11.4.9, 11.4.10, 11.4.12, 11.5.1, 11.9.5. 11.3.2, 11.3.8, 11.3.15, 11.3.17, 11.3.37, 11.4.3a, 11.4.5. 11.4.6, 11.7.1, 11.9.1, 11.9.10	Desktop and field
Food resources	Almost exclusively on mistletoe fruits. Grey mistletoe *Amyema quandang* and needle-leafed mistletoe *A. cambagei* are heavily relied on in the breeding season. *A. maidenii* Maiden's mistletoe is another preferred food species. During periods of food shortage and in the non-breeding season, nectar (from flowering mistletoe, eucalypts, non-eucalypt shrubs and possibly banksias) and arthropods may be consumed. *Amyema congener* is a frequently utilised food source in parts of BBS. Arthropods are an important dietary item provided to nestlings and for adults during the breeding season.[54]	Field
Land forms/land zones	N/A	N/A
Soils	N/A	N/A
Water (for drinking)	N/A	N/A
Hydrological needs	N/A	N/A
Patch size	Most common in wider blocks of remnant woodland than in narrower strips, although it will utilise narrow roadside strips and small patches of vegetation if ample mistletoe fruit is available.[54]	Desktop
Connectivity	N/A	N/A
Shelter/denning/roosting	Roosts in outer foliage of trees anywhere from 3 m to 20 m above the ground	Field
Micro habitat features	A high abundance of mistletoe.	Field
Breeding resources	The species is unlikely to breed in central Queensland.	Field

[54] DoE 2015

Attribute	Description	Verification area
Habitat condition	Requires habitat in condition that supports a high abundance of mistletoe.	Field

6.6 References

ALA 2020. *Grantiella picta: Painted honeyeater* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ffca4ed4-42c1-44a8-b499-7f0930275040

Department of the Environment 2015. *Conservation Advice* Grantiella picta *painted honeyeater*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf.

Department of the Environment 2020. *Grantiella picta* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of the Environment, Water, Heritage and the Arts DEWHA 2009. *EPBC Policy Statement 3.17 – Weeping Myall Woodlands*, Commonwealth of Australia, Canberra.

Garnett ST, Szabo JK and Dutson G 2011. *The Action Plan for Australian Birds 2010*. Birds Australia, CSIRO Publishing, Melbourne.

Higgins PJ, Peter JM, Steele WK, eds. 2001 *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 5: Tyrant-flycatchers to Chats. Oxford University Press, Melbourne.

Oliver, D. L., Chambers, M. A., Parker, D. G. 2003. *Habitat and resource selection of the Painted Honeyeater (Grantiella picta) on the northern floodplains regions of New South Wales*. Emu, 103, 171-176.

Rowland, J. 2012. *Painted honeyeater,* Grantiella picta. *Targeted species survey guidelines*. Queensland Herbarium, Department of Environment and Science, Brisbane.

7. Australian painted snipe (*Rostratula australis*)

7.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Endangered

Nature Conservation Act 1992: Vulnerable

7.2 Ecology and distribution

The Australian painted snipe (*Rostratula australis*) is a stocky wading bird that weighs 125-130 g and is approximately 240-300 mm in length with a wingspan of 500-540 mm. Adult females have metallic green wings and back, barred with chestnut and black. Their heads are chestnut coloured with a white crown stripe and white around the eye (see Figure 7-1). Adult males have duller colouring, lacking chestnut colouring on the head, nape and throat. Males are also smaller than females.[55]

Figure 7-1: Australian painted snipe (*Rostratula australis*) (Birdlife Australia 2020)

7.2.1 Known distribution

The Australian painted snipe is most common in eastern Australia, although it has been recorded in wetland habitats of all Australian states. It has a scattered distribution throughout Queensland, NSW, Victoria and south-eastern South Australia; and it most commonly recorded in the Murry-Darling region (see Figure 7-2). The extent of occurrence is not suspected to have changed; however, the area of occupancy has declined significantly and continues to decline as a result of wetland modification and clearance since European settlement (50% of wetlands have been lost). Due the species' scattered occurrence, absence from current wetland sites is hard to determine. The current population size is predicted to be in decline and the most recent estimate of population size was 2500 mature individuals in 2012.[55,56].

[55] DoE 2020

[56] DSEWPaC 2013

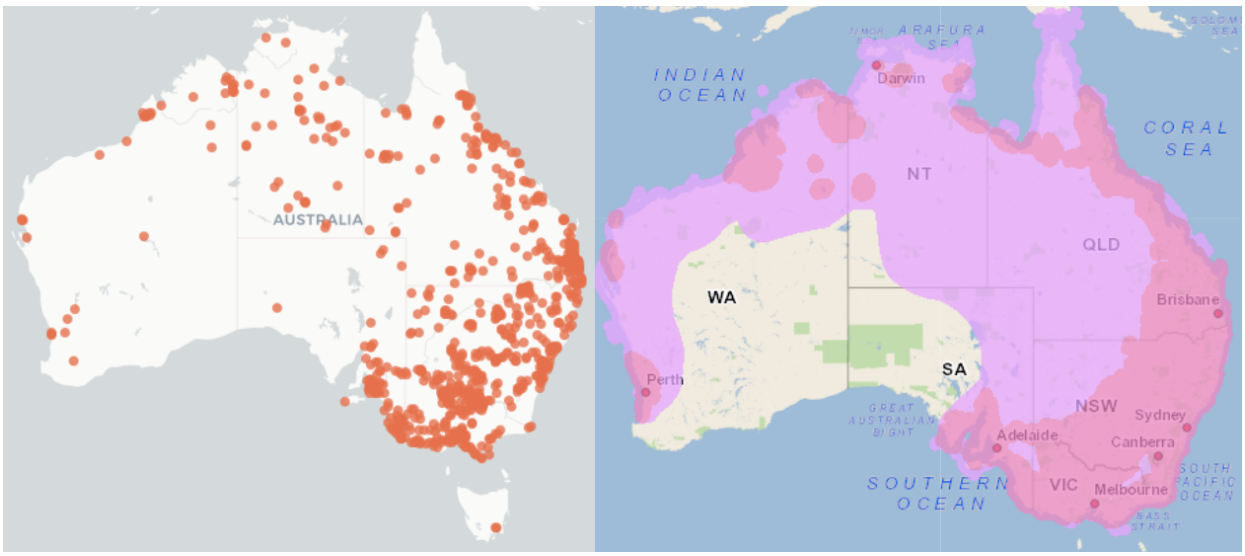

Figure 7-2: Distribution range of the Australian painted snipe (ALA 2020; DoE 2020)

7.2.2 Biology and reproduction

The Australian painted snipe feeds on vegetation, seeds, insects, worms and molluscs and crustaceans within dense wetland vegetation; however, it may forage on nearby mudflats and grassland.[57] It has a bill adapted to probe within soft mud and predominantly feeds in shallow water and along the water's edge of suitable habitats.[58,59] The species is crepuscular, loafing and resting within grass or reeds during the day.[57]

The species breeds in response to wetland conditions and hence timing varies across its range. In Queensland, breeding is typically between December and May and occurs on ephemeral wetlands. It requires continuous reed beds or stands of reed-like vegetation with surrounding cover to breed.[55,59] Nesting has been recorded in and near swamps, cane grass fields, flooded areas including grazing land and among tussock grasses, couch grasses and samphires (*Tecticornia* spp.)[60] Within these habitats they build nests on raised mound or thick vegetation surrounded by shallow water. The males are responsible for building the nest, incubating the eggs and rearing the young. Generally, there are four eggs which hatch after 19-20 days.[57] Once eggs are laid, the female will search for other males to mate with.[59]

Australian painted snipes breed from one year of age and can live up to 16.2 years, with an estimated generation length of 8.6 years.[59]

7.3 General habitat requirements

Australian painted snipes occur within shallow freshwater wetland habitats and occasionally brackish wetlands. These wetlands can be either ephemeral or permanent and include swamps, claypans, lakes,

[57] Marchant & Higgins 1993

[58] Ecological Associates 2010

[59] TSSC 2013

[60] DoEE 2019

dams, inundated grassland, saltmarsh, rice crops, bore drains and even sewage farms. They select habitats which have substantial cover of grasses, scrub, reeds and *Duma* spp. (lignum).[56] Although the species can utilise modified habitats for foraging, they do not breed within areas that lack suitable cover. During the day, Australian painted snipes will loaf and rest under clumps of lignum, tea-tree or similar dense bushes.[57]

The species requires highly productive wetland habitats to supply an adequate amount of benthic organisms for food. Optimum habitat conditions are typically temporary wetlands which are drying out due to the high productivity and accessibility of food sources. These areas are often very dry during drought but are subject to rapid inundation following rainfall events.[61] Migration patterns for the species is poorly understood but movement to and from flooded areas has been frequently observed within Queensland. [55,61]

7.4 Central Queensland habitat definition

Preferred Australian painted snipe habitat in central Queensland is defined as:

- Shallow, permanent or ephemeral, freshwater wetlands which provide areas of bare, exposed wet mud and a mosaic of ground cover[62] (tufted grasses, sedges, small woody plants).

It should be noted that the presence and/or extent of preferred habitat will be influenced by seasonal conditions (expansion of permanent wetlands, or creation of ephemeral wetland habitat)

Suitable Australia painted snipe habitat in central Queensland is defined as:

- Shallow permanent or ephemeral freshwater or brackish wetlands and other inundated/waterlogged areas[63] with a variable ground cover (e.g. grasses, shrubs and rushes).

Habitat for this species does not include tall, dense reedbeds associated with stabilized water levels, wetlands that are cropped, and areas of low water quality due to nutrient run-off, agricultural chemicals and turbidity[64].

7.5 Habitat identification guidance

Table 7 provides specific information about key attributes of Australian painted snipe habitat requirements, and where these data can be obtained. Collectively, these data enable Australian painted snipe habitat as preferred and suitable described above.

[61] Black et al. 2010

[62] May include rushes and sedges up to 1 m in height

[63] Can include gilgais, lakes, springs, swamps, claypans, inundated or waterlogged grassland/saltmarsh, dams, rice fields, sewage farms and bore drains

[64] Tzaros et al. 2012

Table 7: Australian painted snipe habitat identification

Attribute	Description	Verification area
Vegetation composition	Permanent or ephemeral shallow freshwater wetlands, gilgais, lakes, swamps, claypans, inundated or waterlogged grassland/saltmarsh, dams, rice fields, sewage farms and bore drains with fringing vegetation and grass / reed cover[65]	Desktop and field
Vegetation structure	Suitable wetlands usually support a mosaic of low, patchy vegetation, as well as lignum and cane grass. Breeding habitat requirements may include shallow wetlands with areas of bare wet mud and shrub / tree canopy nearby.	Field
Regional ecosystem associations that may comprise preferred/suitable habitat	All lacustrine, palustrine, riverine, estuarine and marine REs within central Queensland. Also non-remnant areas when gilgai formations occur. Non-exhaustive list includes wetland REs such as 11.3.27 and wetlands (including gilgais) embedded within 11.3.2, 11.3.3, 11.3.25, 11.3.3, 11.4.3, 11.4.7 and 11.9.5.	Desktop and field
Food resources	The aquatic composition of this species' food resources is a critical component of its habitat needs. It should include small crustacea, molluscs and aquatic worms (not necessarily earthworms) found in shallow water and wet mud.[65]	Field
Land forms/land zones	Primarily LZ 3 (wetlands) and LZ 4 and 9 (clay pans and gilgai formations)	N/A
Soils	Associated with clay substrates[66]	Desktop
Water (for drinking)	N/A	N/A
Hydrological needs	Requires permanent or ephemeral freshwater habitat for breeding and foraging	Desktop and field
Patch size	N/A	N/A
Connectivity	N/A	N/A
Shelter/denning/roosting	Shelters under grass or reeds and can often be difficult to detect as it uses low vegetation of small depressions in the ground as cover.[65]	Field
Micro habitat features	Microhabitat consists of a good cover of grasses, rushes and low scrub, *Duma* spp. (lignum), open timber or samphire.[48]	Field
Breeding resources	Nesting typically occurs in ephemeral wetlands drying out after an influx of fresh water, provided they have complex shorelines (nests are almost invariably placed on small islands) and a combination of very shallow water, exposed	Field

[65] Higgins et al. 1996

[66] DoE 2019

Attribute	Description	Verification area
	mud, dense low cover and (sometimes) some tall dense cover.[65]	
Habitat condition	Prefers intact freshwater wetlands that are unaffected by fragmentation or degradation due to cattle overgrazing or other agricultural activities (e.g. water diversion, chemical runoff).	Field

7.6 References

ALA 2020. *Rostratula australis: Australian painted snipe* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:008f9f9d-9a91-4c34-9a2b-fd82c5a43e13

Black, R., Houston, W and Jaensch, R. 2010. *Evidence of regular seasonal migration by Australian painted snipe* Rostratula australis *to the Queensland tropics in autumn and winter.* Stilt, Vol. 58, pp. 1-9.

