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Preliminary Documentation Submission

Lot 172 // DP 755923 & Lot 823 // DP 247285, Manyana, NSW

Ref: 2020/8704

Prepared for Ozy Homes Pty Ltd

28 December 2023 Version: 2.3 – Final

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Glossary and abbreviations

Acronym	Description
ANU	Australian National University
APZ	Asset Protection Zone
BAM	Biodiversity Assessment Method
BC Act	*NSW Biodiversity Conservation Act 2016*
BES	Bushfire Environmental Services
BOM	Bureau of Meteorology
C/A	Cover/abundance – 6 class scale per Poore (1955)
CC	Construction Certificate
Commonwealth	Australian Government Department of Climate Change, Energy, the Environment and Water (or preceding department)
Council	Shoalhaven City Council
DAWE	(former) Commonwealth Department of Agriculture, Water and the Environment (now DCCEEW)
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DEC	New South Wales Department of Environment and Conservation
DECC	New South Wales Department of Environment and Climate Change
Department	Commonwealth Department of Climate Change, Energy, the Environment and Water
DoEE	(former) Commonwealth Department of Environment and Energy (now DCCEEW)
DPIE	NSW Department of Planning, Industry and Environment
EEC	Endangered Ecological Community

Acronym	Description
EPBC Act	*Commonwealth Environment Protection and Biodiversity Conservation Act 1999*
EMP	Environmental Management Plan
FFMP	Flora and Fauna Management Plan
GEEBAM	Google Earth Engine Burnt Area Map
ha	Hectares
HBT	Hollow-bearing tree or habitat tree
IBOC	Illawarra Bird Observers Club
inf	infrastructure
KBA	Key Biodiversity Area
LGA	Local Government Area
locality	5 km radius from the site
MNES	Matter of National Environmental Significance
NPWS	New South Wales National Parks and Wildlife Service
PD	Ecoplanning (2023). *Preliminary Documentation Submission– Lot 172 // DP 755923 & Lot 823 // DP 247285, Manyana, NSW* (this document)
sd	standard deviation
SE	South-East
site	Lot 172 // DP 755923 and Lot 823 DP // 247285, Manyana, NSW
TSC Act	*NSW Threatened Species Conservation Act 1995* (superseded by BC Act)
WBFB	Birdlife Australia Woodland Birds for Biodiversity
winter-spring	The food bottleneck period for the Grey-headed Flying-fox as defined in Table 3.2 of Eby and Law (2008), including June-July and August-September bi-months

Acronym	Description
winter and spring	The period which is the subject of this Preliminary Documentation Submission, which combines the winter-spring period as well as late spring, and extends from June through November

Executive Summary

A Referral (ref: 2020/8704) to the Commonwealth Minister for the Environment (**Minister**) was submitted on 24 June 2020 for the proposed action to construct a residential development and ancillary infrastructure at Lot 172 // DP 755923 and Lot 823 DP // 247285, Manyana, NSW. The Minister determined that the proposed action is considered to be a 'controlled action' for Grey-headed Flying Fox and *may* be a 'controlled action' for Swift Parrot and Greater Glider under the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**). The Minister requested further information in the form of Preliminary Documentation. This document provides the specified information required by the Minister under Section 95A of the EPBC Act. On behalf of the Minister, the former Department of Agriculture, Water and the Environment (now, Department of Climate Change, Environment, Energy and Water; the **Department**) considered that more detail is required in relation to three species listed as Matters of National Environmental Significance (**MNES**).

Grey-headed Flying-fox (GHFF) (*Pteropus poliocephalus*) – Vulnerable

In its review of the Referral document, the Department considered that 17.18 hectares (ha) of habitat critical to the GHFF would be removed as a result of the proposed action, as 'the proposed action area includes important winter and spring foraging habitat, including Grey Ironbark (*Eucalyptus paniculata*), Blackbutt (*E. pilularis*) and Coast Banksia (*Banksia integrifolia*). This is due to a potential food bottleneck period for this species in the winter-spring months (June through September).

Further mapping and analysis are provided in this document, which relies upon the latest GHFF foraging habitat maps produced by the NSW Government (DPIE 2019), as informed by Eby and Law (2008). This additional analysis included systematic survey of the proposed action area, which identified a maximum area of 1.25 ha of potential winter and spring foraging habitat for the GHFF within the impact area of the proposed action when spring flowering Turpentine (*Syncarpia glomulifera*) is included as an important food tree, as well as winter-spring flowering Grey Ironbark and Coast Banksia. The habitat within the site is not considered habitat critical to the survival of GHFF and the impacts to GHFF are not considered significant as:

- Blackbutt has been considered an important winter and spring diet plant by the Department. Blackbutt flowers in summer on the South Coast and consequently the site. It is therefore not an important winter-spring diet plant for GHFF on site.
- The Final Recovery Plan for GHFF (DAWE 2021) expands habitat critical to the survival of GHFF to include native species that are known to be productive as foraging habitat during the final weeks of gestation, and during the weeks of birth, lactation and conception (August to May). At the site, this would include Blackbutt and *Corymbia gummifera* (Red Bloodwood). It is estimated up to 5.93 ha of these species will be cleared in the seven year staged development period.
- When Blackbutt and Red Bloodwood are in flower, this is the time of greatest nectar production on the south coast (Eby and Law 2008), and hence they are unlikely to present a significant foraging resource at the Site.
- Grey Ironbark and Coast Banksia occur on the site in low numbers, occupying an area of approximately 0.22 ha.
- Turpentine is found in the *subcanopy* stratum, to a height of approximately 14 m, beneath a 20 to 25 m tall canopy of Blackbutt, with the subcanopy cover area totalling approximately 1.02 ha. Trees produce less flower and less nectar when growing in the

subcanopy than they do when growing in locations where the canopy is unconstrained. Eby and Law (2008) *Ranking the feeding habitats of Grey-headed flying foxes for conservation management* does not consider subcanopy eucalypts in ranking nectar habitat quality and therefore preferred foraging areas for GHFF. The occurrence of this species in the subcanopy is therefore considered 'low-quality' foraging habitat.

- Mapping has been field-validated and confirms that the site is not an area classed as important winter-spring foraging habitat for the GHFF as per the habitat rankings of Eby and Law (2008).
- In making their assessment, the Department considered the Yatteyattah flying-fox camp as permanently occupied and that the foraging habitat on site would be more frequently utilised due to its proximity to a permanently occupied camp. However, this camp is infrequently occupied in winter and spring and is not a permanently occupied camp.
    - Yatteyattah has been occupied in winter and spring in 2 of the last 9 years.
    - When GHFF have been recorded in this camp in large numbers in winter and spring, their presence has coincided with mass flowering events of Spotted Gum (winter) or Forest Red Gum (spring), and there is evidence that nectar is not a limiting resource in the landscape during these mass flowering events.
    - Yatteyattah is no longer considered to be a nationally important camp as it been more than 10 years since the camp had greater than 10,000 individuals present (DAWE 2021 and DCCEEW 2023)
- Large numbers of GHFF occupy the South Coast of NSW in winter and spring only during years of mass flowering events; otherwise, the species is rare south of Nowra during these months.
    - Seasonal patterns of movement in the South Coast are consistent and well-documented in relation to the above, and have not changed in the past 10 years or since the 2019-2020 bushfires.
    - The typical winter and spring refugium for this species is south east Queensland and north east NSW. Despite recently documented wider-ranging foraging behaviour outside this refugium, the wider-ranging foraging behaviour observed has not extended as far south as the South Coast and the species remains uncommon south of Nowra during these months (DCCEEW 2023).
- Mitigation measures are proposed which will delay the clearing of GHFF foraging habitat in Stages 1 through 4 of the development. These measures will delay clearing of 0.21 ha of winter and spring habitat, reducing the amount of clearing in these stages by 60 % during the first 7 years post-bushfire when recovery of the surrounding habitat is less advanced. A further 0.36 ha (22 %) of the total winter and spring foraging habitat on site will be permanently retained.
    - The proposed action will clear a total of 1.25 ha of winter and spring GHFF foraging habitat (Turpentine, Grey Ironbark and Coast Banksia) over a 9-year (or greater) period post-bushfire, with up to 1,604 m² (0.16 ha) cleared in Stage 1 and up to a cumulative total of 1,826 m² (0.18 ha) cleared prior to commencement of Stage 4 no earlier than 7 years post-bushfire.
    - An estimated 5.93 ha of summer-autumn foraging habitat (Blackbutt and Red Bloodwood) will be cleared over the 9 year (or greater) staged development period, which is estimated to <0.01% of the equivalent habitat within the locality
    - Plantings of GHFF winter and spring diet plants will be incorporated into the development such that the total winter and spring forage available is expected to be greater than that currently present when these plantings are mature. The

staging of the development is likely to allow time for plantings of Coast Banksia in the earlier stages to reach flowering size prior to commencement of clearing in the final stages of development.

Greater Glider (*Petauroides volans*) – Vulnerable

Surveys conducted on the site in May-June 2020 (114 person-hours of survey over 10 nights) are sufficient to determine that the species is absent from the site. Based on survey adequacy estimates used by the Department to specify post-fire survey requirements (Wintle et al 2005; Southwell 2020), the probability of a false absence is estimated at <0.05. Based on recent regional survey (Gaia Research 2021; Daly 2023), Greater Gliders are considered unlikely to be capable of dispersing into the site for many years, possibly decades.

Swift Parrot (*Lathamus discolor*) – Critically Endangered

The Department considered that the potential important foraging resources for Swift Parrot in the proposed action area were understated in the Referral given that a known feed tree for the species, Blackbutt, was recorded on site.

Blackbutt flowers in summer months on the site and does not represent important potential foraging habitat for Swift Parrots in the region, which are present in the region between April and September. Important foraging areas in the non-breeding range of the Swift Parrot are locations where large numbers have been observed foraging, or locations where birds forage with site fidelity or site persistence. None of the known key foraging tree species for the Swift Parrot on the South Coast (Spotted Gum, Swamp Mahogany, and Forest Red Gum) are found on the site. The primary threats to the Swift Parrot are habitat loss and nest predation within its breeding range in Tasmania (Saunder and Tzaros 2011; Bird Life 2014).

Assessment of impacts

The subject species of this assessment are not resident within the proposed action area. Only GHFF are likely to visit the site to forage. GHFF are rare south of Nowra in winter and spring months, occurring in large numbers only during mass flowering events. A total of 1.25 ha of low-quality potential winter and spring foraging habitat (Grey Ironbark, Turpentine and Coast Banksia) for GHFF will be cleared on the site. A total of 5.93 ha of summer and autumn foraging habitat (Blackbutt and Red Bloodwood) will be cleared on the Site.

For the above reasons, and as outlined and discussed in detail in this Preliminary Documentation Submission and associated attachments, it is concluded that the proposed action does not represent a significant impact to the Grey-headed Flying-fox, Greater Glider or Swift Parrot.

1 Introduction

This Preliminary Documentation submission follows the determination of a controlled action (ref: 2020/8704) for the residential development and ancillary infrastructure (**proposed action**) at Lot 172 // DP 755923 and Lot 823 DP // 247285, Manyana, NSW (**the site**). On 16 August 2020, the Commonwealth Minister for the Environment (**Minister**) determined on the basis of information available in the Referral (Ecoplanning 2020a) that the proposed action is likely to have a significant impact on Matters of National Environmental Significance (**MNES**) protected by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) under controlling provisions s18 and s18A (**Determination**), in particular threatened fauna species. On 21 August 2020, the Commonwealth Department of Agriculture, Water and Environment (**Department**) identified further information required in relation to these species to support claims and conclusions made in Referral documentation. These species (**subject species**) are addressed herein:

- Grey-headed Flying-fox (**GHFF**) (*Pteropus poliocephalus*) – Vulnerable
  Likely to have a significant impact.
- Greater Glider (**GG**) (*Petauroides volans*) – Vulnerable
  May have a significant impact.
- Swift Parrot (**SP**) (*Lathamus discolor*) – Critically Endangered
  May have a significant impact.

1.1 Proposed action

The proposed action is the development of a residential subdivision which will require clearing approximately 17.18 ha of vegetation in six stages (including 1 ha of cleared/disturbed land (BES 2006)). Clearing of each stage is subject to approval of the Sub-division Works Certificate (SWC) for that stage. Stage 1 CC (no: CC18/2030) was approved on 19 November 2019 (**Appendix A**). In accordance with the Major Project Approval (MP 05_0059) (**Attachment L**), clearing of vegetation associated with CC approval for each stage is permitted commensurate with that stage only, and clearing associated with subsequent stages cannot occur until all works in relation to the approval of the previous stage are complete. The projected time frame for staging is presented in **Table** 2.1, however, delays are anticipated, and these represent the earliest possible dates that vegetation clearing could occur.

1.2 Referral

A Referral was submitted on 24 June 2020 (EPBC 2020/8704) (Ecoplanning 2020c). The Referral was submitted despite extensive survey and contemporary assessment concluding that the proposed action is not likely to have a significant impact on MNES protected under the EPBC Act. These assessments were undertaken at the request of Manyana Coast Pty Ltd (the designated proponent) in order to exercise due care and diligence as prescribed under s18 of the EPBC Act. Assessments conducted in 2018 concluded that formal assessment and approval under the EPBC Act is not required (Ecoplanning 2018a,b). Following the extensive bushfires on the South Coast of NSW in 2019-2020, the proponent undertook further due diligence by engaging additional survey and assessment of potential impacts to MNES from the proposal (Ecoplanning 2020a). This assessment also concluded that formal assessment and approval under the EPBC Act is not required.

Notwithstanding, the proponent elected to submit a referral out of an abundance of caution and at the request of the Department. The Referral stated that the proponent believed that the proposed action is not a controlled action.

1.3 Species Workshop

On 15 December 2020, the Department convened a species workshop to discuss uncertainties and complexities surrounding impacts on the subject species. The participants included experts who have published peer-reviewed literature and are actively involved in research pertaining to the subject species, as well as officers from the Department, Ecoplanning staff, and the proponent.

The participants discussed some of the key uncertainties surrounding the subject species in the context of the 2019-2020 bushfires and the subject species' potential to occur on site. The participants were provided with a draft of this Preliminary Documentation Submission.

Following the species workshop, the Department provided the proponent with formal comments on the draft of the Preliminary Documentation Submission, including additional issues raised by the participants of the workshop. This document, the Preliminary Documentation Submission v 2.3 – Final , incorporates and responds to the additional information previously requested by the Department on 21 August 2020, together with the Department's draft comments provided to the proponent following the species workshop. Regarding the Department's draft comments, this document provides a response to these comments in the context of the issues raised at the species workshop.

1.4 Public exhibition

A draft of the Preliminary Documentation (v2.2) was put on Public Exhibition on 21 June 2021. A detailed Response to Public Submissions (RtPS) has been prepared for the proponent by Precise Planning (2023) to respond to the numerous submissions received on the draft Preliminary Documentation. The Precise Planning RtPS identified five submissions that were considered to be of an 'expert' nature with regards to ecology. Those five expert submissions have been addressed in detail in Ecoplanning (2023).