Ecological Associates 2010. *Literature review of the ecology of birds of The Coorong, Lakes Alexandrina and Albert Ramsar wetlands*. Ecological Associates report CC-014-1-D prepared for Department for Environment and Heritage, Adelaide

Department of Environment and Energy (DoEE) 2019. *Draft National Recovery Plan for the Australian Painted Snipe* (Rostratula australis). Australian Government.

Department of the Environment (DoE) 2020. *Rostratula australis* in Species Profile and Threats Database, Department of the Environment, Canberra.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2013. *Approved Conservation Advice for* Rostratula australis *(Australian painted snipe)*. Canberra: Department of Sustainability, Environment, Water, Population and Communities.

Garnett, S., Szabo, J. & Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing, Melbourne.

Higgins, P.J. & S.J.J.F. Davies (eds) 1996. Handbook of Australian, New Zealand and Antarctic Birds. Volume 3: Snipe to Pigeons. Oxford University Press, Melbourne.

Rogers, D., Hance, I., Paton, S., Tzaros, C., Griffioen, P., Herring, M., ... & Weston, M. (2005). The breeding bottleneck: Breeding habitat and population decline in the Australian Painted Snipe. In Status and conservation of shorebirds in the East Asian–Australasian Flyway: Proceedings of the Australasian Shorebirds Conference (pp. 15-23).

Threatened Species Scientific Committee (TSSC) 2013. *Commonwealth Listing Advice on* Rostratula australis *(Australian Painted Snipe)*. Department of Sustainability, Environment, Water, Population and Communities.

Tzaros, C., Ingwersen, D. and Rogers, D. 2012. *Australian Painted Snipe*. Pp. 274-275 *in* Curtis, L.K., Dennis, A.J., McDonald, K.R., Kyne, P.M. and Debus, S.J.S. eds. *Queensland's Threatened Animals*. Collingwood, Victoria: CSIRO Publishing.

8. Ornamental snake (*Denisonia maculata*)

8.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

8.2 Ecology and distribution

The ornamental snake (*Denisonia maculata*) varies in colouration from brown to grey-brown and black (see Figure 8-1). The body scales are often lighter with dark streaks or flecks, the head is usually darker, and the belly is white/cream with dark spots or flecks. The species has distinctly barred lips.[67]

Figure 8-1: Ornamental snake (*Denisonia maculata*) (Andrew Veary)

8.2.1 Known distribution

The ornamental snake has a restricted distribution with the Brigalow Belt North and Brigalow Belt South regions (see Figure 8-2). Within its range, it is sparsely distributed.

[67] Cogger 2000

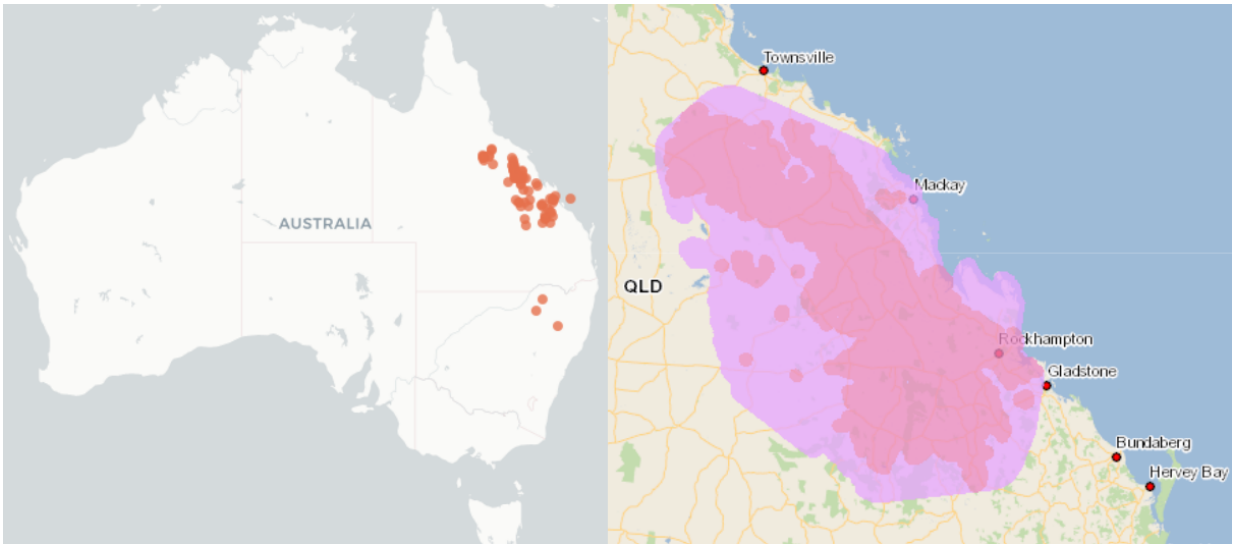

Figure 8-2: Distribution range of the ornamental snake (ALA 2020; DoE 2020)

8.2.2 Biology and reproduction

The ornamental snake feeds almost exclusively of frogs (approximately 95% of its diet) and is most frequently observed where frogs are observed.[68,69] A number of different frog species occur throughout the ornamental snake's range and they have been observed consuming a variety of species.[68]

The life cycle of ornamental snakes is poorly understood. However, it is known that they reach sexual maturity at a minimum length of 24.7 cm for females and 23.0 cm for males. The species is viviparous with a litter size of between 3-11 snakelets.[69]

8.3 General habitat requirements

Ornamental snakes occur within woodland and open forest habitats in moist areas such as; floodplains, undulating clay pans, near waterbodies (swamps and lakes) and along watercourses. It prefers these moist areas due to its diet of mostly frogs. Its preferred habitat is woodland or open forest associated with gilgai mounds and depressions in Queensland Regional Ecosystem Land Zone 4. These areas provide suitable microhabitat features for the species including deep cracking clay soils in which the snake shelters. The species also shelters under logs and vegetation debris/litter where it can remain inactive for many months during dry periods. Ornamental snakes are often associated with Brigalow dominated communities including endangered TEC Brigalow (*Acacia harpophylla* dominant and co-dominant) and occur within a variety of region ecosystems (11.4.3, 11.4.6, 11.4.8, 11.4.9, 11.3.3 and 11.5.16).[68,70]

Remnant vegetation is not required for the species to occur, as gilgai formations can be retained in cleared / non-remnant environments.[71] Ornamental snakes have been observed within cleared areas

[68] DoE 2020

[69] Shine 1983

[70] DoE 2014

[71] DSEWPaC 2011

where there is adequate ground cover to provide shelter (logs, rocks and artificial debris).[72] These areas include cleared non-remnant paddocks and woodland regrowth.[73] It is suggested that ornamental snakes typically occur as dense populations within limited, sharply delineated areas of suitable habitat.[74] This habitat has the following characteristics:[68,74]

- Low areas of the catchment that are subject to flooding and frequent inundation.
- Gilgai of varying size and depth.
- Soils with high clay as theses have higher water retention capabilities and are subject to cracking when dry.
- Logs or other ground debris to provide shelter.
- Abundant seasonal frog populations.
- Patches of habitat typically larger than 10 ha that are connected to (or within) large areas of remnant vegetation.

8.4 Central Queensland habitat definition

Preferred ornamental snake habitat in central Queensland is defined as:

- Gilgai depressions (with or without the presence of brigalow or other canopy vegetation[75]), mounds and wetlands on cracking clays (predominantly land zone 4) where essential microhabitat features are present including an abundance of deep soil cracks. Other microhabitat features such as fallen woody debris may or may not be present. Seasonal flooding of habitat areas is a requirement.

Suitable ornamental snake habitat in central Queensland is defined as:

- Dispersal areas within 1 km of preferred habitat, which are currently or previously dominated by brigalow or coolibah communities where gilgais or soil cracks are infrequent and/or shallow, including non-remnant areas.

Marginal ornamental snake habitat in central Queensland is defined as:

- Areas currently or previously dominated by brigalow or coolibah communities where gilgais or soil cracks are infrequent or are shallow or non-remnant areas where threats are high (high abundance of weed incursion and cattle compacting soils) but the species still have potential to occur, especially in times where water is present and prey abundance (frogs) is high.

[72] WWF 2008

[73] Curtis 2010

[74] Wilson & Swan 2014

[75] I.e. including remnant, regrowth and non-remnant areas as identified in the QLD vegetation mapping framework, Veary et al. 2011

8.5 Habitat identification guidance

Table 8 provides specific information about key attributes of ornamental snake habitat requirements, and where these data can be obtained. Collectively these data enable ornamental snake habitat to be classified as preferred or marginal as described above.

Table 8: Ornamental snake habitat identification

Attribute	Description	Verification area
Vegetation composition	Brigalow or coolibah (currently or previously present).[76]	Desktop and field
Vegetation structure	The presence of remnant vegetation is not required for the species to occur.[77]	Field
Regional ecosystem associations that may comprise preferred and/or marginal habitat	11.3.1, 11.3.1a, 11.3.1b, 11.3.1d, 11.3.3, 11.3.3a, , 11.3.3c, 11.3.3x1, 11.4.3, 11.4.10, 11.4.6, 11.4.7, 11.4.8, 11.4.8a, 11.4.9, 11.4.9a, 11.4.9b, 11.5.16, 11.5.16a, 11.9.1, 11.9.5, 11.9.5a 11.3.17, 11.3.27, 11.3.37, 11.4.5, 11.4.10	Desktop and field
Food resources	Frogs make up 95% of their diet.[78]	Field
Landforms/land zones	Predominantly land zone 4, but also LZ 3 and 9. Also found in lake margins and wetlands.[79]	Desktop and field
Soils	Flood-prone cracking clay soils that support or have supported Brigalow or Coolibah.[80] Cracking clay soils that are formed by shrinking and swelling, as cracking occurred deeper, more frequently and persisted for longer periods on gilgai mounds compared.[81]	Desktop and field
Water (for drinking)	N/A	N/A
Hydrological needs	Prefers moist, seasonally flooded areas (see landforms above). Requires water for prey (frogs) and thus can become inactive during dry periods.	Desktop and field
Patch size	Habitat patches are typically greater than 10 ha in area and are within, nearby, or connected to larger areas of remnant vegetation.[79]	Desktop
Connectivity	Habitat connectivity between gilgais and other suitable habitats is important. [78]	Desktop

[76] DSEWPaC 2011a

[77] Veary et al. 2011

[78] Shine, R. 1983

[79] DAWE 2020.

[80] Wilson & Swan 2014, Veary et al. 2011

[81] Veary et al. 2011

Attribute	Description	Verification area
Shelter/denning/roosting	Shelters during the day under fallen timber, rocks, bark and in deep soil cracks.[77] During dry periods it can remain inactive in its shelter for months. [77]	Field
Micro habitat features	Woody debris, rocks, bark and in deep soil cracks. [77]	Field
Breeding resources	Unknown. It is not possible to separate foraging and breeding habitat requirements with current available information and they are likely to share the same characteristics.	Field
Habitat condition	Ornamental snakes have also been found in cleared woodlands that contain adequate ground cover and shelter sites, such as logs and deep soil cracks.[82]	Field

8.6 References

ALA 2020. *Denisonia maculata*: *Ornamental snake* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:d1c8c742-e7dd-415e-b4f5-a6f3c05123db

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

Curtis, L.K. 2010. *Queensland's Threatened Animals* (eds A.J. Dennis, K.R. McDonald, P.M. Kyne, & S.J.S. Debus). CSIRO Publishing, Collingwood.

Department of the Environment 2014. *Approved Conservation Advice for* Denisonia maculata *(Ornamental Snake)*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1193-conservation-advice.pdf.

Department of the Environment (DoE) 2020. *Denisonia maculata* in Species Profile and Threats Database, Department of the Environment, Canberra.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2011a. *Draft Referral guidelines for the nationally listed Brigalow Belt reptiles*. Commonwealth of Australia.

DSEWPC 2011b. *Survey guidelines for Australia's threatened reptiles.* Commonwealth of Australia.

Shine, R. 1983. *Food habits and reproductive biology of Australian elapid snakes of the genus Denisonia*. Journal of Herpetology 17: 171-175.

Veary, A.T, Veary, E. L, Burgess, J and Fell, D. 2011. Assessment of Habitat Characteristics as Predictors of Habitat Suitability for the threatened Ornamental Snake. Report/research on behalf of the Australian Coal Association Research Program, Research Project C15044

[82] WWF Australia 2008

Wilson, S & Swan, G 2014. *The ornamental snake (Denisonia maculata): notes on the habitat and population density of a vulnerable elapid snake*. Herpetofauna 44 (1 & 2).

WWF Australia (2008). *Brigalow Belt bioregion – a biodiversity jewel.* World Wildlife Fund Australia.

9. Yakka skink (*Egernia rugosa*)

9.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

9.2 Ecology and distribution

The yakka skink is a large, robust skink that has a thick tail and short legs. It is one of the largest species of skink within its region and can grow up to 40 cm in length; roughly the same size as a blue tongue lizard (*Tiliqua scincoides*). It is a pale fawn colour, with a broad dark brown stripe along its back, from the nape to tail. This stripe is bordered on each side by a pale fan stripe. The flank scales are pale brown to reddish brown in colour and from a variegated pattern. It has a yellow/cream throat with black spots/ flecks and a yellow-orange chest and abdomen (see Figure 9-1).

Figure 9-1: Yakka skink (*Egernia rugosa*) (Bookbook n.d.)

9.2.1 Known distribution

The yakka skink has a patchy, fragmented distribution extending from south-east and central Queensland to tropical north Queensland (see Figure 9-2). The preferred habitat for the species occurs within Brigalow Belt South Bioregions; specifically, the Mulga Lands. Other populations occur throughout the Brigalow Belt North, Einasleigh Uplands, south-east Queensland, wet tropics and Cape York Peninsula. The distribution is highly fragmented due to the clearance of large amounts of potential habitat for the species for agriculture, urban development and mining.[83,84] The species exhibits high site fidelity and has limited dispersal capabilities.

[83] DoE 2014

[84] DoE 2020

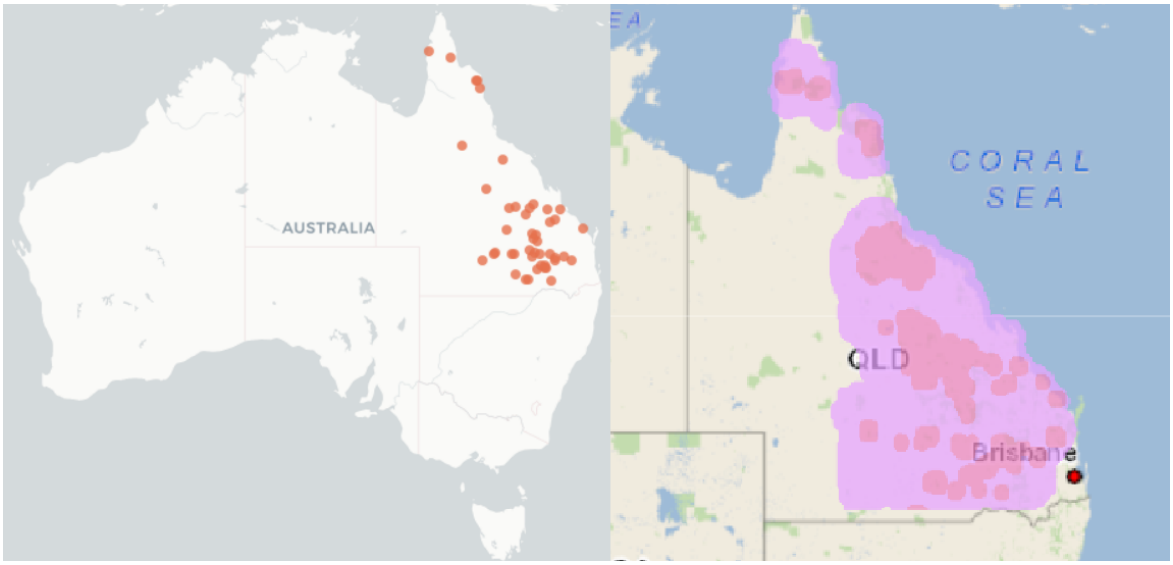

Figure 9-2: Distribution range of the yakka skink (ALA 2020; DoE 2020)

9.2.2 Biology and reproduction

The yakka skink is an omnivore; consuming predominantly fruits, plant material and invertebrates (beetles, spiders and grasshoppers). The skink burrows into the ground or beneath roots/logs, preying upon invertebrates that travel close to the burrow.[84]

The yakka skink is a gregarious species, occurring as colonies or aggregations of varying age and size within suitable habitat.[85] The species is viviparous and produces approximately six young per littler.[84]

9.3 General habitat requirements

The yakka skink occurs in open dry sclerophyll forest, woodland or scrub within Queensland Regional Ecosystem Land Zones (LZ) 3, 4, 5, 7, 9 and 10, primarily within the Mulga Lands and Brigalow Belt South Bioregions. Vegetation types vary, but typically include:

- Brigalow (*Acacia harpophylla*);
- Mulga (*A. aneura*);
- Bendee (*A. catenulata*);
- Lancewood (*A. shirleyi*);
- Belah (*Casuarina cristata*);
- Poplar Box (*Eucalyptus populnea*);
- Ironbark (*Eucalyptus* spp.); and
- White Cypress Pine (*Callitris glaucophylla*).

The species is known to occur within two TEC listed under the EPBC Act; Brigalow (*Acacia harpophylla* dominant and co-dominant) and Weeping Myall Woodlands.[84]

[85] Chapple 2003

The yakka skink requires microhabitat in which it can shelter/burrow. This includes cavities between ground level rocks, logs, roots and abandoned animal burrows. The species can also burrow via excavation within dense ground vegetation; creating deep burrow systems. The yakka skink has been observed in cleared habitat as long as there are adequate shelter sites such as logs, eroded tunnels/holes or rabbit warrens. Structures such as sheds can also be occupied by the species.[84] The species are not known to travel far from shelter sites and will quickly retreat to the site if disturbed.[86]

9.4 Central Queensland habitat definition

Preferred yakka skink habitat in central Queensland is defined as:

- Areas of remnant and regrowth woodlands and open woodlands, as well as non-remnant vegetation, with suitable light clay loam, loam and sandy loam substrates on land zones 3, 5, 7, 9 and 10 supporting microhabitat features including large hollow logs, cavities or burrows under large fallen trees and/or tree stumps, log piles, large rocks and rock piles, deep rock crevices, deeply eroded gullies or sinkholes/areas of tunnel erosion.

Preferred habitat may also be further constrained to areas within 10 km of a known occurrence (noting this may not be appropriate in regions where survey effort is poor).

Marginal yakka skink habitat in central Queensland is defined as:

- Areas of remnant and regrowth woodlands and open woodlands, as well as non-remnant vegetation, with suitable light clay loam, loam and sandy loam substrates on land zones 3, 5, 7, 9 and 10 with only rare occurrences of microhabitat features.

9.5 Habitat identification guidance

Table 9 provides specific information about key attributes of yakka skink habitat requirements, and where these data can be obtained. Collectively these data enable yakka skink habitat to be classified as suitable as described above. The species must be recorded for habitat to be classified as preferred.

Table 9: Yakka skink habitat identification

Attribute	Description	Verification area
Vegetation composition	Dry scleorphyll woodland, open woodland and scrub, where suitable microhabitat features remain[87]	Desktop and field
Vegetation structure	Dominance of vegetation communities by a range of dry sclerophyll species such as *Eucalyptus populnea*, *E. fibrosa, E. crebra, E. orgadophila*, *E. melanophloia*, *Acacia shirleyi*, *A. catenulata*, *A. aneura*, *A. microsperma, Allocasuarina luehmannii, Casuarina cristata* and *Callitris glaucophylla*[88]	Field

[86] Wilson 2003

[87] Ferguson & Mathieson 2014

[88] C. Eddie pers comm

Attribute	Description	Verification area
Regional ecosystem associations that may comprise preferred or suitable habitat	REs that may provide habitat include: 11.3.2, 11.3.6, 11.3.14, 11.3.17, 11.3.18, 11.3.19, 11.3.29, 11.3.30, 11.3.36, 11.3.39, 11.5.1, 11.5.1a, 11.5.4, 11.5.4a, 11.5.2, 11.5.3, 11.5.5, 11.5.5a, 11.5.5b, 11.5.5c, 11.5.9, 11.5.9a, 11.5.9b, 11.5.9c, 11.5.13, 11.5.20, 11.7.1, 11.7.2, 11.7.4, 11.7.6, 11.7.7, 11.9.2, 11.9.7, 11.9.9, 11.9.10, 11.10.7, 11.10.7a, 11.10.9, 11.10.11	Desktop and field
Food resources	Omnivorous - eats plants, fruits and invertebrates (e.g. beetles, grasshoppers, spiders).	Field
Landforms/land zones	LZ 3, 5, 7, 9 and 10. May also occur on LZ 4 & 8, although this does not represent preferred habitat.[89]	Desktop and Field
Soils	Firm but friable loamy and sandy soils, suitable for burrowing.[87] Can include light clay and clay loams but avoids heavy clays[88]	Desktop and Field
Water (for drinking)	N/A	N/A
Hydrological needs	N/A However, areas on landzone 3 that is subject to flooding (i.e. every few years) would unlikely be inhabited by the species, as flooded burrows would not be tolerated.	N/A
Patch size	Unknown, however they exhibit high site fidelity and are not considered strong dispersers.[89]	Desktop
Connectivity	Extensive fragmentation is a key threat to this species as it is unable to disperse far from its colony.[90]	Desktop
Shelter/denning/roosting	See microhabitat features below	Field
Micro habitat features	Burrows (including abandoned burrows of other species e.g. rabbits[89]), large logs, log piles, tree stumps, grass tussocks and cavities between and underneath large rocks.[87]	Field
Breeding resources	It is not possible to separate foraging and breeding habitat requirements with current available information and they are likely to share the same characteristics.	Field
Habitat condition	Will persist in disturbed and cleared habitat provided microhabitat features remain.[90]	Field

[89] DAWE 2020

[90] Hobson et al. .2018

9.6 References

ALA 2020. *Egernia rugosa: Yakka skink* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:33916d2f-0d12-4dce-bd45-73ce89a7cdb6.