This version of the Preliminary Documentation addresses additional comments received by the Department following submission of the RtPS and advice received from the Department, 1 September 2023.

2 Impacts

The Department has identified in Attachment A to its letter to the proponent dated 21 August 2020 (the preliminary documentation requirements) the following expected impacts of the proposed action:

- Clearing and habitat loss (direct impact) associated with the development of residential lots and construction of associated infrastructure.
- Edge effects (indirect impacts) on retained listed threatened species habitat arising from adjacent suburban activities, including but not necessarily limited to noise and light disturbance, roadkill, trampling, littering, weed invasion, predation by pets, altered fire regime and altered hydrology (in terms of quality and quantity).

The Minister considered that the impact of the proposed action is significant due to the reduction in habitat for the subject species arising from the 2019-2020 bushfires, including the Currowan fire which affected Manyana and surrounding bushland in the Shoalhaven Local Government Area (**LGA**). The Minister considered that the importance of the habitat on site and the importance of any population of the subject species occurring on or utilising the site is of increased significance due to the Currowan fire.

Prior to the 2019-2020 bushfires, the Department had received information from the proponent (Ecoplanning 2018a,b) and decided on the basis of this information that a referral for formal assessment of the proposed action under the EPBC Act was not required. However, in the context of the bushfires, the impact of the proposed action was considered by the Department to be significant.

2.1 Local context

In the Manyana-Bendalong area, approximately 812 ha of forest vegetation with an unburnt canopy remained contiguous with the site (5 km radius) in the immediate (February 2020) post-bushfire context (see MNES assessment, Ecoplanning 2020a). In the Ecoplanning (2020a) MNES assessment undertaken post the Currowan bushfire, habitat for each of the subject species within this contiguous patch was ground-truthed, which extends north-eastward from the site to the area south of Nerindillah Creek and west of Bendalong (refer **Appendix B**). Unburnt canopy was found in all areas mapped either 'Low' or 'Medium' on the Google Earth Engine Burnt Area Map (GEEBAM) (DPIE 2021). The GEEBAM defines these burnt classes as follows:

1. [Low] *Little change observed between pre and post fire.*
2. [Medium] *Canopy unburnt - A green canopy within the fire ground that may act as refugia for native fauna, may be affected by fire.*

Ground-truthing in May 2020 confirmed that DPIE (2021) classifications in the Manyana area are accurate, including with respect to intact canopy refugia for the subject species. The subject species of this assessment forage and dwell within the canopy.

Observations of the subject species in the region post-bushfire (Craven and Daly 2020; Gaia Research 2021), peer-reviewed studies of bushfire effects on the subject species and their habitats (McLean et al. 2018; Berry et al. 2015; Lindenmayer et al. 2013; Taylor and Goldingay

2009; Law et al. 2000), and published anecdotal observations (Cornwell et al 2021) confirm that areas of unburnt canopy are habitat for the subject species and are the minimum area of refuge within which local populations, if present pre-fire, would have survived. The regional and anecdotal observations also suggest that even GEEBAM 'High' burnt class areas (canopy scorch) provide habitat within which Greater Gliders may have survived.

During the passage of the Currowan fire, 812 hectares of unburnt canopy habitat remained to provide potential refuge for Grey-headed Flying-fox, Greater Glider, and Swift Parrot within 5 km of the site.

2.2 Bushfire context

The timing of development impacts relative to the 2019-2020 bushfires is provided in **Table 2.1**. The timing of impacts is relevant to the decision of the Minister, as the controlled action decision is contingent on the 2019-2020 bushfire impacts, and a decision by the Department prior to the 2019-2020 bushfires did not consider impacts to warrant a referral. **Table 2.1** and **Figure 2.1** shows the earliest projected timing of vegetation clearing for development stages, the total direct impact at the time the stage is developed, and the time elapsed since the bushfires. Timing has relevance to the assessment of impact, as there are no circumstances under which the total of 17.18 ha of vegetation would be cleared earlier than 9 years after the Currowan fire. Stage 1 will be cleared in the post-fire environment (ca. early 2024), however, the relative impact on the subject species of this habitat clearing will diminish over time as the surrounding vegetation recovers from the fire (refer to **Section 3.4** for recovery estimates).

While the recovery estimates provided cannot provide perfect certainty regarding the finer details of future habitat conditions, what is certain is that in 9 years' time the recovery of the surrounding vegetation will be further advanced than at the present date. To assume that the burnt vegetation 7 years hence will be producing no additional nectar from flowering trees, will provide no new forage and will provide no shelter would ignore the fundamental, observable processes of ecological succession (see Cowles 1899; Walker et al 2007). Additional bushfires may occur in the intervening years, but there is no basis to believe that the site would not be as likely (or more likely, due to greater unburnt fuel loads) to burn as surrounding bushland in any possible future fire.

The cumulative total clearing of 1.25 ha of winter-spring and 5.93 ha of summer-autumn flowering vegetation (GHFF foraging habitat; see **Section 2.3** below for method of estimating summer-autumn forage) 10 years after the fire will represent a lesser relative impact (% cleared vs % available habitat) than clearing immediately after the fire, and clearing 0.16 ha at least 49 months after the fire will result in a lesser relative impact than clearing 0.16 ha four months after the fire, and so on. The exact quantity of nectar, for example, produced in regenerating vegetation versus unburnt vegetation can only be estimated, however, there is no doubt that, in the absence of a bushfire event of a similar scale in the interim, more forage will be available in 2024 than was available in January 2020, and that if an event affecting the availability of foraging habitat occurs in the meantime, such an event would be as likely to affect the site as it would the surrounding habitats. Refer to **Section 3.4** for estimates of recovery of important food trees and **Figure 3.14** for a visualisation of the projected recovery. Refer to **Section 3.1** for winter and spring flowering habitat survey results.

2.3 Estimating extent of impact on Summer-autumn foraging habitat (Blackbutt and Red Bloodwood)

At the time of drafting the Preliminary Documents in 2020, the draft GHFF Recovery Plan (DoEE 2017) considered habitat critical to the survival of the species to be those tree species flowering in the winter-spring foraging period, including a list of Eucalypt species. However, when the final GHFF Recovery Plan (DAWE 2021) was published in March 2021, an additional criterion for habitat critical was added:

> *'Habitat critical to the survival of the Grey-headed Flying-fox may also be vegetation communities not containing the above tree species but which: contain native species that are known to be productive as foraging habitat during the final weeks of gestation, and during the weeks of birth, lactation and conception (August to May)'*

Of the canopy species known from the Site that are not considered in the Winter-spring analysis within this report but flower in Summer-autumn months, *E. pilularis* (Blackbutt) is listed as important for the GHFF in the Recovery Plans and *Corymbia gummifera* is listed as important in Eby and Law (2008).

Based on the vegetation descriptions within the flora and fauna assessment (BES 2006), the canopy of Northern Coastal Sands Shrub/Fern Forest is dominated by *E. piperita* (Sydney Peppermint), *E. pilularis* and *C. gummifera* (Red Bloodwood) (est. 75% of canopy composition), with four other *Eucalyptus* spp. noted as occurring occasionally (est. remaining 25% of canopy). These estimates assume a 50% canopy composition of *E. pilularis* and *C. gummifera* combined within this vegetation community.

BES (2006) describes Bangalay Moist Woodland/Open Forest as having a canopy dominated by *E. botryoides* (Bangalay) (est. 75% of canopy), but also including *E. pilularis*, *E. eugenioides* (Thin-leaved Stringybark), *E. paniculata* (Grey Ironbark) and *A. floribunda* (Rough-barked Apple) (est. residual 25% of canopy). These estimates assume a conservative 10% canopy composition of *E. pilularis* in this vegetation community.

Estimates of the staged loss of habitat during this time are quantified in **Table 3.2**, and discussed further in **Section 3**.

Table 2.1: Development staging

Development Stage	Projected earliest commencement	Time elapsed since Currowan fire (approx.)	Area of Stage (ha)[3]		
			Full	Partial (APZ)[1]	Total (cum.) incl APZ
Stage 1	Mar 2024	51 months	3.40 (+1.02inf[2])	2.50	6.92
Stage 2	Aug 2024	3 years and 6 months	2.64	0.44	9.08
Stage 3	Feb 2025	6 years	2.24	0.42	10.91
Stage 4	Feb 2027	7 years	2.64	0.55	12.65
Stage 5	Feb 2028	8 years	2.47	0.65	15.06
Stage 6	Feb 2029	9 years	2.77	NA	17.18

[1] Partial (APZ) = clearing in accordance with an Asset Protection Zone under the Planning for Bushfire Protection (RFS 2019), i.e. majority canopy retained with reduced shrub/groundlayer;
[2] Stage 1 clearing includes infrastructure crossing over parts of Stage 4 & 5
[3] Subject to rounding errors

Figure 2.1: Staging impacts and temporary APZs

3 Grey-headed Flying Fox

In its preliminary documentation requirements (Attachment A), the Department concluded the following in relation to impacts on the Grey-headed Flying Fox:

> [T]*he proposed action will result in the removal of approximately 17.18 ha of habitat critical to the GHFF, as the proposed action area includes important winter and spring foraging habitat (Eucalyptus paniculata, Eucalyptus pilularis and Banksia integrifolia).*

The Department requested additional information on GHFF impacts and also commented on the Draft Preliminary Documentation Submission provided prior to the Species Workshop in December 2020 (Ecoplanning 2020b).

Based on the additional assessment and analysis requested by the Department, as well as information and analysis in the Matters of National Environmental Significance Assessment (Ecoplanning 2020a), it is considered that the habitat within the site is not critical to the survival of GHFF and the impacts to GHFF are not significant. The key points supporting this conclusion are:

- Blackbutt, which has been considered an important winter and spring diet plant by the Department, flowers in summer on the South Coast of NSW and is therefore not an important winter-spring diet plant for GHFF.
- When Blackbutt does flower, it is not a limited resource on the south coast as it is very common in the locality and has high nectar production during those months (Eby and Law 2008)
- Grey Ironbark and Coast Banksia occur on the site in low numbers, occupying an area of approximately 0.22 ha.
- Turpentine is found in the subcanopy stratum on the site beneath a canopy of Blackbutt, largely consisting of small trees (>75% of trees are <40 cm DBH) and is likely to provide low quality foraging habitat in this stratum.
- Mapping has been field-validated and confirms that the site is not an area classed as important winter-spring foraging habitat for the GHFF as per the habitat rankings of Eby and Law (2008).
- The Yatteyattah flying-fox camp is infrequently occupied in winter and spring and is not a permanently occupied camp (note the camp is no longer considered to be nationally important as it has not had more than 10,000 individuals present in the past 10 years (DAWE 2021 and DCCEEW 2023)
- Large numbers of GHFF occupy the South Coast of NSW in winter and spring only during years of mass flowering events; otherwise, the species is rare south of Nowra during these months (DoEE 2011). These seasonal movements are well documented historically, have not changed over the past 10 years, and have not changed post-bushfire.
- Mitigation measures are proposed which will delay the clearing of GHFF foraging habitat in Stages 1 through 4.

Table 3.1 below provides brief responses to each of the Department's requests for additional information on GHFF impacts and the Department's comments provided after the Species Workshop in December 2020. The remainder of this chapter provides information and analysis supporting the conclusion and key points above.

Table 3.1: Responses to Department requests for information and comments on GHFF

Information requested by the Department in its preliminary documentation requirements	Additional comments by the Department provided after the Species Workshop in December 2020	Response
Additional field verified mapping and analysis of winter and spring foraging habitat for the GHFF within the proposed action area and within 5km of the site.	*Please clarify whether the mapping of winter/spring foraging habitat in Figures 2.1 - 2.5 and the calculations in Table 2.2 of the current PD include Turpentine (Syncarpia glomulifera). If not, please update the mapping, calculations, and discussion of winter/spring GHFF foraging resources, in, and around the proposed action area to include this tree species.* *Please provide field verified mapping of the GHFF winter/spring foraging habitat in the proposed action area.*	Following the Species Workshop, based on the opinion of one of the participants, the Department considered that Turpentine is also important winter and spring foraging habitat in the region. Additional survey was undertaken on 12 and 13 February 2021 to accurately map the total area of winter and spring foraging habitat on the site, discussed below. The mapping and area calculations within 5 km of the site and within 20 km of the Yatteyattah GHFF camp were also updated to account for Turpentine as an important food tree and October-November as an important bi-month in the reproductive cycle of the GHFF. Refer to **Figure 3.9** for winter-spring foraging habitat mapped within 5 km of the site (Eby and Law 2008), including Turpentine. Refer to **Figure 3.1** for field verified winter and spring foraging habitat mapped in the proposed action area, including Turpentine. **Figure 3.2** to **Figure 3.7** and the calculations in **Table 3.2**, **3.4**, and **3.5** have been updated to include Turpentine, as well as Grey Ironbark and Coast Banksia. Blackbutt has been included in these calculations (refer also to **Section 3.4.1**). In total, 0.22 ha of winter-spring foraging habitat to the GHFF (food bottleneck) is found on site. Including Turpentine (late gestation/ birth/ early lactation period in GHFF reproductive cycle), 1.61 ha of GHFF foraging habitat considered important during winter-spring is found on site (i.e. Coastal Banksia, Turpentine and Grey Ironbark), of which 1.25 ha is found within the impact area of the proposed action. This equates to 0.43% of the habitat currently intact within 5

Information requested by the Department in its preliminary documentation requirements	Additional comments by the Department provided after the Species Workshop in December 2020	Response
		km of the site (i.e. Coastal Banksia, Turpentine and Grey Ironbark), and 0.006% of the habitat currently intact within 20 km of the Yatteyattah camp (refer **Table 3.4**). The total area of winter-spring foraging habitat within 5 km of the site, including Turpentine and including June-July, August-September, and October-November bi-months, is 2,822 ha, of which at least 292 ha of canopy (10%) was intact post-bushfire (Unburnt-Low-Medium burnt class, per GEEBAM). It is now 4 years since the fire, and full canopy recovery is highly likely in this time. The total area of winter and spring foraging habitat within 20 km of the Yatteyattah GHFF camp as per above, is 49,410 ha, of which at least 19,278 ha of canopy (39%) was intact. It is now 4 years since the fire, and full canopy recovery is highly likely in this time.
An updated assessment of impact on the GHFF resulting from the proposed action based on summary data and maps from the Department's rapid assessment of the extent of post-fire winter and spring foraging habitat for the GHFF.	*The department agrees that the assessment can be based on the mapping produced by the proponent using Eby and Law (2008), providing this mapping includes Turpentine (Syncarpia glomulifera). Please update the assessment to include Turpentine within the proposed action area.*	The assessment has been updated to include Turpentine as requested. Refer to **Figure 3.1** to **Figure 3.8**, **Figure 3.10**, **Figure 3.12** and **Table 3.4**, **Table 3.5**, and **Section 3.7**.

A review of rates of recovery of winter and spring flowering eucalypt species in the Shoalhaven LGA post fire and make predictions of recovery of these foraging resources at the following spatial scales: the Shoalhaven LGA, 20 km from the Yatteyattah nationally important flying-fox camp, and within 5 km of the proposed action area over the next 6, 12 and 24 months.	*The department considers that the species workshop highlighted that Turpentine (Syncarpia glomulifera), which is present in the proposed action area, is important habitat for the GHFF. Furthermore, there is a high degree of uncertainty in predicting the recovery rates of winter/spring foraging tree species.* *Please update your assessment to consider the uncertainty of post-fire recovery of GHFF winter/spring foraging habitat and how this will impact the GHFF.*	The assessment has been updated to further address habitat recovery, including Turpentine. Refer to **Section 0**. Recovery rates have been projected for the spatial scales of 5 km from the site and 20 km from the Yatteyattah camp. Recovery rates within the Shoalhaven LGA are not considered relevant to this assessment. The administrative boundaries of the LGA do not align with bioregions or other biologically significant spatial scales relevant to the GHFF. Regional significance of foraging habitat for GHFF is discussed in **Section 3.6**. The rates of recovery are discussed in terms of one year post-fire (January 2021), three years post-fire (January 2023), and five years post-fire (January 2025), and not over the 6 month (February 2021), 12 month (August 2021), and 24 month (August 2022) time frames suggested by the Department. Impacts have not occurred as of February 2021 and the proponent proposes not to impact vegetation prior to August 2022. Observations reported by Law et al (2000) have been used to project recovery time frames, and these observations relate to one year, three year, and five year time frames. The 24 month timing requested by the Department falls within 4 months of the 3 year recovery projections provided in **Section 0**. The difference in the projected 1 year recovery and the projected 3 year recovery used in this assessment relates to a precautionary estimate accounting for tree species which flower on multi-year cycles and not to differences in the condition of the tree, so it is considered that the 3 year post-bushfire projection is equivalent to the 24 month projection (32 months post-bushfire) requested by the Department. While Law et al (2000) observed flowering within one year in areas of low intensity fire and within three years in areas of canopy scorch, this assessment has extended the projection by two years beyond these

Information requested by the Department in its preliminary documentation requirements	Additional comments by the Department provided after the Species Workshop in December 2020	Response
		observations to account for tree species which may flower with less than yearly frequency. This represents a conservative estimate - erring towards an assumption that flowering could occur later than what was observed by Law et al (2000).
Additional evidence of measures taken to avoid impact to the GHFF and its habitat in the design of the proposed action including minimisation of vegetation clearance and consideration of alternative layout configurations.	*Based on the additional field verified mapping of winter/spring GHFF habitat onsite and the information from the species workshop, please outline any new proposed avoidance measures (e.g. adjusting layout/staging). If there are no alternative layout configurations or avoidance and mitigation measures, in accordance with departmental policies, offset measures must be considered.*	The proposed action will avoid and permanently retain approximately 3.45 ha of potential summer-autumn foraging habitat (NCSSFF), as well as 0.36 ha of potential spring foraging habitat for GHFF within the reserve. The existing approvals require avoidance of this native vegetation. The staging of the development is to be linked to timing of recovery of foraging habitat post-bushfire, such that the majority of important GHFF habitat will be cleared at least 5 years post-bushfire. Refer to **Section 3.3.2**, **Section 3.5.3**, and **Section 6.1** for further detail.
Detailed proposals to reduce the scale and intensity of the impacts of the proposed action on the GHFF including: • *on site measures to mitigate impacts to the species and its habitat during construction and operation of the development (e.g. as components of a Construction Environment Management Plan/ Vegetation Management Plans or similar) and staging*	*Based on the additional field verified mapping of winter/spring GHFF habitat onsite and the information from the species workshop, please outline any new proposed avoidance measures (e.g. adjusting layout/staging). If there are no alternative layout configurations or avoidance and mitigation measures, in accordance with departmental policies, offset measures must be considered.*	Impacts to an additional 0.21 ha of winter and spring GHFF habitat (i.e. Coastal Banksia, Turpentine and Grey Ironbark), will be delayed in the early stages of the project via updated site CC plans, including alternative layout configurations of stockpiles, APZ clearing management, and placement of temporary infrastructure. This is a 60% reduction of impact during Stage 1, delaying clearing of this habitat to at least 5 years post-fire (refer **Table 3.2** and **Figure 6.1**). The Flora and Fauna Management Plan (Ecoplanning 2021a) and Environmental Management Plan (Ecoplanning 2021b) have been updated to detail actions required to protect both permanently and temporarily retained GHFF habitat during development (refer **Section 6.1**).

Information requested by the Department in its preliminary documentation requirements	Additional comments by the Department provided after the Species Workshop in December 2020	Response
of commencement of construction and associated vegetation clearance to coincide with recovery of winter and spring flowering eucalypt species in the Shoalhaven LGA. • *offsite measures to facilitate recovery of GHFF and its habitat in the immediate vicinity of the proposed action area.*		GHFF foraging habitat has been incorporated into updated landscape plans and incentive schemes for the development, such that the available winter-spring GHFF foraging habitat on the site is projected to be greater than that currently present after the development is complete and after plantings mature (refer **Section 6.2**). The staging of development will allow plantings of GHFF foraging habitat in the earlier stages time to grow to flowering size by the time the majority of existing GHFF foraging habitat is cleared in the later stages (see **Plates 6**, **8**, and **9**). The staging of the development is proposed to be linked to recovery of GHFF foraging habitat in the surrounding region, with timing as shown in **Table 3.2**, such that 11% of the winter-spring foraging habitat on site (0.18 ha) would be cleared in the first 5 years post-bushfire, with the remaining 66% (1.06 ha) to be cleared no earlier than 5 years post-bushfire and 23% (0.36) of the habitat on the site permanently retained.

Information requested by the Department in its preliminary documentation requirements	Additional comments by the Department provided after the Species Workshop in December 2020	Response
Provide a proposal to offset residual significant impacts to the GHFF through a land-based offset in accordance with the Department's EPBC Act Environmental Offsets Policy or through an endorsed offsetting policy (see detailed description of endorsed offset policies below).	*Please undertake an updated assessment of significant residual impact based on the revised field verified mapping of winter/spring GHFF habitat onsite to determine required offsets, including consideration of impacts to the Turpentine (Syncarpia glomulifera).* *The significant residual impact assessment must provide a clear and definitive conclusion, with justification, of residual significant impacts on GHFF habitat to align with the EPBC Act Environmental Offsets Policy (2012).*	Based on the updated assessment and avoidance and mitigation measures, no residual significant impacts are anticipated (refer **Sections 3.7**, **3.8** and **Section 6**). Offsets are not proposed given the minimal scale of impact in the post-fire environment (1,604 m²), now 4 years ago, the prolonged period over which further impacts will occur, allowing for recovery of the surrounding bushland (refer **Section 2.2**, **Section 0**, and **Section 3.5.3**), the poor quality of the foraging resources available on the site (refer **Section 3.3.2** and **Section 3.7**), and the intermittent use of the Yatteyattah GHFF camp. The total impact area of 1.25 ha of winter-spring foraging habitat, much of this area small subcanopy trees, and 5.93 ha of summer-autumn foraging habitat over 9 years, is not considered significant in consideration of the species' range-wide habitat availability – between 2 million and 6 million hectares, with 17% overlap with the 2019-2020 bushfires (refer **Table 3.3**) – and the current estimated population size of between 300,000 and 900,000 individuals. The potential that a significant impact (a mass die-off event at a scale that could affect the species as a whole, or at any scale) could occur, either because of or exacerbated by, the loss of 1.25+5.93 ha of foraging habitat, much of this small subcanopy trees which would provide relatively little nectar, is extremely low.

3.1 Additional GHFF habitat survey

Following the Species Workshop in December 2020, Ecoplanning undertook additional survey for GHFF important winter and spring food trees, in particular, Turpentine (*Syncarpia glomulifera*), Grey Ironbark (*Eucalyptus paniculata*), and Coast Banksia (*Banksia integrifolia*) (refer **Section 3.3.1** and **3.3.2**). Blackbutt (*Eucalyptus pilularis*) was not surveyed as it is not a winter or spring flowering species on the South Coast of NSW (refer **Section 3.4.1**) but has been estimated based on percentage of canopy for summer-autumn food trees.

Survey methods are detailed in **Appendix C**.

3.1.1 Results

Grey-headed Flying-fox combined Winter-Spring foraging habitat (i.e. Coastal Banksia, Turpentine and Grey Ironbark), occupies an area of approximately 1.61 ha on the site, and 8.19 ha of Summer-Autumn foraging habitat (Blackbutt, Red Bloodwood). **Table 3.2** provides a breakdown of foraging habitat area by tree species, (see **Table 3.3** for context). **Figure 3.1** displays GHFF foraging habitat area on the site.

Note that 0.79 ha of GHFF winter-spring food trees were recorded in the west of the site (Stage 6 and Stage 5 west of the Reserve) and 0.22 ha of GHFF winter-spring food trees were recorded in the western half of the Reserve using methods detailed in **Appendix C.1**, and each tree within this area has not been individually marked and displayed in **Figure 3.1**. The numbers shown within these areas in **Figure 3.1** indicate the total subcanopy cover of Turpentine tree recorded in these areas using the methods detailed in **Appendix C.1**.

Figure 3.2 to **Figure 3.7** shows the area of GHFF foraging habitat cleared during each of the six stages.

Table 3.2: GHFF important foraging habitat by month, by species, and area cleared

Develop-ment Stage	Projected commence ment (earliest)	Time elapsed since Currowan fire (approx.)	Cumulative area (ha)[1]			Not cumulative (ha)[1]				
			Winter-Spring	Summer-Autumn	Total	Coast Banksia	Grey Ironbark	Turpentine	NCSSFF	BMWOF
Stage 1	Jan 2024	4 years and 10 months	0.16	2.02	2.18	<0.01	0.05	0.11	1.93	0.01
Stage 2	Jul 2024	5 years and 6 months	0.18	2.50	2.68	<0.01	0	0.02	0.30	0.18
Stage 3	Jan 2026	6 years	0.18	2.71	2.89	0	0	0	0	0.21
Stage 4	Jan 2027	7 years	0.32	3.48	3.80	0	0.12	0.01	0.64	0.13
Stage 5	Jan 2028	8 years	0.86	4.69	5.54	0	0.04	0.50	1.20	0
Stage 6	Jan 2029	9 years	1.25	5.93	7.18	0	0	0.40	1.25	0
Retained in Reserve			0.36	2.26	2.63	0	0	0.36	2.26	0
Total			**1.61**	**8.19**	**9.81**	**<0.01**	**0.22**	**1.39**	**7.58**	**0.54**

Note: Assumes trees not within the direct impact footprint of can be avoided where they occur in temporary APZs.
Areas of Stage 1 clearing delayed as a mitigation measure of (0.21ha), have been included in the relevant stage (Stage 2 (+0.02 ha), Stage 4 (+0.13 ha), and Stage 5 (+0.06 ha)) as detailed in **Section 6.2**.
[1] Rounding errors apply