Chapple, D.G. 2003. Ecology, Life-History, and Behaviour in the Australian Scincid Genus Egernia, with Comments on the Evolution of Complex Sociality in Lizards. Herptological Monographs. 17:145-180

Cogger, H.G. 200. *Reptiles and Amphibians of Australia - 6th edition*. Sydney, NSW: Reed New Holland.

Department of the Environment 2020. *Egernia rugosa* in Species Profile and Threats Database, Department of the Environment, Canberra.

Department of the Environment 2014. *Approved Conservation Advice for* Egernia rugosa *(Yakka Skink)*. Canberra: Department of the Environment.

Eddie, C. 2012. *Yakka Skink*. Pp.224-225 *in* Curtis, L.K., Dennis, A.J., McDonald, K.R., Kyne, P.M. and Debus, S.J.S. eds. *Queensland's Threatened Animals*. Collingwood, Victoria: CSIRO Publishing.

Ferguson, D. and Mathieson, M. 2014. *Yakka skink, Egernia rugosa. Targeted species survey guidelines*. Queensland Herbarium, Department of Environment and Science, Brisbane.

Hobson, R., Venz, M., Wilson, S., Vanderduys, E., Sanderson, C., Cogger, H. & Shea, G. 2018. *Egernia rugosa*. The IUCN Red List of Threatened Species 2018

Peck, S., Gardner, M. Seddon, J. and Baxter, G. (2017) Life-history characteristics of the yakka skink, *Egernia rugosa*, indicate long-term social structure. *Australian Journal of Zoology* **64**(5): *xx – xx.*

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

10. Collared delma (*Delma torquata*)

10.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

10.2 Ecology and distribution

The collared delma is one of the smallest legless lizards (family Pygopodidae) with a maximum total length of approximately 19 cm and maximum snout-vent length of 7 cm. The scales are brown to reddish brown in colour, becoming paler on the belly. The species has a dark brown banded head and neck with cream-yellow stripes and a blunt and short snout (see Figure 10-1).[91]

Figure 10-1: Collared delma (*Delma torquata*) (Steve Wilson 2019)

10.2.1 Known distribution

The collared delma has a known distribution limited to a number of sites within Queensland (see Figure 10-2). A large number of records are from the western suburbs of Brisbane as well as the following sites within south east and central Queensland: [91,92]

- Bunya Mountains;
- Blackdown Tablelands National Park;
- Expedition National Park;
- Western Creek, near Millmerran; and
- Toowoomba Range.

[91] Peck & Hobson 2007

[92] Davidson 1993

The home range and movement patterns of the species is poorly understood; although it is suggested that their home range is likely small.[93],[94]

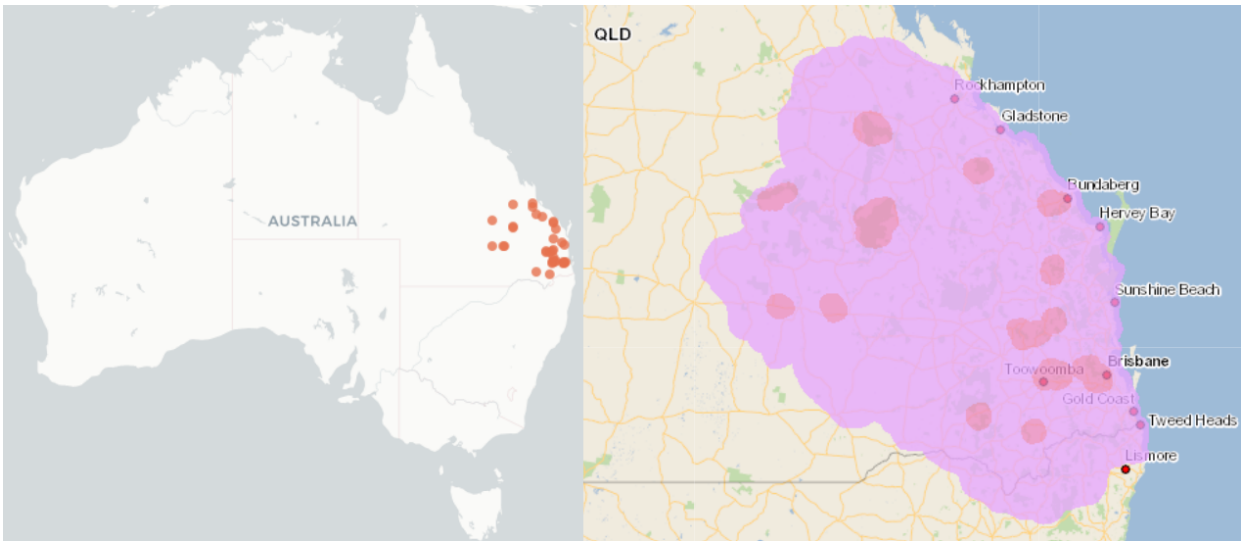

Figure 10-2: Distribution range of the collared delma (ALA 2020; DoE 2020)

10.2.2 Biology and reproduction

The collared delma feeds on a variety of insects and spiders, with cockroaches appearing to be the most common food source. The species has also been observed within subterranean termite colonies.[93,94]

The life cycle of the collared delma is poorly understood. The species is known to lay two white eggs in December which then hatch between February and March.[91]

10.3 General habitat requirements

The collared delma occurs within eucalypt woodland and open forest comprised of a variety of canopy species depending on the location and with ground cover of predominantly native grasses including kangaroo grass (*Themeda triandra*), barbed-wire grass (*Cymbopogon refractus*), wiregrass (*Aristida* sp.) and lomandra (*Lomandra* sp.). The species has specific microhabitat requirements, whereby adequate ground cover is required via the presence of logs, park, rocks, vegetation debris and leaf litter.[93,95] It has been suggested that the species is not able to dig and burrow underground, therefore explaining its requirement for microhabitat which it can shelter beneath.[94] The collared delma is often associated with rocks (both large and small); however, the presence of rocks is not considered to be essential. The species does not appear to have a preference for a specific soil type and has been observed on a variety of soils including sandy loams, grey and black cracking clays, stony lithosols and basalt derived Podzolics. Generally, the species occurs in Queensland Ecosystem land zones (LZ) 3, 9 and 10 in a number of regional ecosystems (11.3.2, 11.9.10, 11.10.1 and 11.10.4).[93]

[93] DoE 2020

[94] Porter 1998

[95] DEWHA 2008

10.4 Central Queensland habitat definition

Based on guidance from species experts, only one habitat definition for this species is provided and includes the categories of both preferred and suitable as per section 2.3 above.

Preferred and suitable collared delma habitat in central Queensland is defined as:

- Any contiguous patch of habitat containing crucial and required features, occurring within the species' known distribution. Crucial features include:
  - Eucalypt communities on well-drained slopes
  - Intact, undisturbed leaf litter
  - Scattered undisturbed surface stones, typically 15-30 cm.

10.5 Habitat identification guidance

Table 10 provides specific information about key attributes of collared delma habitat requirements, and where these data can be obtained. Collectively these data enable collared habitat to be classified as suitable as described above. The species must be recorded for habitat to be classified as preferred.

Table 10: Collared delma habitat identification

Attribute	Description	Verification area
Vegetation composition	Found in v vegetation communities dominated by various *Eucalyptus* spp[96]. Ground cover is usually dominated by native grasses, such as kangaroo grass, barbed-wire grass, wiregrass and lomandra[97]	Desktop and field
Vegetation structure	Open forests to open woodlands, with a native grassy understorey.	Field
Regional ecosystem associations that may comprise suitable habitat	11.3.2, 11.3.25, 11.3.29, 11.3.30, 11.3.36, 11.9.9, 11.9.9b, 11.9.10, 11.10.1, 11.10.1d, 11.10.4, 11.10.7, 11.10.11 11.3.1, 11.3.4, 11.3.6, 11.3.7, 11.3.14, 11.3.17, 11.3.18, 11.3.19, 11.3.39, 11.4.3, 11.4.7, 11.4.8, 11.4.10, 11.4.12, 11.5.1, 11.5.2, 11.5.3, 11.5.4, 11.5.5, 11.5.9, 11.7.1, 11.7.2, 11.7.4, 11.7.4c, 11.7.6, 11.7.7, 11.8.2, 11.8.4, 11.8.5, 11.9.1, 11.9.2, 11.9.5, 11.9.7, 11.10.2, 11.10.6, 11.10.3, 11.10.9, 11.10.13, 11.11.1, 11.11.2, 11.11.3, 11.11.4, 11.11.11, 11.12.1, 11.12.2, 11.12.3	Desktop and field
Food resources	Insects and spiders	Field
Land forms/land zones	LZ associations poorly known and may occur within all but LZ 1 & 2.	Desktop
Soils	Has been recorded in a range of soil types, however, must contain the presence of essential microhabitat features	Desktop

[96] DoE 2020

[97] DEWHA 2008

Attribute	Description	Verification area
Water (for drinking)	N/A	N/A
Hydrological needs	N/A	N/A
Patch size	Very little is known about movements, although it is likely to be very small based on previous studies (18 m movement over 2 years)[98].	Desktop
Connectivity	Habitat fragmentation is known to degrade habitat.	Desktop
Shelter/denning/roosting	See microhabitat features below.	Field
Micro habitat features	Native grasses, surface rocks, logs, bark, coarse woody debris and thick mats of leaf litter (typically 30-100 mm thick).	Field
Breeding resources	The life cycle of the collared delma is poorly understood and breeding resources are not well known with current information.	N/A
Habitat condition	Requires the essential microhabitat features listed above. Invasion of weeds, particularly Dwarf Lantana also impact condition.	Field

10.6 References

ALA 2020. *Delma torquate: Collared delma* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:92ec5b2c-1f8f-4d29-b088-77bacaeeb99f

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

Davidson, C. 1993. *Recovery Plan for the Collared Legless Lizard* (Delma torquata). Page(s) 1-10. Brisbane, Queensland: Department of Environment and Heritage

Department of the Environment 2020. *Delma torquata* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of the Environment, Water, Heritage and the Arts 2008. Approved Conservation Advice for Delma torquata (Collared Delma). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1656-conservation-advice.pdf

Peck, S. & R. Hobson 2007. *Survey results and management options for the Collared Delma* (Delma torquata) *along the proposed Toowoomba Bypass, Toowoomba Range, South-east Queensland, November 2006*. Queensland Parks and Wildlife Service.

[98] Porter 1998

Porter, R. 1998. *A preliminary field investigation of the collared delma* Delma torquata *(Reptilia: Pygopodidae)*. Queensland: Lone Pine Koala Sanctuary.