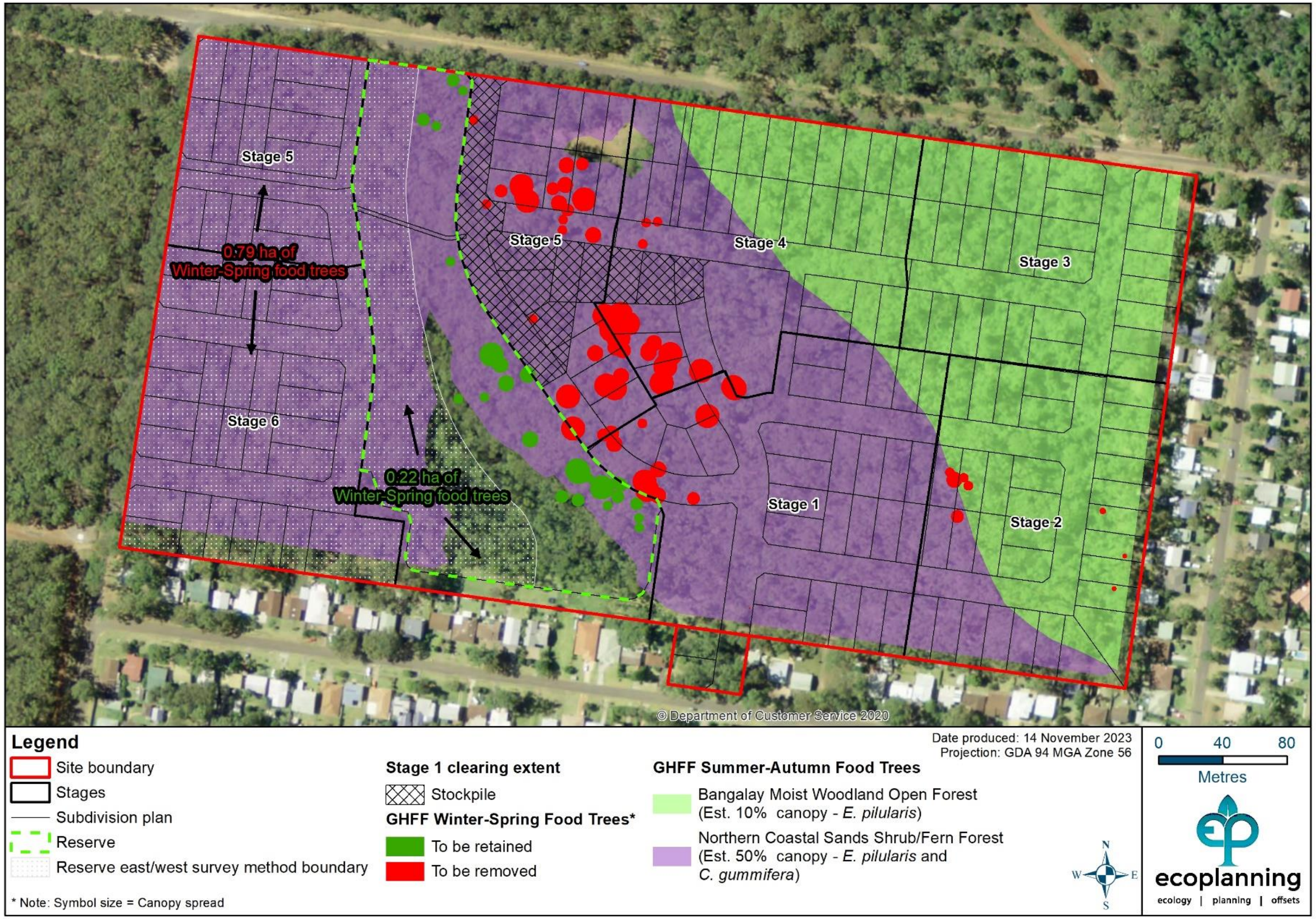


Figure 3.1: GHFF important foraging habitat on site

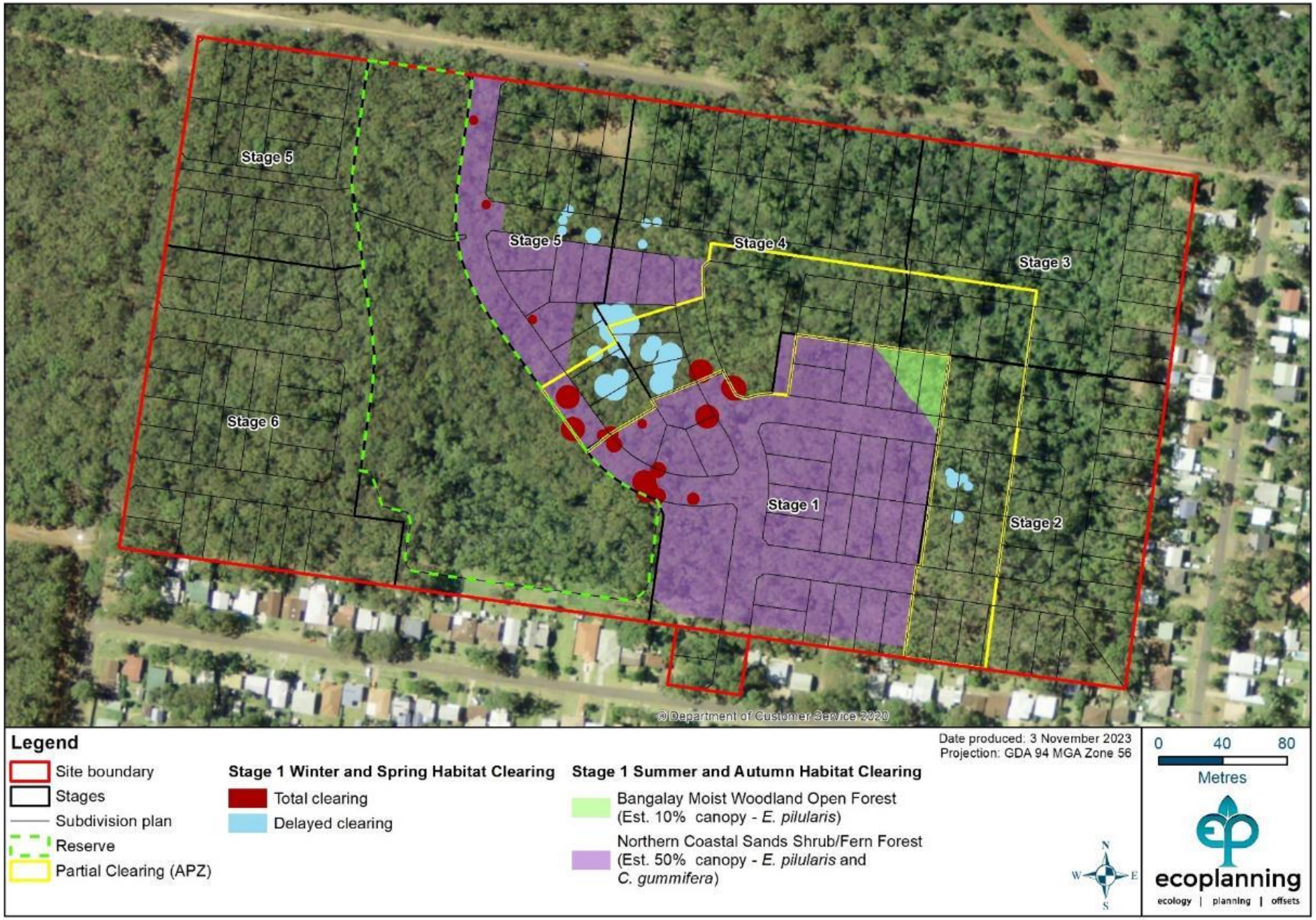


Figure 3.2: Stage 1 clearing showing winter and spring flowering habitat and delayed clearing

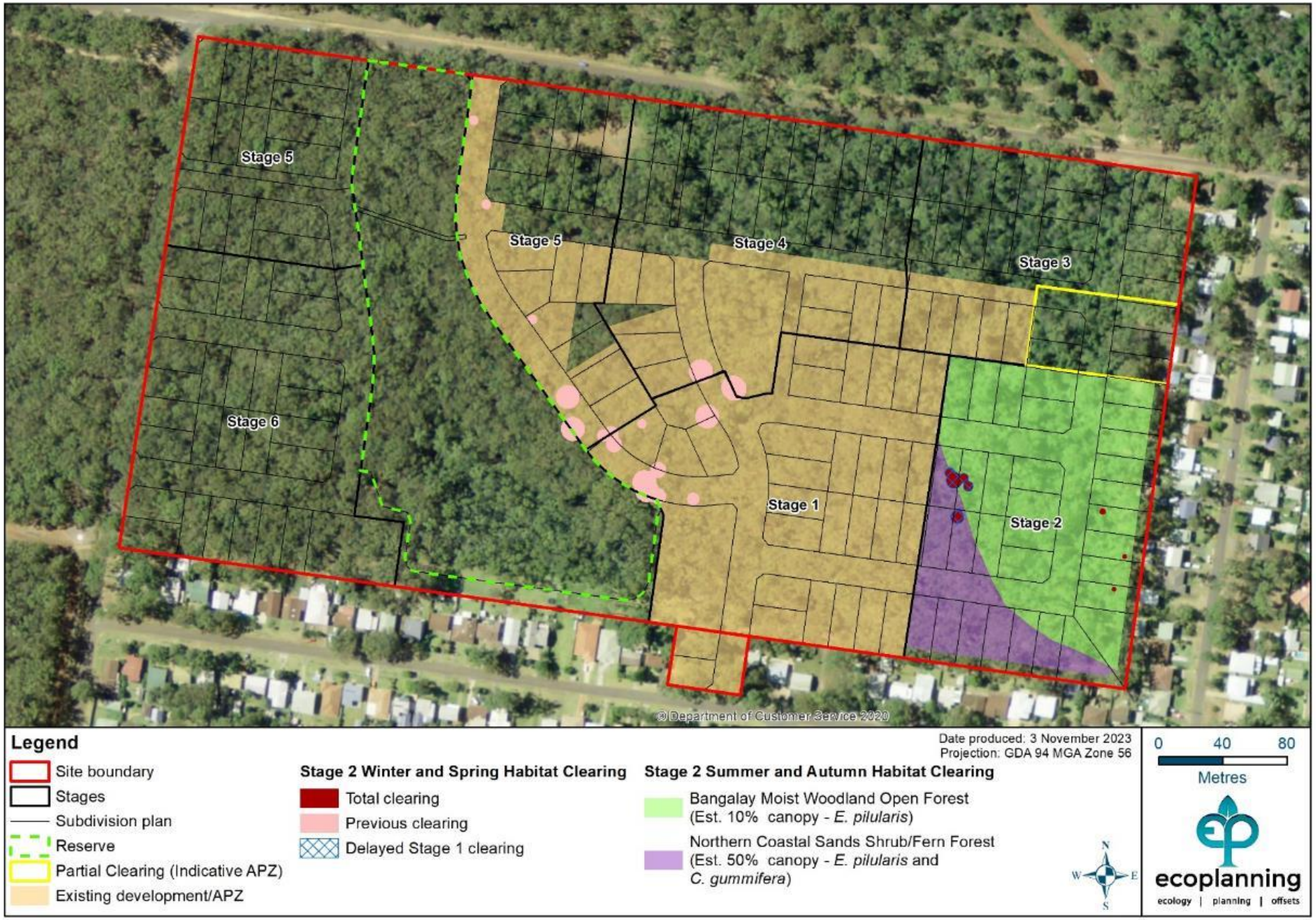


Figure 3.3: Stage 2 clearing showing winter and spring flowering habitat and previous clearing

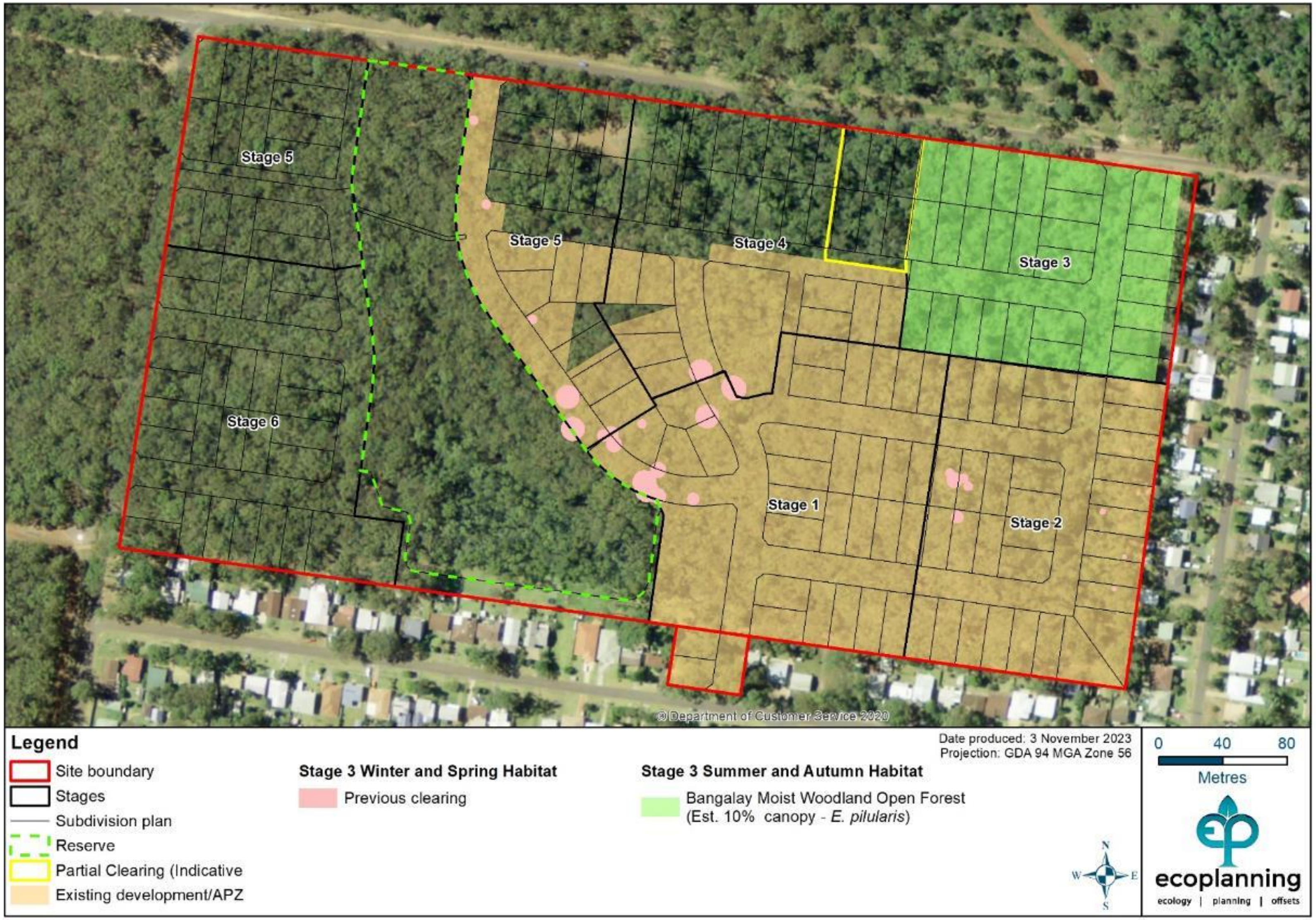


Figure 3.4: Stage 3 clearing showing winter and spring flowering habitat and previous clearing

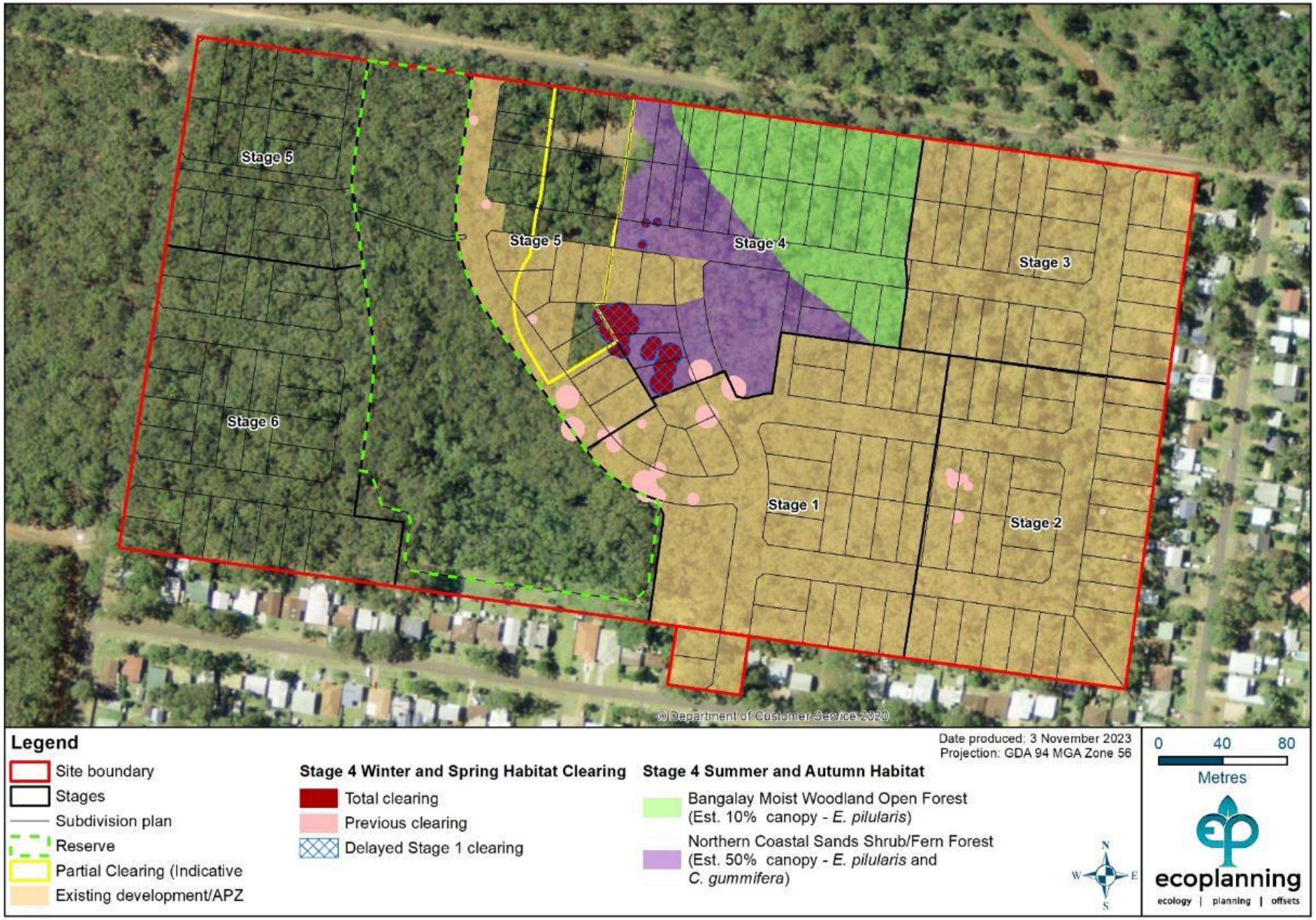


Figure 3.5: Stage 4 clearing showing winter and spring flowering habitat and previous clearing

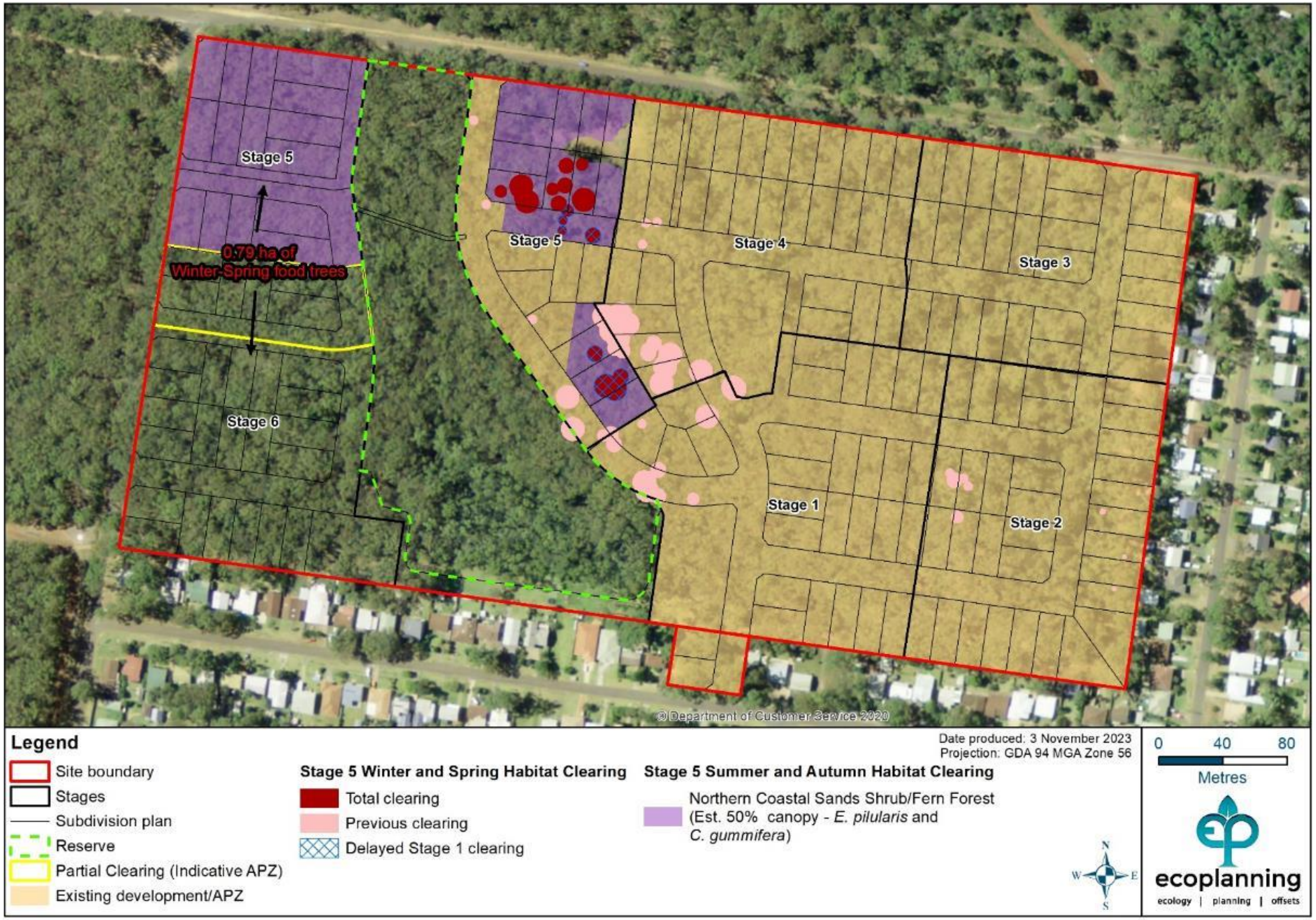


Figure 3.6: Stage 5 clearing showing winter and spring flowering habitat and previous clearing

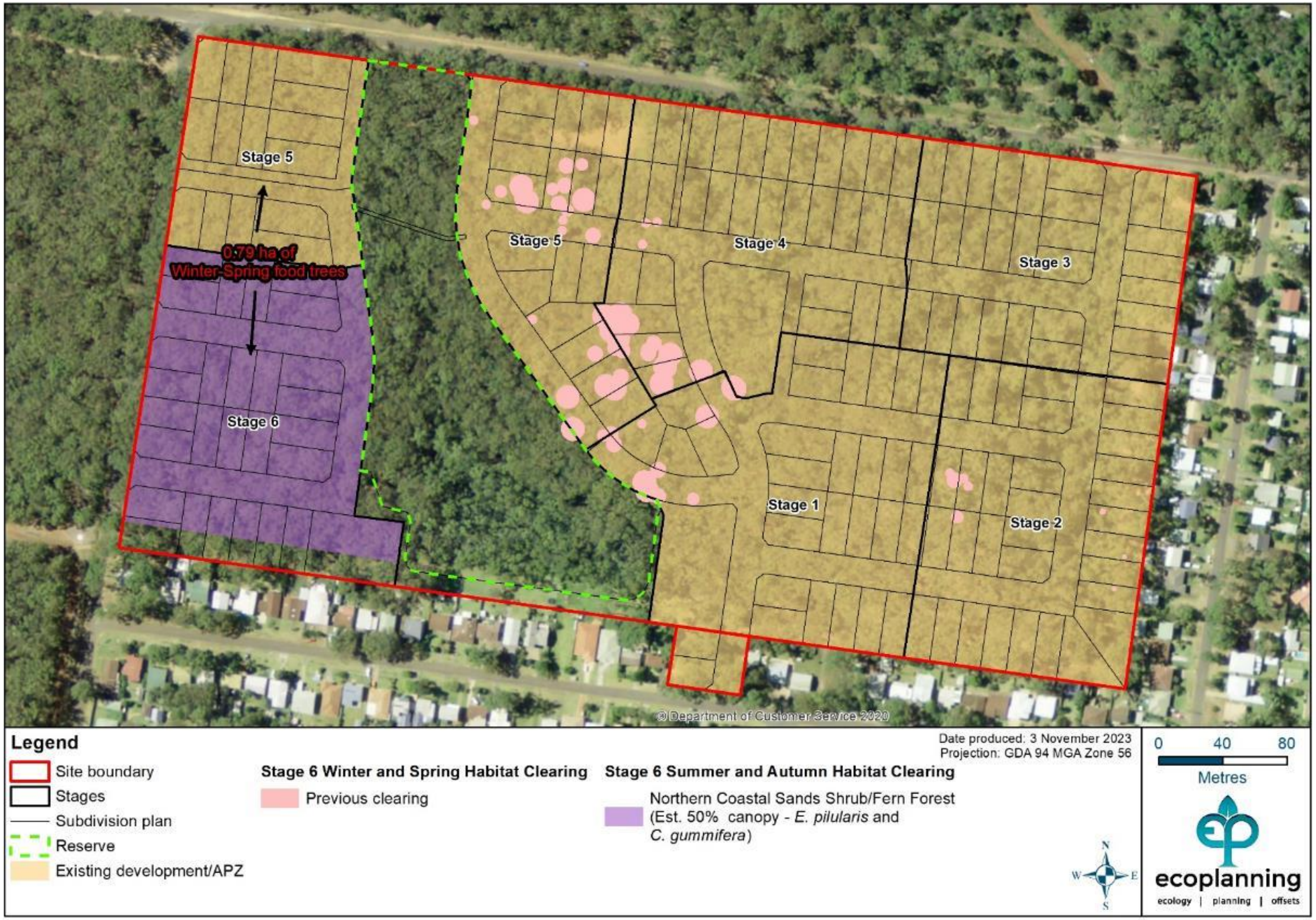


Figure 3.7: Stage 6 clearing showing winter and spring flowering habitat and previous clearing

3.2 Winter and spring foraging habitat

3.2.1 Determination

The Department made the Determination that the proposed action is likely to have a significant impact on the Grey-headed Flying-fox, due to a potential loss of 17.18 ha of winter-spring foraging habitat critical to the survival of the species. The Department used the *Draft Recovery Plan for the Grey-headed Flying-fox Pteropus poliocephalus* (**GHFF Draft Recovery Plan**) (DoEE 2017a) as a primary source for foraging habitat information, and in particular, diet plants which flower during winter and spring months. A range-wide reduction in available foraging habitat occurs in the winter to early spring (winter-spring) period due to a reduction in the number of diet plants in flower, creating a food bottleneck which is known to cause dietary stress potentially leading to mass die-offs when combined with heat stress events in summer.

Species Workshop

During the species workshop, an additional concern was raised independent of the risk of mass die-off due to food shortages in the food bottleneck period. The Department considered on the basis of expert opinion that Turpentine is an important food tree on the South Coast because it flowers during the late gestation, birth, and early lactation period when female GHFF could rapidly lose condition due to food shortages. The additional impact assessed is the potential lack of reproductive success of female GHFF with young. The concerns raised in the Species Workshop held in December 2020 are reflected in the *National Recovery Plan for the Grey-headed Flying-fox 'Pteropus poliocephalus'* (**GHFF Recovery Plan**) (DAWE 2021a), which was adopted effective 19 March 2021.

3.2.2 Habitat critical to the survival of GHFF

The GHFF Draft Recovery Plan lists sixteen tree species as critical winter foraging habitat, where they form part of a vegetation community. These species are, *Eucalyptus tereticornis* (Forest Red Gum), *E. albens* (White Box), *E. crebra* (Narrow-leaved Ironbark), *E. fibrosa* (Broad-leaved Ironbark), *E. melliodora* (Yellow Box), *E. paniculata* (Grey Ironbark), *E. pilularis* (Blackbutt), *E. robusta* (Swamp Mahogany), *E. siderophloia* (Grey Ironbark), *Banksia integrifolia* (Coast Banksia), *Castanospermum australe* (Black Bean), *Corymbia citriodora* (Lemon-scented Gum), *C. eximia* (Yellow Bloodwood), *C. maculata* (Spotted Gum) (south of Nowra, New South Wales), *Grevillea robusta* (Silky Oak) and *Melaleuca quinquenervia* (Broad-leaved Paperbark). Three of these species occur on site (refer to **Table 3.3**) – Blackbutt, Grey Ironbark and Coast Banksia. On the basis of these species' occurrence on site, the Minister made a determination that 17.18 ha of habitat critical to the survival of GHFF will be cleared on site. The Department has produced mapping of the site and surrounding region, showing any vegetation community containing any of the sixteen species listed above as habitat critical to the survival of the GHFF.

The GHFF Recovery Plan adopted 19 March 2021 adds *Eucalyptus seeana* (Narrow-leaved Red Gum), *Eucalyptus sideroxylon* (Mugga Ironbark), and *Syncarpia glomulifera* (Turpentine) to the list of species considered to be a component of critical habitat. One of these species, Turpentine, occurs in the subcanopy of the site. Following the species workshop, the Department considered Turpentine to be an important food tree in the region.

The Department considered that the habitat found on site is of greater importance due to its proximity to the flying fox camp found at the Yatteyattah Nature Reserve located approximately 8 km west of the site, which was formerly recognised as a nationally important camp. This camp is no longer considered a nationally important camp, as it has not had >10,000 individuals present for more than a 10 year period; see DAWE 2021). GHFF predominantly forage within 20 km of camps, and foraging habitat found in closer proximity to camps is likely to be more frequently utilised. The frequency of use of the available foraging resources is therefore an important component of the Department's assessment of impact.

Refer to **Appendix D** for clarification of the definition of habitat critical to the survival of GHFF as it relates to this assessment.

3.2.3 Phenology of diet species

The Department's assessment did not account for regional variation in phenology (i.e. variation in regional timing) of GHFF diet plants when assessing Blackbutt as important habitat on the site. Eby and Law (2008) compiled phenological data from a broad range of peer reviewed literature and canvassing the knowledge and observations of experts and local apiarists. A summary of the relevant phenological data for tree species considered by the Department to be critical winter foraging habitat is provided in **Table 3.3**. The timing of biological considerations presented in Table 10.2 of Eby and Law (2008) is provided in **Table 3.3** for comparison (see **Appendix E**). The geographic scale and relative productivity of vegetation communities containing productive foraging habitat is also reproduced in **Table** 3.3 from Tables 7.4, 8.4, 9.4, 10.4, and 11.4 of Eby and Law (2008). For further context, **Appendix E** reproduces Table 10.2 and 8.2 of Eby and Law (2008), which display the bi-monthly flowering schedules of GHFF diet plants found in the South East NSW Region, where Manyana is located.

Table 3.3: Important diet species listed in the GHFF Recovery Plan (DAWE (2021) and Eby and Law (2008))

Species	Occurs on site	Occurs in vegetation communities within 5km of the site	Flowers in winter-spring months	Flowers in summer-autumn on South Coast	Flowering bi-months on South Coast					
					Summer-Autumn			Winter-Spring		
					Dec/Jan	Feb/Mar	Apr/May	Jun/ Jul	Aug/Sep	Oct/Nov
Eucalyptus albens	No	No (inland NSW)	N/A	N/A						
Eucalyptus crebra	No	No (north of Illawarra)	N/A	N/A						
Eucalyptus fibrosa	No	No	No	Yes	X	X				
Eucalyptus melliodora	No	No (western slopes/ inland NSW)	N/A	N/A						
Eucalyptus pilularis	Yes	Yes	No	Yes	X	X				
Eucalyptus robusta	No	Yes	Yes	Yes			X	X	X	
Eucalyptus siderophloia	No	No (north of Illawarra)	N/A	N/A						
Eucalyptus tereticornis	No	Yes	Yes	No					X	X
Castanospermum australe	No	No (NE NSW)	N/A	N/A						
Corymbia citriodora	No	No (Qld only) Landscape plantings	N/A	N/A						
C. eximia	No	No (North of Nowra)	N/A	N/A						
C. gummifera	Yes	Yes	No	Yes		X	C			
C. maculata (south of Nowra)	No	Yes	Yes	Yes		A	X	B		
Grevillea robusta	No	No (NE NSW) Landscape plantings	N/A	N/A						

Species	Occurs on site	Occurs in vegetation communities within 5km of the site	Flowers in winter-spring months	Flowers in summer-autumn on South Coast	Flowering bi-months on South Coast					
					Summer-Autumn			Winter-Spring		
					Dec/Jan	Feb/Mar	Apr/May	Jun/ Jul	Aug/Sep	Oct/Nov
Melaleuca quinquenervia	No	No (North of Jervis Bay)	N/A	N/A						
Banksia integrifolia	Yes	Yes	Yes	Yes			X	X	X	
Eucalyptus paniculata	Yes	Yes	Yes	Yes	B	B	A	A	X	B
Species not listed in Draft GHFF Recovery Plan (DoEE 2017) but added to the GHFF Recovery Plan (DAWE 2021a) adopted 19th March 2021										
Syncarpia glomulifera	Yes	Yes	Yes	No						X
Features of habitat productive for GHFF in SE NSW pre-fire – range wide fire overlap estimated at 17% (Eby and Law 2008)										
Productive area (range-wide all regions combined) (ha)					6,637,529	6,216,280	1,891,656	2,216,622	3,525,711	5,746,606
Productive area SE NSW (ha)					1,064,891	1,301,561	298,059	179,221	123,388	510,553
% regional land area productive in SE NSW					26.2	32.0	7.3	4.4	3.0	12.5
Area-weighted index SE NSW -for comparing overall habitat quality through time					0.07	0.10*	0.02	0.01	0.01	0.03
Timing of biological considerations for GHFF										
Food shortages								X	X	
Pregnancy (final trimester) & birth								X	X	X
Lactation					X	X				X
Mating and conception					X	X	X			
Migration paths					X	X	X	X	X	X
Fruit industries					X	X			X	X

X = uniform; A = north from the Illawarra; B = from the Illawarra to Bega; C = south from Bega; **BLUE** rows indicate presence on Site

* SE NSW scores highest out of all regions during this bi-month.