Wilson, S. 2015. A Field Guide to reptiles of Queensland. 2nd edition. New Holland Publishers

11. Large-eared pied bat[99] (*Chalinolobus dwyeri*)

11.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

11.2 Ecology and distribution

The large-ear pied bat is a medium-sized bat with short, broad wings. These wings suggest that the bat has a high amount of manoeuvrability and flies slowly. The bat is approximately 100 mm long and weighs 7-12 grams. Its fur is shiny and black with a white stripe on the torso (ventral side) where it connects to the wings and tail. As the name suggests, it has large ears. Lobes of skin also occur near the lower lip; between the mouth and ear (see Figure 11-1).[100,101]

Figure 11-1: Large-eared pied bat (*Chalinolobus dwyeri*) (T. Reardon n.d)

11.2.1 Known distribution

The distribution of the large-ear pied bat is poorly understood as it is a relatively newly described species, is nocturnal, unobtrusive and appropriate targeted survey techniques have only been available since the 1990s.[101,102] There are records of the species ranging from north of Rockhampton in Queensland, to Ulladulla in the south of NSW (Figure 11-2).[101] Throughout this range it is suggested to occur as restricted, patchy populations, rarely containing more than 50 individuals.[100]

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[99] Large-eared wattled bat is the new common name for this species. Large-eared wattled bat was adopted by Jackson & Groves (2015) in Taxonomy of the Mammals of Australia and will be the name used in the forthcoming 4th Edition of The Mammals of Australia (eds. Baker & Gynther; formerly van Dyck & Strahan, 3rd Edition). We have continued to use the name Large-eared pied bat for consistency with the species' listing advice.

[100] DoE 2020

[101] Hoye 2005

[102] Ryan 1966

In Queensland, the species has been recorded in the Carnarvon, Expedition Ranges and Blackdown Tablelands. Within these areas the species is restricted to sites in the vicinity of sandstone escarpments. These known populations likely make up a large proportion of the entire population in Queensland; however, exact population numbers and health are not known. Smaller populations are known to occur within limestone caves and mines in south-eastern Queensland and Shoalwater Bay.[101]

Only four maternity roost sites have been recorded, all of which occur within NSW. The species has very specific roosting habitat requirements (see below) and potential roost sites are not distributed evenly throughout its range. Populations are likely to be isolated and have limited interaction with each other.[101]

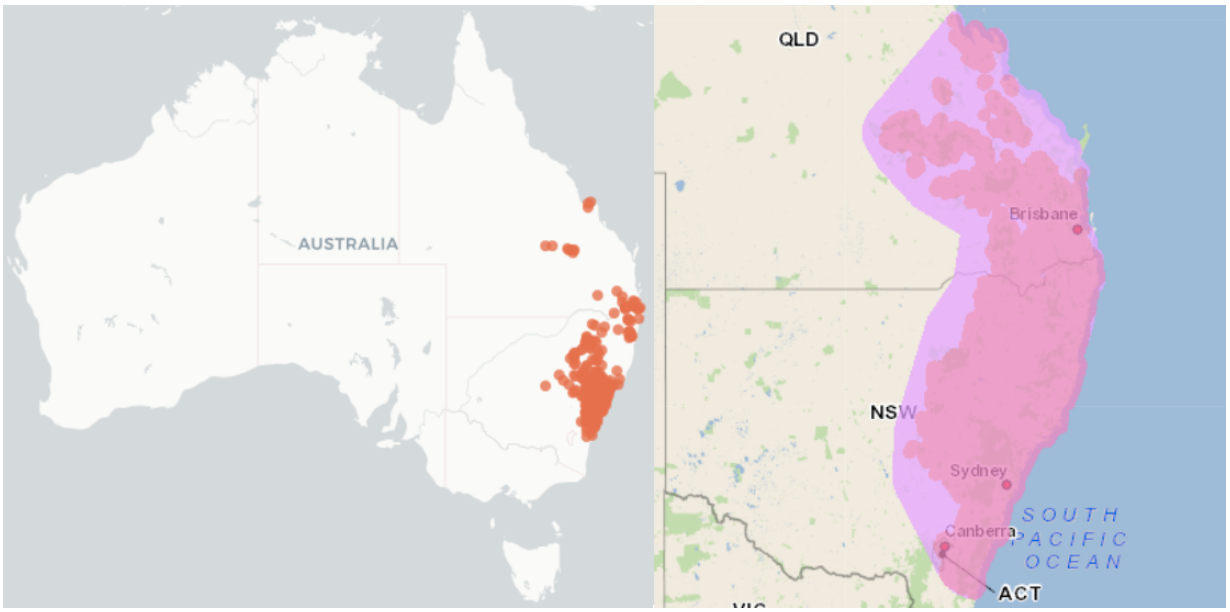

Figure 11-2: Distribution range of the large-eared pied bat (ALA 2020; DoE 2020)

11.2.2 Biology and reproduction

The diet of the large-ear pied bat is not well understood however their morphology (slow flying, highly manoeuvrable) suggests that they forage below the canopy and likely consume insects.[100,101]

Information regarding their life cycle predominantly comes from an early study of a colony in NSW.[103] The species reaches sexual maturity at one year of age and mating occurs in early winter. Females were observed to have given birth to 1-2 young by early December and were seen lactating. Nursery colonies were typically established by adult males and females in September, with males leaving in summer once the young were born. Juveniles remained in the roost for 2-3 months before leaving, followed shortly by the adult females; resulting in an abandoned roost over winter.[103] Similar life cycle observations have been recorded for other colonies with slight differences likely attributed to the varying thermal properties of the roosting sites.[104]

[103] Dwyer 1966

[104] Pennay 2008

11.3 General habitat requirements

The habitat for the large-ear pied bat is dependent upon available roosting sites which have specific requirements and limit the species distribution throughout its range. They require sandstone cliff/escarpment that is adjacent or close to high productivity sites such as woodland or rainforest which the species uses for foraging. Records of the species have predominantly occurred within close proximity to cliffs or rocky terrain. Roosting has been recorded in caves, old mine shafts, overhangs and disused Fairy Martin (*Hirundo ariel*) nests.[100,105] Recently it was discovered that suitable roosting sites can also be less complex than large cliffs or caves, such sites include:[106]

- Dark zones amongst boulders or collapsed cliff line;
- The roof of hollowed out boulders (not big enough to show up on topographic mapping);
- Small honeycombed holes in sandstone; and
- Long slits in exfoliating sheets of sandstone.

Suitable roosting sites can also be more isolated than first thought as the species is able to traverse open areas to access foraging habitat.[106]

The nursery roosts require a more specific structure. They need to be deep enough to enable juvenile bats to practice flying safely inside and also need to have indentations in the roof where heat can be captured. Arch caves with dome roofs are one example that fits these characteristics; however, suitable sites are very rare within the landscape, especially within proximity to fertile foraging habitats. Thus, retaining connectivity between remnant vegetation and potential nursery roost sites is considered to be important for the species long term survival.[105]

The species forages in a variety of vegetation types including dry and wet sclerophyll forest, grassy woodland, *Callitris* dominated forest, tall open eucalypt forest with a rainforest sub-canopy, sub-alpine woodland and sandstone outcrop country.[107] A number of TEC listed under the EPBC Act also provide suitable foraging habitat throughout the species' geographic range, including:[100]

- Brigalow (*Acacia harpophylla* dominant and co-dominant) (QLD and NSW)
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (NSW)
- Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia (NSW)
- New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands (NSW)
- Temperate Highland Peat Swamps on Sandstone (NSW)
- Weeping Myall - Coobah - Scrub Wilga Shrubland of the Hunter Valley (NSW)
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (QLD and NSW).

[105] TSSC 2012

[106] Lothian 2019

[107] DERM 2012

11.4 Central Queensland habitat definition

Separate definitions are provided for preferred & suitable roosting versus foraging habitat on the recommendation of species experts.

Preferred large-eared pied bat habitat in central Queensland is defined as:

- Roosting – sandstone cliff-lines (land zone 10), with a north-westerly to south-westerly aspect, containing small caves and fissures. Sheltered caves of several metres depth may be critical maternity sites.
- Foraging – open forests and woodlands including riparian zones, foot-slopes and valley floors, within 2.5 km of preferred roosting habitat. Foraging activity appears to be concentrated particularly along ecotones between moist and dry vegetation types and abrupt edges between woodland and pasture.

Marginal large-eared pied bat habitat in central Queensland is defined as:

- Roosting – larger scarps in land zone 7 (i.e. ironstone jump-ups) and volcanic plugs in land zone 8; abandoned mine adits.
- Foraging – woodland and forest associated with marginal roosting habitat.

11.5 Habitat identification guidance

Table 11 provides specific information about key attributes of large-eared pied bat habitat requirements, and where these data can be obtained. Collectively these data enable large-eared pied bat habitat to be classified as preferred or suitable as described above.

Table 11: Large-eared pied bat habitat identification

Attribute	Description	Verification area
Vegetation composition	Relevant to foraging only – particularly box gum woodlands or other riparian vegetation types.[108]	Desktop and field
Vegetation structure	Open forests and woodlands including riparian zones, foot-slopes and valley floors [109]	Field
Regional ecosystem associations	Relevant to foraging primarily – 11.3.1, 11.3.6, 11.3.7, 11.3.10, 11.3.11, 11.3.12, 11.3.14, 11.3.17, 11.3.18, 11.3.19, 11.3.27, 11.4.1, 11.4.3, 11.4.8, 11.4.9, 11.4.10, 11.4.12, 11.9.1, 11.9.2, 11.9.4, 11.9.5, 11.9.7, 11.9.10, 11.10.6, 11.10.8, 11.10.9, 11.10.11, 11.10.13	Desktop and field
Food resources	Diet unknown. Foraging likely occurs along watercourses and in fertile valleys and plains within several kilometres of its roosting habitat.	Field

[108] TSSC 2012

[109] DERM 2011

Attribute	Description	Verification area
Land forms/land zones	Predominately roosts in caves and overhangs in sandstone cliffs, equivalent to land zone 10[110]. May utilise LZ 7 and 8. Foraging often associated with LZ3	Desktop
Soils	N/A	N/A
Water (for drinking)	Presence of a waterbody within 3 km of roost	N/A
Hydrological needs	N/A	N/A
Patch size	Unknown	N/A
Connectivity	Retaining connectivity between remnant vegetation and nursery roosts is likely to be important.[108]	Desktop
Shelter/denning/roosting	Caves, overhangs, abandoned mine tunnels and disused fairy martin nests.	Field
Micro habitat features	As described above.	Field
Breeding resources	As described above.	Field
Habitat condition	The majority of records are from canopied habitat, although narrow connecting riparian strips in otherwise cleared habitat are sometimes quite heavily used.[109]	Field

11.6 References

ALA 2020. *Chalinolobus dwyeri: Large-eared pied bat* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:4ce623b3-da72-4548-8b99-a5894df28779

Department of the Environment 2020. *Chalinolobus dwyeri* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of Environment and Resource Management 2011. *National recovery plan for the large-eared pied bat* Chalinolobus dwyeri. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-large-eared-pied-bat-chalinolobus-dwyeri.

Dwyer, P.D. 1966. *Observations on* Chalinolobus dwyeri *(Chiroptera: Vespertilionidae) Australia*. Journal of Mammalogy. 47:716-718.

Hoye, G.A. 2005. *Recovery plan for the large-eared pied bat Chalinolobus dwyeri*. Fly By Night Bat Surveys Pty Ltd. Brisbane: Queensland Parks and Wildlife Service.

[110] DERM 2011

Lothian, Andrew (2019. *Large-eared pied bat activity and buffer zones & large-eared pied bat roost locations*. Consulting Ecology (Journal of the Ecological Consultants Association of NSW). Vol 43.

Pennay, M. 2008. A maternity roost of the Large-eared Pied bat Chalinolobus dwyeri (Ryan) (Microchiroptera: Vespertilionidae) in central New South Wales Australia. Australian Zoologist. 34:564-569.

Threatened Species Scientific Committee (TSSC) 2012. *Commonwealth Listing Advice on* Chalinolobus dwyeri *(Large-eared Pied bat)*. Department of Sustainability, Environment, Water, Population and Communities. Canberra, ACT.