3.2.4 Winter and spring foraging habitat extent

The Department carried out mapping of winter and spring flowering vegetation communities on the basis that all of the species listed in **Table 3.3** flower in the winter-spring months (food bottleneck classed as bi-months June-July and August-September) in the South East NSW Region (DoEE 2017). This assumption regarding range-wide phenology of diet plant species does not reflect the findings of Eby and Law (2008). The Department's mapping produced estimates that 5,622 ha of Winter-Spring foraging habitat occurs within 5 km of the site, including the site itself, and 51,192 ha of winter-spring foraging habitat occurs within 20 km of the Yatteyattah GHFF camp.

Eby and Law (2008) produced mapping which provides more spatial detail and more detail regarding the relative habitat quality (in terms of nectar production and reliability) accounting for regional variations in phenology of diet plant species. This mapping is commensurate with the mapping in Figure 5d and Figure 5e of Eby, Sims, and Bracks (2019). Refer to **Appendix F** for discussion of the accuracy of this mapping in the region surrounding Manyana.

Figure 3.8 shows the extent of winter-spring habitat within 5 km of the site and **Figure 3.9** shows this habitat within 20 km of the Yatteyattah flying-fox camp. The mapping and rankings use the most recent dataset (DPIE 2019).

For the purposes of this assessment, **Figure 3.9** has combined mapping for the bi-months June-July (J-J), August-September (A-S), and October-November (O-N) to produce a map of areas considered to be important foraging habitat, including both the food bottleneck period and late gestation/ birth/ early lactation. The rank assigned to each vegetation community in this combined map is the highest rank assigned out of any of the three bi-months.

The extent of the 2019-2020 bushfires in relation to winter-spring foraging habitat is shown in **Figure 3.10**. **Table 3.4** displays the area of winter-spring habitat (Eby and Law 2008), and the area in relation to fire severity (GEEBAM burnt area class), within 20 km of the Yatteyattah camp and within 5 km of the site.

Table 3.4: GHFF foraging habitat

<table>
<tr><th rowspan="2">Spatial scale</th><th rowspan="2">Area of productive[1] foraging habitat (ha)</th><th colspan="6">Area of productive[1] foraging habitat burnt (ha)</th></tr>
<tr><th>Unburnt</th><th>Low</th><th>Medium</th><th>High</th><th>Very High</th><th>Unknown[2]</th></tr>
<tr><td>Site (total)
(winter-spring)</td><td>1.61</td><td>1.61</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Site (total)
(summer-autumn)</td><td>8.19</td><td>8.19</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Site (impact area)
(winter-spring)</td><td rowspan="2">1.25</td><td>1.25</td><td>0</td><td>0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td colspan="3">Equates to 0.43% of intact habitat within 5 km;
0.006% of intact habitat within 20 km</td></tr>
<tr><td rowspan="2">Site (impact area)
(summer-autumn)</td><td rowspan="2">5.93</td><td>5.93</td><td>0</td><td>0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td colspan="3">Equates to 0.72% of intact habitat within 5 km;
0.025% of intact habitat within 20 km</td></tr>
<tr><td>Immediate vicinity of site (cumulative impacts of potential future developments) (winter-spring)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Immediate vicinity of site (cumulative impacts of potential future developments) (summer-autumn)</td><td>92</td><td>31</td><td>13</td><td>11</td><td>6</td><td>30</td><td>1</td></tr>
<tr><td rowspan="2">5km from the site
(winter-spring)
Refer to Figure 3.8.</td><td rowspan="2">2,822</td><td>74</td><td>72</td><td>146</td><td>631</td><td>1,857</td><td rowspan="2">42</td></tr>
<tr><td colspan="3">10% canopy intact</td><td colspan="2">88% canopy burnt</td></tr>
</table>

Spatial scale	Area of productive[1] foraging habitat (ha)	Area of productive[1] foraging habitat burnt (ha)					
		Unburnt	Low	Medium	High	Very High	Unknown[2]
5km from the site (summer-autumn) Refer to **Figure 3.11**.	3,703	273	245	304	774	2,047	61
		22% canopy intact			76% canopy burnt		
20km from the Yatteyattah flying-fox camp (winter-spring) Refer to **Figure 3.9**.	49,410	5,222	7,576	6,480	9,740	19,687	703
		39% canopy intact			60% canopy burnt		
20km from the Yatteyattah flying-fox camp (summer-autumn) Refer to **Figure 3.12**.	77,173	6,623	8,951	8,571	13,588	36,618	821
		31% canopy intact			68% canopy burnt		

[1]Ranked 1, 2, 3, or 4 per Eby and Law (2008)

[2]Classed as GHFF foraging habitat (Eby and Law 2008) but as ‘Not native vegetation’ or ‘No data’ in GEEBAM

Figure 3.8: Winter-spring foraging habitat within 5km

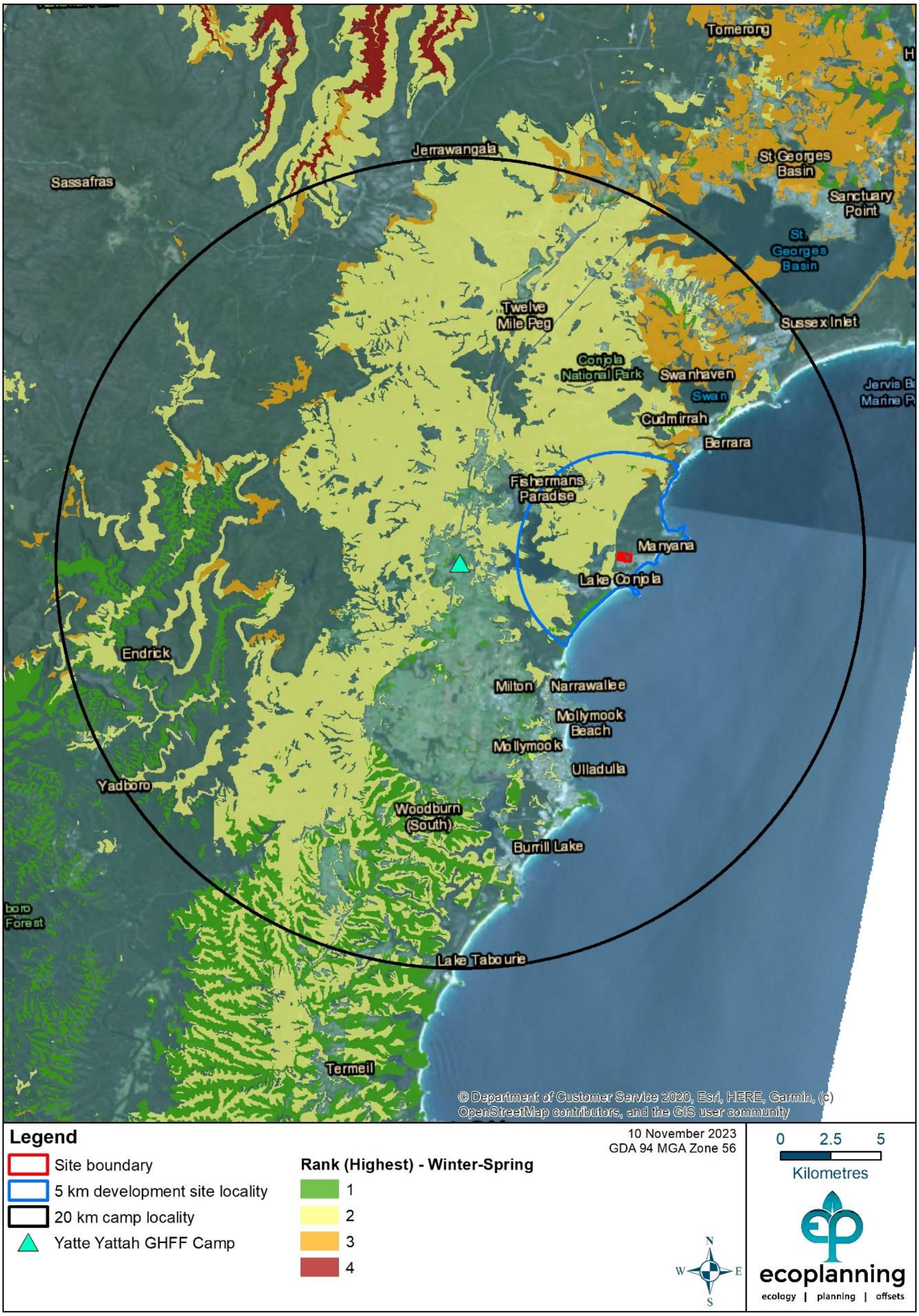


Figure 3.9: Winter-spring foraging habitat within 20km of Yatteyattah camp

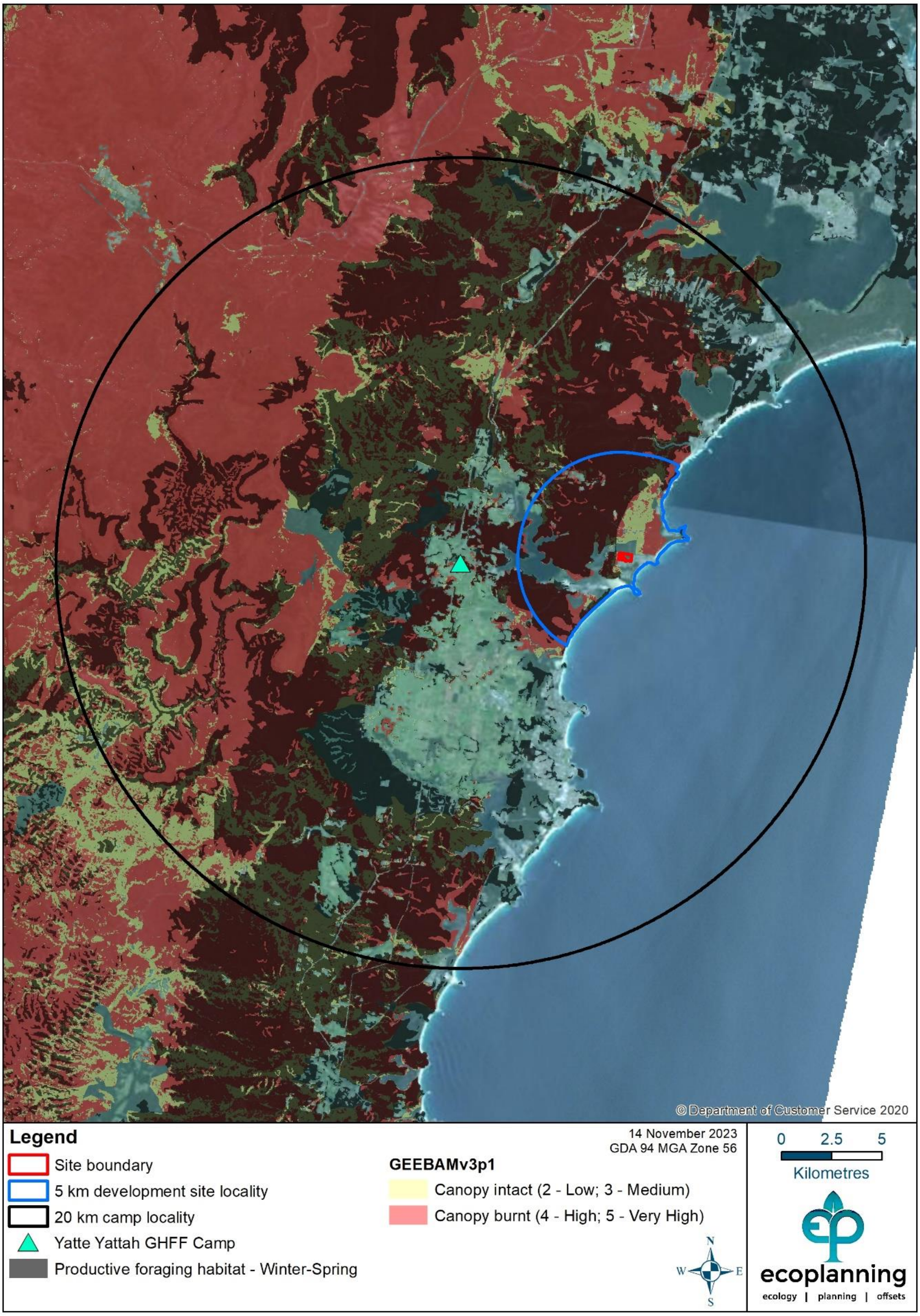


Figure 3.10: Winter-spring foraging habitat over burnt area

Figure 3.11: Summer-autumn foraging habitat within 5km

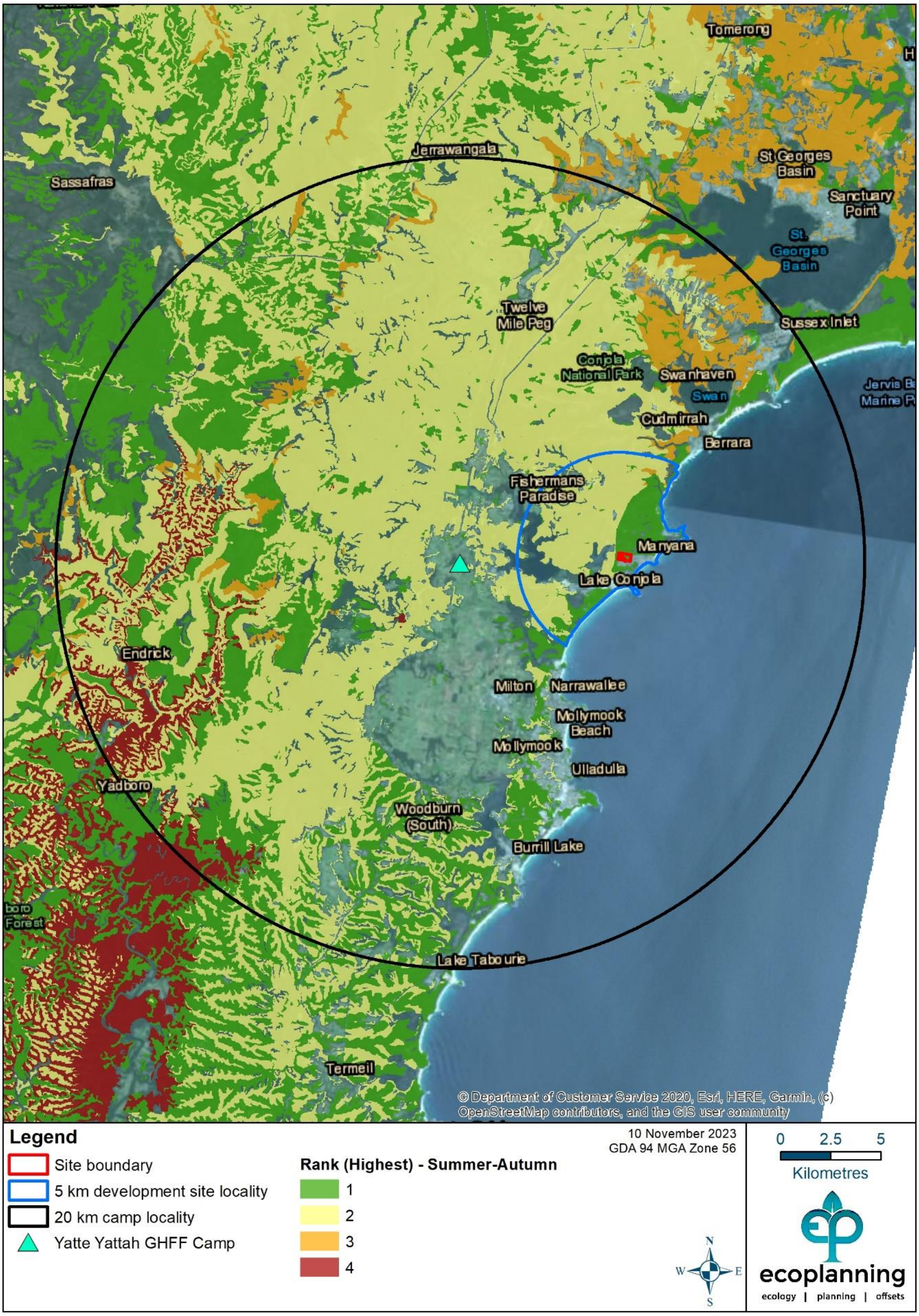


Figure 3.12: Summer-autumn foraging habitat within 20km of Yatteyattah camp

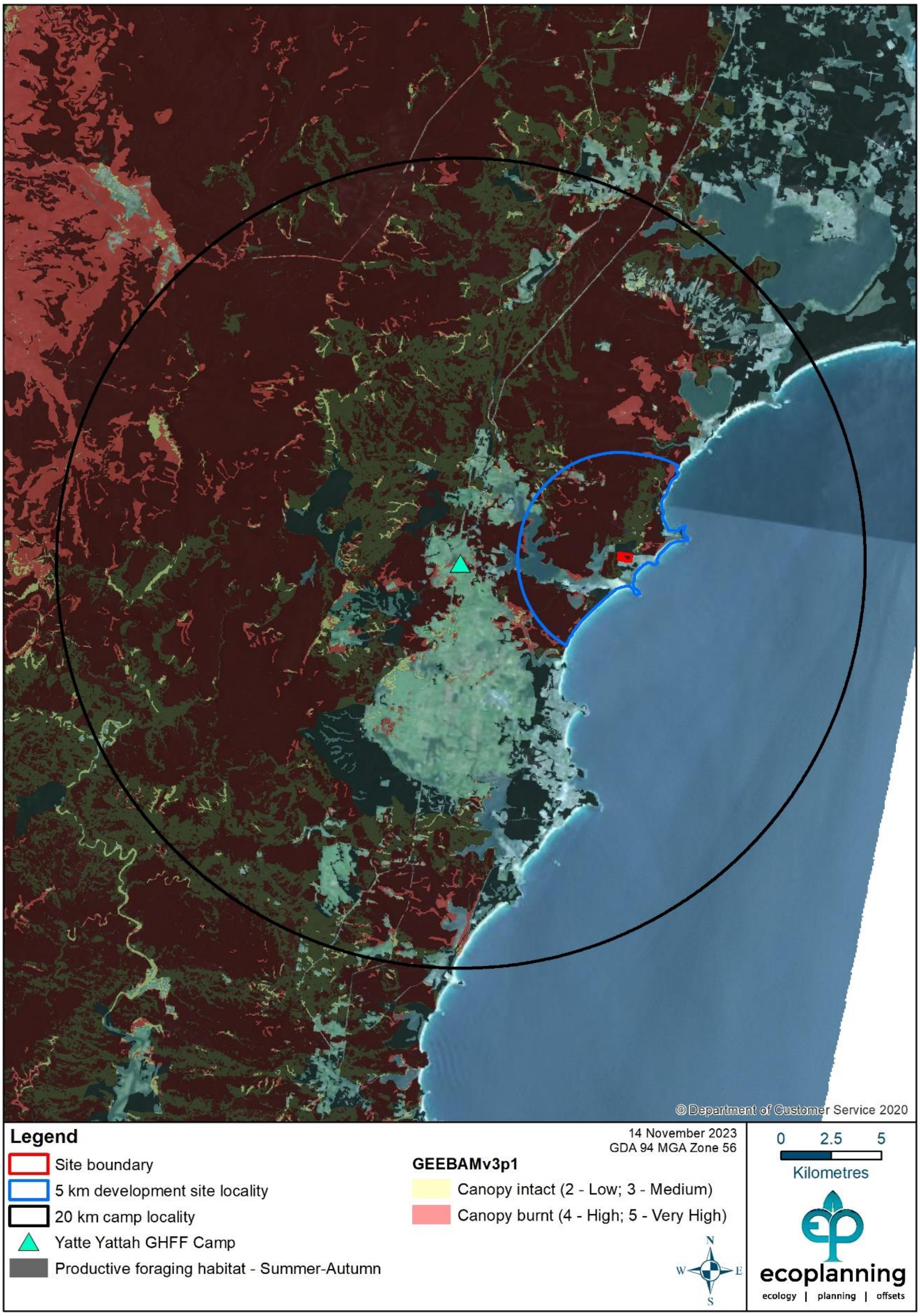


Figure 3.13: Summer-autumn foraging habitat over area burnt

3.3 Winter and spring foraging habitat on site

The Department considered that the site contains habitat critical to the survival due to winter-spring foraging habitat of the GHFF due to the presence of Blackbutt, Grey Ironbark, and Coast Banksia on site. Of these, Blackbutt does not flower in winter on site (refer to **Table 3.3**), and Grey Ironbark and Coast Banksia occur in low numbers on the site.

The Department further considered, following the species workshop, that Turpentine is an important food tree on the site, as its flowering coincides with the late gestation/ birth/ early lactation period in the reproductive cycle of the GHFF.

3.3.1 Grey Ironbark and Coast Banksia

The two species which flower in winter-spring on the South Coast are found in low numbers on the site. Ecoplanning's targeted parallel transect surveys (**Section 3.1**, **Appendix C**) confirmed that Coast Banksia has a very widely scattered occurrence in the south east of the site, while Grey Ironbark occurs as a single patch in the centre of the site. Grey Ironbark is a canopy element on site, however, the height of the dominant Blackbutt canopy exceeds the height of all Grey Ironbark individuals found on site (see **Plate 1**). The total area of both Grey Ironbark and Coast Banksia on site is approximately 0.22 ha.

Regional vegetation mapping

Winter-spring foraging habitat mapped within 5 km of the site relates to vegetation communities containing Swamp Mahogany and Coast Banksia, including swamp forests, coastal heathlands, and littoral thickets which are not similar to the vegetation communities found on site. A small area within 5 km of the site to the north also contains lowland forests with mapped Spotted Gum. The largest areas of high ranking winter-spring foraging habitat found to the south of the site (**Figure 3.8**) primarily relate to coastal Banksia heathlands and forests containing Coast Banksia, including PCT 772 Coast Banksia – Coast Wattle dune scrub and PCT 659 Bangalay – Old-man Banksia open forest. The vegetation found on site is not commensurate with, or similar to, these vegetation types and nowhere on site do Banksia species form a dominant or even frequent component of the vegetation community.

The biometric vegetation mapping of the site and adjacent areas records the site itself as BioMetric vegetation type **SR516**, which is equivalent to **PCT 694**, which is broadly accurate but has not been verified by formal BAM survey plots to assign the site vegetation to PCT. Note that the BioMetric vegetation type mapping does not correspond exactly to the South Coast – Illawarra Vegetation Integration (**SCIVI**) (Tozer et al 2006) mapping in the locality – boundaries between vegetation communities/ vegetation types are slightly different between these map layers. The SCIVI map unit for the site is **DSF p64**.

If the methodology of Eby and Law (2008) were applied to the site, the site would be ranked '0' (unranked) in the winter-spring bi-months. The area of winter-spring foraging habitat on site, if calculated using their methods, is 0 ha. Refer to **Appendix G** for discussion of mapping limitations and accuracy.

Conclusion

Due to the very small number of winter-spring flowering (food bottleneck period) diet plants found on site, and therefore the very small number of individual GHFF which could possibly be sustained by the nectar production of these plants during the years when they are in flower, the clearing of these plants on site would be unlikely to significantly contribute to food bottlenecks in the winter-spring months.

Moreover, regionally, these plants are a minor component of the landscape-wide foraging habitat available and are highly unlikely to draw large numbers of GHFF to the region by themselves. Coast Banksia occurs in a very limited area in the South East NSW Region (Eby and Law 2008). Regionally, Grey Ironbark (0.22 ha on site) is mapped primarily in Batemans Bay Cycad Forest (SCIVI map unit p90) (55,661 ha) where it is co-dominant with Spotted Gum.

The Spotted Gum forests in the Batemans Bay area further to the south of the site are well documented to be important for GHFF when they occur in the South East NSW Region in winter months, and are the primary factor bringing GHFF into the region in winter (SAWE 2021). When Spotted Gum does flower en masse, the productivity is so great as to not be a limited resource in the landscape (Law and Chidel 2007). The nectar production of Spotted Gum, if flowering and therefore if attracting GHFF to the South Coast, would be unlikely to represent a limited foraging resource.

A reduction of 548 m² of winter-spring canopy area, composed of four Grey Ironbarks and four Coast Banksia cleared in the first 5 years after the bushfires, followed by a cumulative total 0.22 ha of winter-spring canopy area cleared no earlier than 5 years after bushfire, would represent a negligible impact to GHFF. The likelihood that clearing this vegetation on site could contribute to a food bottleneck post-bushfire which would lead to a mass die-off of GHFF is extremely small.

Plate 1: **Grey Ironbark (trunk in centre) tree to be cleared in Stage 1;**
Height approx. 2 m below Blackbutt canopy (illuminated foliage in picture is only Blackbutt foliage, and not from the Grey Ironbark);
Tree recorded as 15 m canopy spread and 0.018 ha impact area for analysis of GHFF impacts

3.3.2 Turpentine

Turpentine tree occurs on site as a component of the subcanopy to a height of 14 m, beneath the dominant canopy of Blackbutt, which reaches 25 m height (BES 2006). Turpentine subcanopy of flowering-size trees (>20 cm DBH) covers an area of 1.39 ha on site (refer **Section 3.1.1**). Within this area, >75% of trees are small-medium size (<40 cm DBH) and <25% are large (>40 cm DBH), when divided into the size classes used by Law and Chidel (2007) to describe nectar production. Refer to **Appendix C** for survey methods and photos of Turpentine tree.

Subcanopy trees growing with constrained canopies and reduced light produce less nectar than canopy trees (OEH 2016; Davis et al 2016; Birtchnell and Gibson 2006). Smaller trees produce less flower and nectar than mature trees (Law and Chidel 2007; Birtchnell and Gibson 2006). Grey-headed Flying-fox forage for nectar primarily in *canopy* vegetation (GHFF Recovery Plan; Eby and Law 2008). It is thus unclear how much foraging behaviour of GHFF might occur within the smaller (<40 cm DBH; <10 m height) subcanopy trees beneath the 25 m high forest canopy due to the movement obstacles associated with flying from one small subcanopy tree to another beneath the forest canopy, the increased vulnerability to predators such as Powerful Owl (*Ninox strenua*), and the poorer food resource produced (less flower produced in small trees; less nectar produced in shaded, constrained canopies). **Plate C5** shows a typical occurrence of Turpentine on the site. Turpentine tree is not expected to be a significant foraging resource on the site. Notwithstanding, GHFF can and frequently do forage in vegetation as low as about one metre in height in open positions, such as Banksia in low heathland, fruiting trees in lower strata of rainforests, or shrubby street plantings. The degree to which a food resource such as a small Turpentine tree beneath a forest canopy might be utilised has not been studied in detail. For the purposes of this assessment, a precautionary approach has been adopted and subcanopy Turpentine has been included in the analysis of GHFF habitat despite the factors described above.

Regionally, locations where Turpentine is generally referred to as a ‘key species’ or as a ‘winter and early spring’ food resource are Lower North East NSW and Upper North East NSW, where it flowers in *early* spring (August-September as well as October-November) and thus provides food during the winter-spring food bottleneck period (refer Table 8.2 and Table 9.2 of Eby and Law (2008); Figure 1 of OEH (2016)). The inclusion of Turpentine tree in the current assessment therefore extends into a different period of biological considerations (per Table 3.2 of Eby and Law (2008)) than Grey Ironbark and Coast Banksia.

Regional vegetation mapping

Regionally, Turpentine is a dominant component of vegetation communities over a mapped area totalling approximately 250,000 ha and as such is a dominant canopy component of about half the area of mapped spring (O-N) habitat in SE NSW (Eby and Law 2008).

Much of the area of mapped spring habitat within 20 km of the Yatteyattah camp consists of the forest community Batemans Bay Cycad Forest (p90) which contains dominant Spotted Gum (flowering April-July) and Grey Ironbark (flowering August-November). Remnants of Forest Red Gum (flowering August-November) dominated communities of the coastal plain are also likely to be significant. Historically, when large numbers of GHFF have been observed at the Yatteyattah camp in October-November, they were seen foraging on Forest

Red Gum adjacent to the camp (Parry-Jones 1993). November 2012 is the only recent major occurrence documented and available through the National Flying-fox Monitoring Program (DAWE 2021b). Records for Yatteyattah in this dataset begin November 2012, but it is known that in winter of that year (pre-November) a mass flowering event in the Spotted Gum-Ironbark forests north of Bateman's Bay brought large numbers of Swift Parrots to that area (Tzaros and Ingwersen 2012). It is likely that the GHFF occurring in Yatteyattah in November 2012 were feeding in the same Spotted Gum-Ironbark forests, possibly feeding on Ironbark species which flower later than Spotted Gum, co-occur in these forests, and have been observed sustaining Swift Parrots (Tzaros and Ingwerson 2009). In other known big years, diet studies have confirmed feeding on Spotted Gum (scats contained only stamens) in 1985, and when large numbers were observed in 1990 it was coincident with flowering Forest Red Gum (Parry-Jones 1993). The conclusion reached by Parry-Jones (1993) was that occupation of this camp in winter and spring occurred due to heavy flowering of Spotted Gum and Forest Red Gum. Parry-Jones (1985) observed that this camp is either occupied or deserted in winter in a manner consistent with the flowering of Spotted Gum.