Ryan, R.M. 1966. *A new and imperfectly known Australian Chalinolobus and the taxonomic status of African Glauconycteris.* Journal of Mammalogy. 47:86-91.

12. Corben's (south-eastern) long-eared bat (*Nyctophilus corbeni*)

12.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Vulnerable

12.2 Ecology and distribution

Corben's long-eared bat (*Nyctophilus corbeni*), also known as the south-eastern long-eared bat, was originally classified as the greater long-eared bat (*Nyctophilus timoriensis*) until recently when it was officially described as a separate species.[111] It is a relatively large species of microbat with a head a body length of 50-75 mm and a tail length of 35-50 mm. Females are typically larger than males, weighing between 14-21 g; compared to 11-15 g for males. The species has a broad head and long erect ears (approximately 30 mm in length) that fold back when resting. It has light brown to dark grey-brown fur (see Figure 12-1).[112]

Figure 12-1: Corben's long-eared bat (*Nyctophilus corbeni*) (T. Reardon n.d)

12.2.1 Known distribution

As Corben's long-eared bat was only recently descried as a separate species, its past distribution is not well defined. It is known to occur in southern central Queensland, central western NSW, north-western Victoria and eastern South Australia (see Figure 12-2). It appears to be most abundant inland of the Great Dividing Range and a number of records for the species are from the Nandewar and Brigalow Belt South bioregions in New South Wales and Queensland. It is considered uncommon throughout its range, rarely being recorded.[112]

[111] Parnaby 2009

[112] TSSC 2015

There is minimal information regarding the species population; and it is not known whether their numbers are declining. However, habitat loss and fragmentation are likely impacting suitable habitat for the species and reducing their area of occupancy.[112,113]

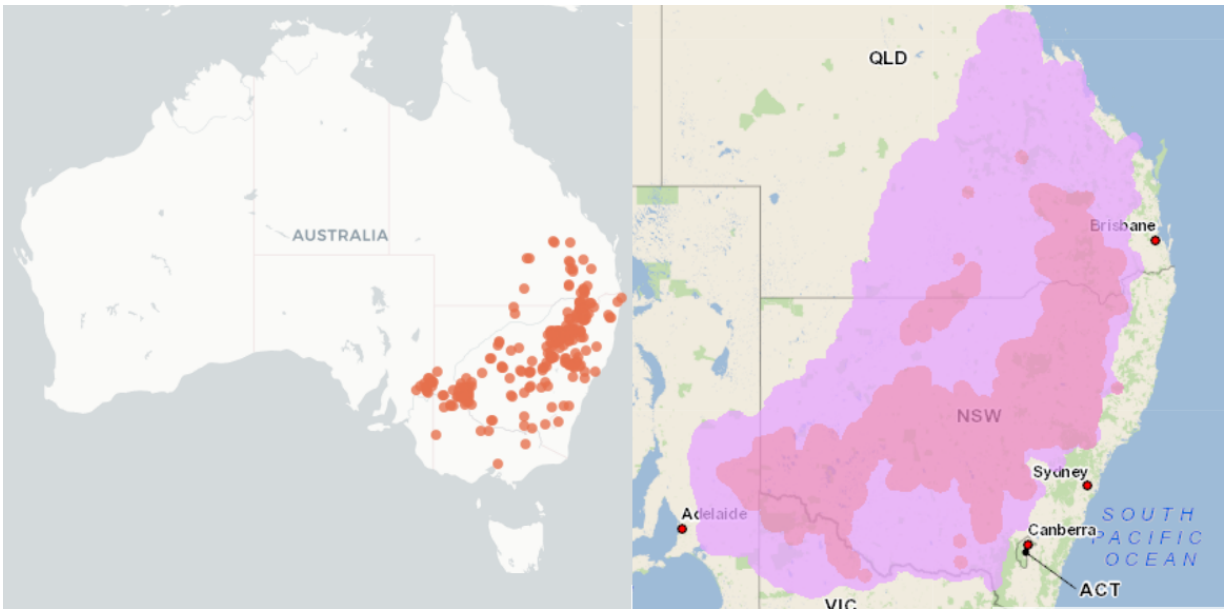

Figure 12-2: Distribution range of Corben's long-eared bat (ALA 2020; DoE 2020)

12.2.2 Biology and reproduction

Corben's long eared bat is insectivorous and forages on a range of insects both in flight and on the ground. Whilst in the air, it consumes insects (including caterpillars) via foliage-gleaning or catches flying insects such as moths and beetles. Ground level prey include grasshoppers sand beetles. Foraging typically occurs around patches of trees and many individuals can share the same foraging area.[112,114,115]

The species roosts solitarily within suitable habitat (see below) during the day and travels significant distances over night between foraging and roosting areas; changing roosting location frequently.[112,116] On average they travel 2 km each night but have been observed travelling up to 7 km.[117] The species has also been recorded roosting in groups to form maternity colonies of 10-20 individuals.[116] The reproductive biology of Corben's long-eared bat is poorly understood; however, pregnant and lactating females have been observed during November in Queensland and NSW, and breeding is likely to be seasonal.[113]

[113] Schulz & Lumsden 2010

[114] Law et al. 2016

[115] Lumsden & Bennett 2006

[116] Lumsden et al. 2008

[117] NGH Environmental 2013

12.3 General habitat requirements

Corben's long-eared bat usually roosts within tree hollows, cervices or under bark in a variety of vegetation types that contain suitable foraging and roosting habitat, these include:[112,113,118]

- Box/ironbark/cypress pine woodlands;
- Bulloak woodlands;
- Brigalow woodland;
- Belah woodland;
- Smooth-barked apple woodland;
- River red gum forest;
- Black box woodland; and
- Mallee shrublands.

In Queensland and NSW, the species is most abundant within box/ironbark/cypress-pine vegetation which occurs as a north-south belt along the western slopes and plains of New South Wales and southern Queensland.[112]

The species is typically more abundant in habitats with the following characteristics: [112,114]

- Large areas of vegetation rather than smaller patches – likely due to the large home range of the species.
- Old-growth vegetation - likely due to the species roosting requirements, particularly tree hollows.
- Vegetation with a district canopy and well-developed understorey.
- Areas with high stem density and a large proportion of dead trees (especially dead *Allocasuarina luehmannii*).

12.4 Central Queensland habitat definition

Preferred Corben's long-eared bat habitat in central Queensland is defined as areas that comprise the following features in combination:

- Woodland or open forest with a complex understorey, typically on land zones 5 and 7; occasionally land zones 3 and 10 and characterised by the following floristic associations:
  - Canopy layer of *Eucalyptus fibrosa* subsp. *nubilus* and/or *E.* crebra and/or *E. populnea* and/or *E. microcarpa*/*E. moluccana*, often with *Angophora leiocarpa* and/or *Corymbia* spp., over a low tree layer of *Callitris* spp. and/or *Allocasuarina luehmannii*.
- Centred around three key groups of regional ecosystems, including:
  - 11.5.1 / 11.5.4 – cypress/bulloak/eucalypt on sandy or duplex soils; undulating plains
  - 11.7.4 / 11.7.7 – cypress/bulloak/eucalypt on shallow soils; low hills
  - 11.3.18 / 11.3.2 – poplar box/cypress/bulloak on sands and duplex soils; alluvial plains

[118] DoE 2020

- Large tract size i.e. greater than ~500 ha[119]
- High stem-density of the low tree layer
- High density of dead trees especially Bulloak, cypress and eucalypts, which are critical for providing abundant roost microhabitat
- High abundance of hollows (especially in small diameter dead trees) is particularly important as they are used to a greater extent than fissures & loose bark.

Suitable Corben's long-eared bat habitat in central Queensland is defined as:

- Areas adjacent and connected to areas of preferred habitat (noting particularly the requirement for large tract size), where vegetation is structurally and floristically similar to that of preferred habitat (see footnote for examples[120]).

12.5 Habitat identification guidance

Table 12 provides specific information about key attributes of Corben's long-eared bat habitat requirements, and where these data can be obtained. Collectively these data enable Corben's long-eared bat to be classified as suitable as described above. Given that the species utilises a wide range of inland woodland types, the species must be recorded for habitat to be classified as preferred.

Table 12: Corben's long-eared bat habitat identification

Attribute	Description	Verification area
Vegetation composition	Bulloak, cypress and eucalypt communities	Desktop and field
Vegetation structure	Woodland or open forest with a complex understorey and high stem density of low tree layer	Field
Regional ecosystem associations that may constitute suitable habitat	As noted above in habitat descriptions	Desktop and field
Food resources	Consumes beetles, bugs and moths, with foraging concentrated around patches of trees in the landscape.	Field
Land forms/land zones	Typically on land zones 5 and 7; occasionally land zones 3 and 10	Desktop
Soils	N/A	N/A
Water (for drinking)	Requires free standing water for drinking.	N/A
Hydrological needs	N/A	N/A
Patch size	Large tract size is important i.e. >500 ha	Desktop
Connectivity	Large tract size is important i.e. >500 ha	Desktop

[119] Law et al. 2018

[120] RE11.3.2, where there is a complex low-tree/understorey layer, especially with cypress; RE11.3.1 where dense low tree/shrub layer is present and extensive; waterholes in RE11.3.25 when that constitutes a narrow riparian strip through more extensive RE11.5.1; RE11.7.5 "heathland" where it is surrounded by or is part of a mixed RE with 11.7.4 and/or 11.7.7

Attribute	Description	Verification area
Shelter/denning/roosting	Roosts in tree hollows, crevices and under loose bark[121]	Field
Micro habitat features	The availability of suitable roosting habitats is essential for the conservation of the species.	Field
Breeding resources	Maternity colonies roosting in dead trees including ironbarks, cypress and bulloak.	Field
Habitat condition	Given the species' requirements for large areas of land, smaller fragments may not provide viable habitat for the species.[109]	Field

12.6 References

ALA 2020. *Nyctophilus corben: Corben's long-eared bat* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:23686af5-4d75-40f9-b29a-4d6d316b47fd#overview

Bradley Law, Leroy Gonsalves, Mark Chidel, Traecey Brassil 2016. *Subtle use of a disturbance mosaic by the south-eastern long-eared bat (Nyctophilus corbeni): an extinction-prone, narrow-space bat,* Wildlife Research 43(2), 153-168.

Department of the Environment 2020. *Nyctophilus corbeni* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Law, B., Gonsalves, L., Brassil, T. & Hill, D. (2018). Does thinning homogenous and dense regrowth benefit bats? Radio-tracking, ultrasonic detection and trapping. *Diversity* **2018***, 10(2),* 45; https://doi.org/10.3390/d10020045

Lumsden, L.F. & A.F. Bennett 2006. *Flexibility and specificity in the roosting ecology of the Lesser Long-eared Bat* Nyctophilus geoffroyi: *A common and widespread Australian species.* Pp. 290-307. **In:** Akbar, Z., G.F. McCracken, and T.H. Kunz. (eds.). Functional and Evolutionary Ecology of Bats. New York: Oxford University Press.

Lumsden L, Nelson J, Lindeman M 2008. *Ecological research on the Eastern Long-eared Bat Nyctophilus timoriensis (south-eastern form). A report to the Mallee Catchment Management Authority.* Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment. Melbourne, Australia.

NGH Environmental 2013. *Biodiversity Assessment - Liverpool Range Wind Farm - Transmission Line Study Area*. Prepared for Epuron.

[121] Department of the Environment (2020). Nyctophilus corbeni in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Parnaby, H 2009. *A taxonomic review of Australian greater long-eared bats previously known as* Nyctophilus timoriensis (*Chiroptera: Vespertilionidae) and some associated taxa.* Australian Zoologist. 35:39-81.

Schulz M and Lumsden L 2010. *Draft national recovery plan for the south-eastern long-eared bat* Nyctophilus corbeni. Victorian Government Department of Sustainability and Environment. Melbourne, Australia.

Threatened Species Scientific Committee (TSSC) 2015. *Conservation Advice* Nyctophilus corbeni *south-eastern long-eared bat*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/83395-conservation_advice-01102015.pdf.

13. Ghost bat (*Macroderma gigas*)

13.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Endangered

13.2 Ecology and distribution

The ghost bat is largest microbat in Australia, weighing up to 150 g. It has a head and body length of 10-13 mm, forearm length of 10-11 cm and a wingspan of 60 cm; it does not have a tail. The species has a nose-leaf, long interjoined ears and large eyes (Figure 13-1).

Figure 13-1: Ghost bat (*Macroderma gigas*) (Duncan Mackenzie 2014)

13.2.1 Known distribution

The ghost bat once had a wide-ranging distribution across most of Australia, contracting northwards during times of increased aridity (preceding the last glacial maximum). Prior to European settlement, restricted subpopulations still occurred throughout the arid zone where suitable microclimates were available within caves. Most of these subpopulations have since disappeared with the species contracting further northward.[122] The last record of the species within the arid zone was in 1961.[123]

The ghost bat has a patchy distribution across northern Australia with colonies occurring in the Pilbara, Kimberley, northern Northern Territory, the Gulf of Carpentaria, western Queensland and coastal to near coastal eastern Queensland from Cape York to Rockhampton (see Figure 13-2).[122] Individual populations (colonies) are genetically distinct from each other (regionally and locally) and are highly structured; suggesting that individuals do not move between different sites. Females are also highly philopatric to their natal roost sites, with males contributing to gene flow between breeding

[122] TSSC 2016

[123] Butler 1962

sites.[122,124,125] Populations are likely to be declining and are at significant risk of further declines due to habitat loss and human disturbance; particularly habitat containing breeding sites.[122]

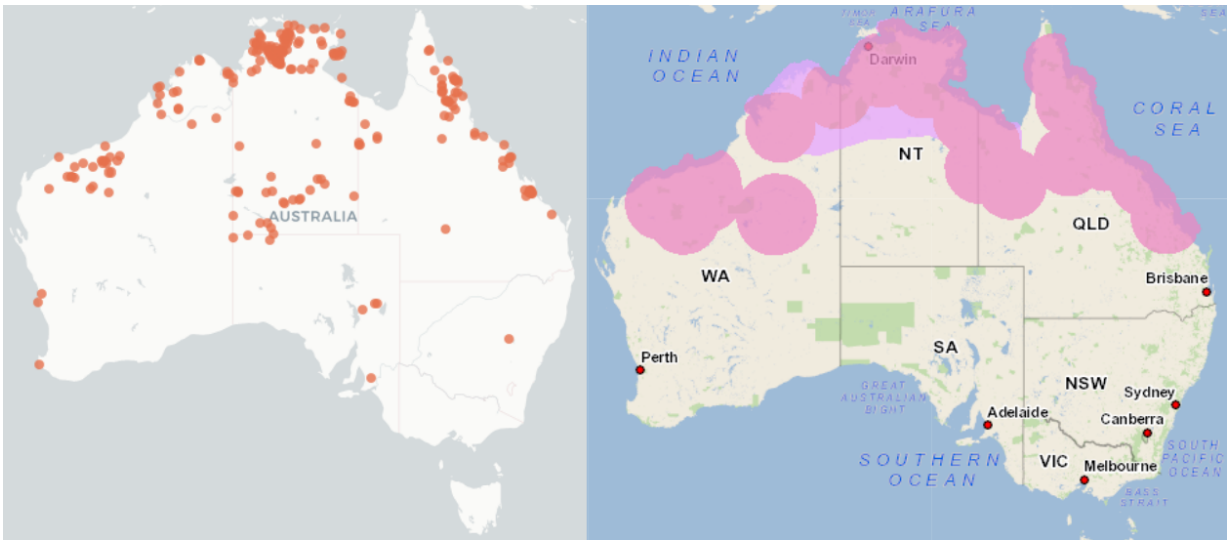

Figure 13-2: Distribution range of the ghost bat (ALA 2020; DoE 2020)

13.2.2 Biology and reproduction

The ghost bat is Australia's only carnivorous bat, consuming small mammals (bats, rats, mice), small birds, reptiles, frogs and large insects. Their prey varies depending upon availability and they require a relatively consistent supply of food throughout the year.[122,126] It forages by either ambushing prey from a perched location or gleaning surfaces (including the ground) while flying. Foraging typically occurs within around 2 km from the daytime roost site, covering an average area of 61 ha. Foraging locations can be shared with a number of individual bats and their vantage points change frequently while hunting (around every 15 minutes).[122]

Female ghost bats begin breeding between 2-3 years of ages and typically give birth to a single young in late spring (commencing October). Females have been observed forming maternity roosts in warm caves to give birth, with some females moving to different caves with their young if disturbed or conditions become unfavourable (e.g. as summer progresses). Juvenile ghost bats begin flying at around 7 weeks of age.[122] Generation length is estimated to be approximately 8 years and the species has been recorded living up to 22.6 years in captivity (wild ghost bat longevity is unknown).[127]

[124] Worthington Wilmer et al. 1994

[125] Worthington Wilmer et al. 1999

[126] Hourigan 2011

[127] Woinarski et al. 2014

Ghost bats move between multiple different caves depending upon the season and weather conditions. They congregate in a small number of roost sites to breed, many of which have not been identified, and disperse up to 150 km from breeding areas during winter.[122,126,128]

13.3 General habitat requirements

Ghost bats occupy a variety of habitats throughout their distribution including rainforest, tropical savanna, monsoon and vine scrub, open woodlands and arid areas. Within these areas they require suitable daytime roost sites and breeding roost sites. Roost sites include caves, rock crevices and old mines. As discussed, the species frequently changes roost location; however, there are some permanent roost sites across its range. The species is easily disturbed while roosting and may permanently abandon a roost site if disturbed.[122,126]

For the ghost bat to persist in an area, populations require multiple caves/shelters that provide daytime roost sites within the vicinity (typically less than 5 km) of a gully or gorge system that opens onto a plain or riparian vegetation; providing adequate foraging habitat.[122] Roost site characteristics that enable regular or permanent occupancy are described below.[122,129]

Nocturnal roost/foraging sites:

- Shallow caves/shelters
- Well-lit during the day
- Often poorly insulated from the elements
- Usually in high locations

Diurnal roost sites:

- Deeper, more complex caves or mines with multiple chambers
- Dome ceilings, fissures and/or passages
- Relatively stable microclimate (temperature between 23-28°C and levels of humidity between 50 and 100%)
- Roof height of at least 2-3 m

Maternal roost sites:

- Similar to diurnal sites but are large enough to support a growing population and have more stable conditions
- Multiple entranced caves are preferred

13.4 Central Queensland habitat definition

Separate definitions are provided for roosting versus foraging habitat on the recommendation of species experts. The definition is also limited to suitable habitat, as the species is restricted to only two breeding

[128] Richards et al. 2008

[129] Astron 2017

sites in Queensland (Mt Etna and Cape Hillsborough), from which is disperses outside of breeding season.

Suitable ghost bat habitat in central Queensland is defined as:

- Roosting – any disused mine tunnels or escarpments with caves and crevices within ~200 km of the breeding roosts at Mt Etna and Cape Hillsborough. Roost sites are likely to be restricted to deeper caves and abandoned tunnels in the central Queensland region, where cool winter nights would make more exposed, shallow overhangs unsuitable for at least the early part of the day.
- Foraging – woodland, forest, wetland and cleared agricultural/pastoral land within ~3 km of daytime roosts.

13.5 Habitat identification guidance

Table 13 provides specific information about key attributes of ghost bat habitat requirements, and where these data can be obtained. Collectively these data enable preferred habitat to be classified as suitable as described above. The species must be recorded for habitat to be classified as preferred.

Table 13: Ghost bat habitat identification

Attribute	Description	Verification area
Vegetation composition	A wide range of habitats from rainforest, monsoon and vine scrub in the tropics to open woodlands and arid areas.[130]	Desktop and field
Vegetation structure	Inhabits various vegetation communities including woodlands and open and closed forests.	Field
Regional ecosystem associations	REs occurring where caves, rock shelters, overhangs and vertical rock cracks have potential to be developed such as on LZs 8, 10, 11 and 12.	Desktop and field
Food resources	Small mammals (including other bats), birds, reptiles, frogs and large insects.[131]	Field
Land forms/land zones	Geology that forms caves, rock shelters, overhangs and vertical rock cracks. To persist in an area, small colonies require a group of caves/shelters that provide alternative day and night roost sites, and a gully or gorge system that opens onto a plain or riparian line that provides good foraging opportunities, typically less than 5 km from the diurnal roost site.[131]	Desktop
Soils	N/A	Desktop

[130] Hourigan, C. 2011

[131] TSSC 2016

Attribute	Description	Verification area
Water (for drinking)	Requires free standing water.	Desktop and field
Hydrological needs	N/A	Desktop and field
Patch size	Unknown. However, the species can forage up to 150 km from maternity roosts during the non-breeding season. Known maternity roosts are genetically distinct throughout the species range.	Desktop
Connectivity	Importance unknown. However, geographically disjunct colonies occur throughout the species range.	Desktop
Shelter/denning/roosting	Diurnal roosts include caves, rock crevices and old mines. Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23°−28°C and a moderate to high relative humidity of 50−100 percent.[131]	Field
Micro habitat features	Caves, rock shelters, overhangs, vertical cracks, and mines during the year as day roosts.[130]	Field
Breeding resources	Ghost bats concentrate in relatively few roost sites when breeding. Few of these sites are known. Known populations in central Queensland include Cape Hillsborough near Mackay and Mt Etna near Rockhampton.[131]	Field
Habitat condition	Ghost bats are easily disturbed when roosting. Remnant, and protected roosting sites may be important.	Field

13.6 References

ALA 2020. *Macroderma gigas: Ghost bat* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:63bc796a-5a85-45bc-b4bc-edecc931cc50

Astron 2017. *Mesa H Ghost Bat*, *Macroderma gigas - Contextual Study*. Prepared for Robe River Mining Co. Pty Ltd.

Butler, W. H. 1962. *Occurrence of the Ghost Bat,* Macroderma gigas, *in the Great Victoria Desert, W.A.* The Western Australian Naturalist 8, 42-43.

Department of the Environment 2020. *Macroderma gigas* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Hourigan, C. 2011. *Ghost bat,* Macroderma gigas. *Targeted species survey guidelines*. Queensland Herbarium, Department of Environment and Science, Brisbane.

Richards, G. C., Hand, S., Armstrong, K. A., & Hall, L. S. 2008. *Ghost Bat* Macroderma gigas. In The Mammals of Australia. Third Edition. (Eds S. Van Dyck & R. Strahan), pp. 449-450. Reed New Holland, Chatswood.

Threatened Species Scientific Committee 2016. *Conservation Advice* Macroderma gigas *ghost bat*. Canberra: Department of the Environment.

Woinarski, J. C. Z., Burbidge, A. A., & Harrison, P. L. 2014. *The Action Plan for Australian Mammals 2012*. CSIRO Publishing, Collingwood.

Worthington Wilmer, J., Moritz, C., Hall, L., & Toop, J. 1994. *Extreme population structuring in the threatened ghost bat,* Macroderma gigas*: evidence from mitochondrial DNA.* Proceedings of the Royal Society of London B Biological Sciences 257, 193-198.

Worthington Wilmer, J., Hall, L., Barratt, E., & Moritz, C. 1999. *Genetic structure and male-mediated gene flow in the Ghost Bat (*Macroderma gigas). Evolution 53, 1582-1591.

14. Grey-headed flying-fox (*Pteropus poliocephalus*)

14.1 Legal status

Environment Protection and Biodiversity Conservation Act 1999: Vulnerable

Nature Conservation Act 1992: Least Concern

14.2 Ecology and distribution

The grey-headed flying-fox weights between 600-1000 g and has a head-body length of 230-289 mm; making it one of the largest bats in the world. It is distinguished from other flying-fox species by its collar of orange-brown fur around its neck and thick leg fur that extends to the ankle (not to the knee like other species). Its head is light grey, as is the belly fur; often with flecks/spots of white and ginger (see Figure 14-1). The species has back fur of varying colour; typically, being either dark grey or frosted silver. Their fur is darker in winter, prior to a moult which occurs in June, revealing lighter fur.[132]

Figure 14-1: Grey-headed flying-fox (*Pteropus poliocephalus*) (NSW National Parks and Wildlife Service 2020)

14.2.1 Known distribution

The grey-headed flying-fox has a distribution spanning across the eastern and south-eastern coast of Australia; from Rockhampton in Queensland to Melbourne in Victoria (see Figure 14-2). It occurs at different locations throughout its distribution depending upon food availability; therefore, patterns of occurrence and abundance vary largely between seasons and years. There are regional trends in distribution and migration patterns for the species due the timing of flower and fruit production of native plant species. Their distribution is generally more widespread in summer and more restricted in autumn and winter. There are also a number of locations were the species is permanently present including Brisbane, Newcastle, Sydney and Melbourne.[132] In 2010, a permanent population of grey-headed flying-fox was also established in Adelaide.[133]

[132] DoE 2020

[133] Natural Resources 2013

The population of grey-headed flying-fox is considered to be one single interbreeding population due to their wide movement patterns. The abundance of this population throughout its distribution is thought to be decreasing due to the loss and modification of suitable habitat, particularly roosting habitat. [132,134]

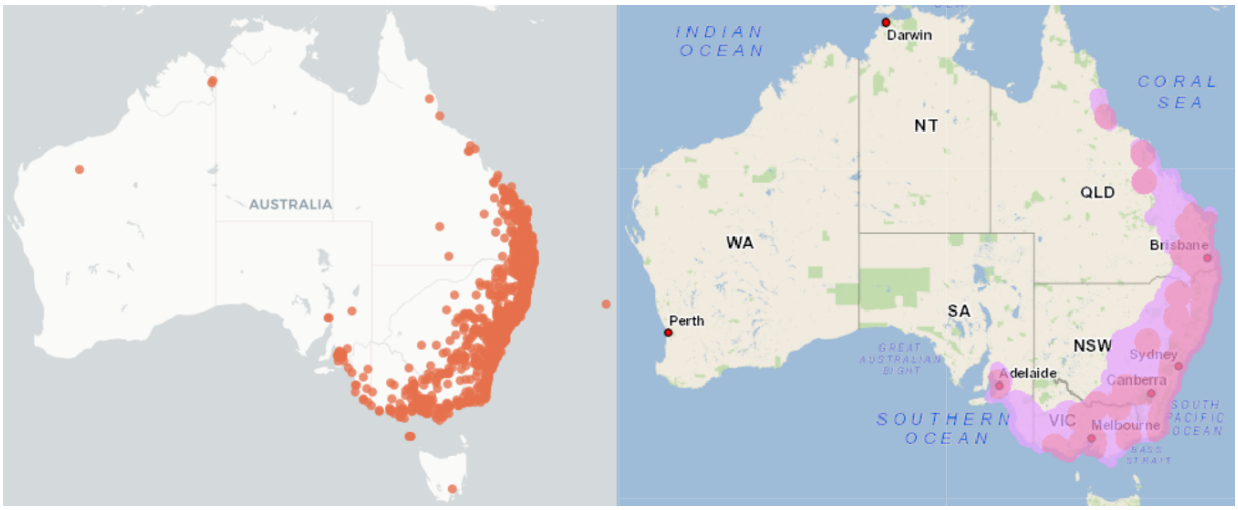

Figure 14-2: Distribution range of the grey-headed flying-fox (ALA 2020; DoE 2020)

14.2.2 Biology and reproduction

The grey-headed flying-fox is a canopy-feeding frugivore and nectivore that feeds on a variety of plant species; selectively foraging where food is available. Their primary food source is nectar and pollen from eucalyptus flowers (*Eucalyptus*, *Corymbia* and *Angophora*), melaleucas and banksias. Eucalypt species flower at varying times during the year and many do not flower every year, this contributes to the grey-headed flying-fox's breeding and migration patterns. The species also feeds on rainforest fruits, cultivated fruit crops and modified vegetation within urban environments. They typically travel within 15 km of their daytime roost site when foraging but can travel up to 50 km to find food if necessary.[132]

Female grey-headed flying-foxes typically reach sexual maturity at 3 years of age and produce one young annually. The species has a slow population growth rate as females will abort or abandon their young in unfavourable conditions (food shortage, high temperatures). Breeding camps form in late spring to early summer when food resources are abundant, with mating occurring in early autumn. After mating the camps begin to break up as males and females segregate in October when females give birth. Females carry their young with them while feeding for 4-5 weeks until the young are furred; at which point they are left in maternal camps to be nursed. Lactation occurs for three to four months after birth until the young are independent at around 12 weeks of age.[132]

The species has an average longevity of 7.1 years and a generation length of 7.4 years.[135] Their life expectancy is highly variable and dependent upon environmental conditions. Heat-related deaths are very common, with mass mortalities often occurring during heatwaves.[135,136]

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[134] TSSC 2011

[135] Tidemann & Nelson 2011

[136] Eby et al. 2004

14.3 General habitat requirements

The grey-headed flying-fox occupies a variety of habitats throughout its large distribution including rainforests, open forests, *Melaleuca* swamps, closed and open woodlands (particularly *Banksia* woodlands) and modified vegetation within urban environments (including non-native species). As discussed, the species migrates between areas based upon food availability and can therefore utilise highly fragmented and patchy vegetation. The species roosts on exposed branches in tress of various size and species, located close to water. [132,137] Camps (both temporary and permanent) are typically established in areas with the following characteristics:[137]

- closed canopy with continuous coverage of > 1 ha;
- canopy height of ≥ 8 m;
- level topography;
- within 50 km of the coast;
- within 500 m of a waterway/waterbody; and
- within 20 km of foraging areas.

A number of permanent camp sites have been established within or in close proximity to urban areas due to the continual supply of food resources and roosting habitat.[132]

14.4 Central Queensland habitat definition

Separate definitions are provided for preferred & suitable roosting versus foraging habitat on the recommendation of species experts.

Preferred grey-headed flying-fox habitat in central Queensland is defined as:

- Roosting – known grey-headed flying-fox camps.
- Foraging – all *Eucalyptus*, *Corymbia, Melaleuca, Angophora* or fruiting rainforest vegetation communities that have potential to provide food resources[138] for the species occurring within 50 km of preferred roosting habitat.

Suitable grey-headed flying-fox habitat in central Queensland is defined as:

- Roosting – any known camps of other flying-fox species (e.g. black and little red flying-foxes).
- Foraging – all *Eucalyptus*, *Corymbia, Melaleuca, Angophora* or fruiting rainforest vegetation communities that have potential to provide food resources[139] for the species occurring within 50 km of suitable roosting habitat.

[137] EGSC 2015

[138] Eby and Law 2008 provides additional guidance as to significant blossom and fruit dietary components

[139] Eby and Law 2008 provides additional guidance as to significant blossom and fruit dietary components

14.5 Habitat identification guidance

Table 14 provides specific information about key attributes of grey-headed flying-fox habitat requirements, and where these data can be obtained. Collectively these data enable preferred habitat to be classified as preferred and suitable as described above.

Table 14: Grey-headed flying-fox habitat identification

Attribute	Description	Verification area
Vegetation composition	Foraging – *Eucalyptus*, *Corymbia, Melaleuca, Angophora* or fruiting rainforest vegetation	Desktop and field
Vegetation structure	Roost sites – closed canopy with continuous coverage of > 1 ha and canopy height of ≥ 8 m.[137]	Field
Regional ecosystem associations that may comprise preferred and suitable habitat	Wide range of REs will be used	Desktop and field
Food resources	Myrtaceae dominant. Nectar and pollen from the flowers of eucalypts (genera *Eucalyptus, Corymbia* and *Angophora*), melaleucas and banksias are the primary food for the species, but in some areas it also utilises a wide range of rainforest fruits and introduced urban fruits.[137] Species commutes daily to foraging areas, usually within 15 km of the day roost site. Are capable of nightly flights of up to 50 km from their roost to different feeding areas as food resources change.[140]	Field
Land forms/land zones	N/A	N/A
Soils	N/A	N/A
Water	Roost sites are typically located near water, such as lakes, rivers or the coast.[140]	Desktop and field
Hydrological needs	N/A	N/A
Patch size	N/A	N/A
Connectivity	Configuration of foraging areas in proximity of camps/roosts is important.[140]	Desktop
Shelter/denning/roosting	Camp sites across their distribution typically include some of the following attributes • Closed canopy; • Continuous canopy area > 1 ha; • Within 50 km of the coast and at less than 65 msl; • Close proximity to waterways (< 500m); • Level topography;	Field

[140] DoE 2020

Attribute	Description	Verification area
	• Canopy height 8m and above; and • Positioned with a nightly commuting distance of generally less than 20km of sufficient food resources.[137] The above are typical attributes but the changing nature of foraging resources has led to more establishment in urban environments in recent years.	
Micro habitat features	Camps are formed in response to the location and timing of local flowering and fruiting events. An area will be occupied for a few weeks to several months until the food resource is exhausted.[137]	Field
Breeding resources	Camps are commonly located in closed forest, Melaleuca swamps or stands of Casuarina and are generally found near rivers or creeks. The species display a degree of flexibility in their choice of camp vegetation and location and may include urban areas.	Field
Habitat condition	A number of 'urban' roost sites that are occupied year-round have become established due to consistently available food resources and suitable roosting habitat.[137] Remnant woodlands and open forests are more likely to host an abundance for food resources.	Field

14.6 References

ALA 2020. *Pteropus poliocephalus: Grey-headed flying-fox* in Atlas of Living Australia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:7065d246-3017-4768-9c8f-8c58c0e538c1

Department of the Environment 2020. *Pteropus poliocephalus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

East Gippsland Shire Council (EGSC) 2015. *Mitchell River Revegetation Program - Bairnsdale Grey-headed Flying Fox Roost Site Strategic Management and Action Plan*.

Eby, P. 2004. *National Count of Grey-headed Flying-foxes April 3 and 4, 2004*. A report to the Department of the Environment and Heritage, Queensland Parks and Wildlife Service, NSW Department of Environment and Conservation, Victorian Department of Sustainability and Environment.

Natural Resources 2019. *Grey-headed Flying-foxes in South Australia*. Department for Environment and Water SA.

Threatened Species Scientific Committee 2001. *Commonwealth Listing Advice on* Pteropus poliocephalus *(Grey-headed Flying-fox)*.

Tidemann, C.R. & J.E. Nelson 2011. *Life expectancy, causes of death and movements of the grey-headed flying-fox (Pteropus poliocephalus) inferred from banding*. Acta Chiropterologica. 13(2):419-429.