If the methodology of Eby and Law (2008) were applied to the site, the site would be ranked '0' (unranked) in the winter-spring bi-months. The area of spring foraging habitat on site, if calculated using their methods, is 0 ha. Refer to **Appendix G** for discussion of mapping limitations and accuracy.

Conclusions

When GHFF occupy the Yatteyattah camp in spring, their occurrence has coincided with mass flowering in Spotted Gum-Ironbark forests, or in the Forest Red Gum dominated forests of the coastal plain. When these forests don't flower, the GHFF don't come to the camp. Consistently occupied winter refugia are in northern NSW (generally north of the Hunter Valley) and in South East Queensland (DoEE 2017). Additionally, GHFF may be present in permanently occupied urban camps, such as those in Sydney. This pattern has not changed in the past ten years, per Eby (2019), and has not changed post-bushfire (DAWE 2021b). The limited available data from the past two years indicates an even greater concentration of GHFF in the unburnt part of their range in South East Queensland in winter (see **Attachment A**).

In the first 5 years post-bushfire, approximately 0.12 ha of Turpentine subcanopy will be cleared. Mitigation measures will delay clearing of 0.21 ha (60%) of spring flowering canopy for the first five years by relocating stockpiles and preferentially retaining Turpentine and Grey Ironbark in temporary Asset Protection Zones. No earlier than 5 years post-bushfire, the remainder of the Turpentine tree will be cleared, to a cumulative total of 1.02 ha.

In order for a GHFF to be affected by the clearing of spring habitat on site, the GHFF would have to first be utilising the Yatteyattah camp in winter or spring in the absence of a mass flowering event, which is a rare occurrence (refer **Section 3.6.1**). Notwithstanding, 92% of the Turpentine trees on the site will remain in the 5 post-bushfire years when recovery of flowering in the surrounding forests is less advanced and less certain. After 5 years, when available data indicates even scorched canopy (GEEBAM burnt class 'High' and some 'Very High') is likely to flower again (Law et al 2000), the remaining Turpentine in the development area will be cleared, leaving 26% (0.36 ha) retained in the Reserve.

3.4 Foraging habitat summer-autumn (outside of winter-spring bottleneck)

3.4.1 Blackbutt

Blackbutt is the only species cited by the Department which forms a dominant component of the canopy on site, being the dominant canopy tree in the Northern Coastal Sands Shrub/Fern Forest (10.79 ha removed; 2.11 ha retained) and a minor component of the Bangalay Moist Woodland/Open Forest (5.39 ha removed). This species is also potentially responsible for a large proportion of the area mapped by the Department as winter-spring foraging habitat within 5 km of the site.

Blackbutt does not flower in the winter-spring months in Manyana or elsewhere in the South East NSW Region (Eby and Law 2008; see **Appendix E**). Blackbutt does not provide forage during a period of food bottleneck on the South Coast, and will instead be flowering during the summer months when 14 to 15 (out of 27 listed) diet plants will be flowering in SE NSW, which is the highest number of listed species flowering throughout the year, the lowest being 4 species in August-September (refer to **Table E.1**, **Appendix E**). Accordingly, the inclusion of Blackbutt (despite its occurrence on the site) as a food source for the GHFF during the winter months is inaccurate.

The listing of Blackbutt in the GHFF Recovery Plan relates to its importance as a winter diet plant in North East NSW and Queensland, where it flowers during the winter months in coastal lowland areas (**Table E.2**, **Appendix E**). Elsewhere, including the South Coast and the foothills and ranges of Upper North East NSW, it flowers during the summer months. Notably, Upper North East NSW and Queensland are well known to be significant refugia for GHFF in winter months, while the South Coast is only known to be important during winters when Spotted Gum is in flower, as noted in the GHFF Recovery Plan: '*Few diet plants flower in winter, and those that flower reliably occur on coastal lowlands in northern New South Wales and southern Queensland* (Eby and Lunney 2002; Eby et al. 1999).' This is consistent with the Eby and Law (2008) phenology data for Blackbutt in Upper North East NSW, where it flowers during winter months.

Blackbutt flowers in SE NSW in the Dec-Jan and Feb-March bi-months (refer **Table 3.3** and **Table E.1**), of which Eby and Law (2008) notes '*February-March is the most productive bi-monthly period in SE NSW; wt p*r* [nectar productivity] *scores are high in this bi- month and the greatest land area is productive*.' **Thus, the Blackbutt found on site would be flowering during summer when the greatest land area and total nectar production would be available for foraging GHFF.**

3.4.2 Red bloodwood

Red Bloodwood is noted to be a summer-autumn flowering resource for the GHFF in Eby and Law (2008), and as such has been included in the summer-autumn foraging estimates. Consequently, this coincides with the time when GHFF migrate to the South Coast, as discussed further below.

3.5 Foraging habitat recovery

3.5.1 Canopy

Law et al (2000) recorded the impacts of fire during a long-term study of canopy tree flowering in response to climatic and disturbance variables. Trees studied included Blackbutt, Turpentine, Swamp Mahogany, Forest Red Gum, Red Bloodwood, Smooth-barked Apple (*Angophora costata*), Rough-barked Apple (*Angophora floribunda*), Grey Gum (*Eucalyptus propinqua*), and several ironbark species (*Eucalyptus siderophloia*, *Eucalyptus tetrapleura*), all of which are relevant to this assessment as they are either GHFF food trees, occur in the area surrounding the site, or are similar to and closely related to GHFF food trees relevant to this assessment.

Regarding low intensity fires, which would be equivalent to GEEBAM 'Low' and 'Moderate' burnt area class, Law et al (2000) recorded the following:

'Immediate effects of low intensity fire were apparent in some species as flower buds were dropped (e.g. E. signata and C. gummifera at Sites 9 and 10 on 1/5/91). However, fires are variable and some species did not shed their buds but flowered within a year (A. costata, C. gummifera, C. variegata, E. acmenoides, E. microcorys, E. siderophloia, E. pilularis, E. resinifera, S. glomulifera). For example, a moderate fire at Site 10 did not scorch the recently formed green buds of C. gummifera. Intense flowering occurred 3 months later (Fig. 4a). ***Species that took more than 1 year to resume flowering after a low-intensity fire either flowered irregularly or on a cycle of greater than 2 years*** *(A. costata, 12, 13, 14, 15; A. floribunda, 13; C. gummifera, 13, 14; E. pilularis, 9, 12, 15; E. signata, 10, 13, 15; E. resinifera, 12).* [emphasis added]*'*

Regarding high intensity 'wildfires' or 'hot controlled burns', which scorched canopies and therefore would be equivalent to GEEBAM 'High' burnt area class, Law et al (2000) recorded:

'These ***fires scorched the crowns of trees but delayed flowering by no more than 3 years*** *in the species which were burnt (A. costata, A. floribunda, C. gummifera, E. acmenoides, E. bancroftii, E. microcorys, E. pilularis, E. propinqua, E. resinifera, E. signata, E. tereticornis, E. tetrapleura).* [emphasis added]*'*

And made the following conclusions:

'… we found little evidence to indicate that high-intensity fire in the coastal forests of northeastern NSW eliminates flowers for more than about 3 years.'

'Low-intensity fire away from riparian areas (such fires are not expected in riparian communities) are likely to reduce flowering immediately in proportion to the amount of crown scorch, but their effects do not appear to extend beyond 1 year.'

For areas of mapped GEEBAM 'Very High' burnt class, it is likely that the above holds true for the majority of the area, however, ground-truthing in May 2020 indicated that in some mapped 'Very High' burnt class areas the canopies were completely consumed and in some cases tree canopies were likely dead (see photo examples in **Appendix B**). While most areas ground-truthed found that 'Very High' burnt class corresponded with consumed canopy only, and not canopy death, this was not always the case, and so it cannot be assumed that all areas of ‘Very High’ burnt class mapped by the GEEBAM will recover at rates similar to that observed by Law et al (2000) for ‘wildfires’ or ‘hot controlled burns’. For these areas, recovery rates are expected to be more variable and prolonged, though it is likely that flowering will recover in the majority of these areas in approximately 3-5 years’ time, as few areas of forest observed in the locality lack any epicormic resprouting whatsoever.

The health of trees, and the recovery of flowering in these areas, is likely to be correlated to the survival of apical growth buds in the crowns of trees. If trees have resprouted from epicormic buds only, the recovery of the tree is likely to be more prolonged, and its ultimate survival less certain. Trees which have resprouted from apical buds, even if all canopy foliage has been consumed by fire, are far more likely to recover more rapidly, with flowering recovery likely to be similar to and not significantly greater than time frames observed by Law et al (2000). Refer to **Appendix H** for further discussion of fire impacts.

3.5.2 Banksia

Fire ecology of Banksia species has been studied in greater detail. Banksia life histories can be broadly grouped into ‘resprouters’ and ‘seeders’. Seeders are killed by fire and return from a seedbank or from fire-scorched serotinous (seed-retaining) capsules. Resprouters often have thicker bark (up to several centimetres) and living tissues with greater defence against fire. Resprouters can return after fire via lignotubers (which are tough underground storage structures with buds that allow rapid regrowth) which allow resprouting even after hot fires that kill the above-ground parts of the tree. Or, resprouters can return via epicormic buds beneath their thick bark or aerial buds which have survived the fire. Banksia resprouters recover much more quickly after fire. Coast Banksia is a resprouter.

Banksia resprouter species have been recorded flowering after a period of two to five years post-fire (Brundrett and Longman 2015; Lamont and Markey 1995; Zammit and Westoby 1987). Studies of nectivorous birds such as honeyeaters in burnt Banksia habitats found that numbers of honeyeaters at a site would drop dramatically in the 2 years after fire, then in about 2 years rebound to numbers even greater than pre-fire, then reduce to pre-fire numbers by about 2-5 years post-fire (Smith and Smith 2016; Woinarski and Recher 1997; Recher et al 1985). This is consistent with observations of flowering recovery times of Banksia resprouter species.

Recovery of Coast Banksia can be predicted to occur within 2 to 5 years post-fire.

3.5.3 Projected recovery

Method

Eby and Law (2008) data files were analysed within the South East NSW (north) region. The file analysed was obtained from a DAWE assessment officer via Microsoft OneDrive sharepoint link entitled SE_NSW_2019 new.zip. The dataset analysed is file name:
GHFlyingFox_Habitat_SouthEast_NSW_north.dbf. This data can be found at:
https://datasets.seed.nsw.gov.au/dataset/flying-fox-foraging-habitat-2019.

The ‘SPECIES’ field in the GHFF habitat dataset contains the species that flower between June and November in South East NSW (refer **Appendix E**). Using this information, each SCIVI map unit was assigned as either containing GHFF important food trees, or not. Areas shown in columns 4 and 5 of **Table 3.5** were obtained by intersecting the SCIVI vegetation layer with the GEEBAM dataset.

These recovery projections are informed by ground-truthing conducted for the MNES Assessment report (Ecoplanning 2020a) and by observations of Law et al (2000). Ecoplanning (2020a) ground-truthing includes 28 photo points (see Appendix C of that report) and covered the area shown in dark blue in Figure 2.3 of that report. Additional ground-truthing was conducted in April 2021 for the present assessment. These recovery projections provide only an estimate of future conditions; however, the projections are considered to be an accurate representation of the time scales involved in the recovery of GHFF foraging habitat in the region.

Result

A visual representation of the time scale of the projected recovery shown in **Table 3.5** is provided as **Figure 3.14**. Note that a value of '2040' was entered arbitrarily to provide a visual for the possible date of full recovery in the graph (rightmost extent of x-axis).

Regarding predictions and projections shown in **Figure 3.14**:

- Minimum predicted assumes the slowest rates of recovery observed by Law et al (2000), being 3 years for 'Low' and 'Medium' burnt class (1 year observed plus 2 years to account for trees that flower on multi-year cycles), 5 years for 'High' burnt class (3 years plus 2 years per above); together with the recovery of Coast Banksia in all burnt classes within 5 years. This prediction makes no assumptions about recovery of 'Very High' burnt class vegetation.
- Projection – The actual trajectory of the recovery of 'Very High' burnt class vegetation is expected to fall somewhere within this shaded area.
    - The lower projection is defined as somewhere between no recovery ever occurring and the full recovery occurring in several decades' time.
    - The upper projection is defined by recovery either requiring several decades, or else occurring throughout all 'Very High' burnt class vegetation at similar rates to the minimum predicted for 'High' burnt class vegetation.
- Maximum predicted assumes that the fastest rates of recovery observed by Law et al (2000) will occur throughout all GEEBAM burnt class vegetation, and that 'Very High' and 'High' burnt class vegetation will both recover at the fastest rates observed for vegetation commensurate with the 'High' burnt class.

Using this data for the purposes of this assessment, it is considered that at least half (27,595 ha) of the total winter and spring GHFF foraging habitat within 20 km of Yatteyattah camp will recover to flowering condition within 5 years post-bushfire. Both the 'minimum predicted' and the 'maximum predicted' recovery rates described above are not considered to be realistic representations of the recovery of GHFF habitat.

Based on observations of trees within GEEBAM mapped 'Very High' burnt class areas in Morton National Park which have flowered in response to stress, but which may still die despite the presence of epicormic foliage, the recovery of flowering in 'Very High' burnt class vegetation is expected to be far more complex than in 'Low', 'Medium', or 'High' burnt class areas. Trees whose canopies have been completely consumed, but which have retained living apical buds in their crowns are very likely to survive and flower at rates similar to GEEBAM mapped 'High' areas, but trees which survived only through epicormic sprouting may face prolonged recoveries or ultimately may not survive. The GEEBAM does not record this level of detail regarding the survival of buds – only whether or not canopy foliage was consumed. Further ground-truthing survey would be required to provide estimates of recovery in 'Very High' burnt class areas, and would necessitate sampling at a scale sufficient to determine the proportion of 'Very High' burnt class which corresponds with apical bud death compared to 'Very High' burnt class which corresponds with consumption of canopy foliage only.

Refer to **Appendix H** for discussion of canopy vegetation recovery estimates.

Table 3.5: Projected winter and spring habitat recovery (ha)

Mapped vegetation community (SCIVI)	GHFF food trees	Recovery	Area	
			5 km from site	20 km from Yatteyattah
Pre-fire – all GHFF vegetation communities			2,791	46,862
Post-fire (January 2020) – all GHFF vegetation communities			39	4,942
Littoral thicket (p63)	Coast Banksia	2-5 years	49	53
All other winter and spring vegetation communities (Eucalypts) – Low-Moderate	Spotted Gum, Forest Red Gum, Swamp Mahogany, Smooth-barked Apple, Grey Ironbark, Turpentine	1-3	213	13,406
All other winter and spring vegetation communities (Eucalypts) – High	Spotted Gum, Forest Red Gum, Swamp Mahogany, Smooth-barked Apple, Grey Ironbark, Turpentine	3-5	630	9,194
All other winter and spring vegetation communities (Eucalypts) – Very High	Spotted Gum, Forest Red Gum, Swamp Mahogany, Smooth-barked Apple, Grey Ironbark, Turpentine	3-5/ Unknown	1,860	19,267

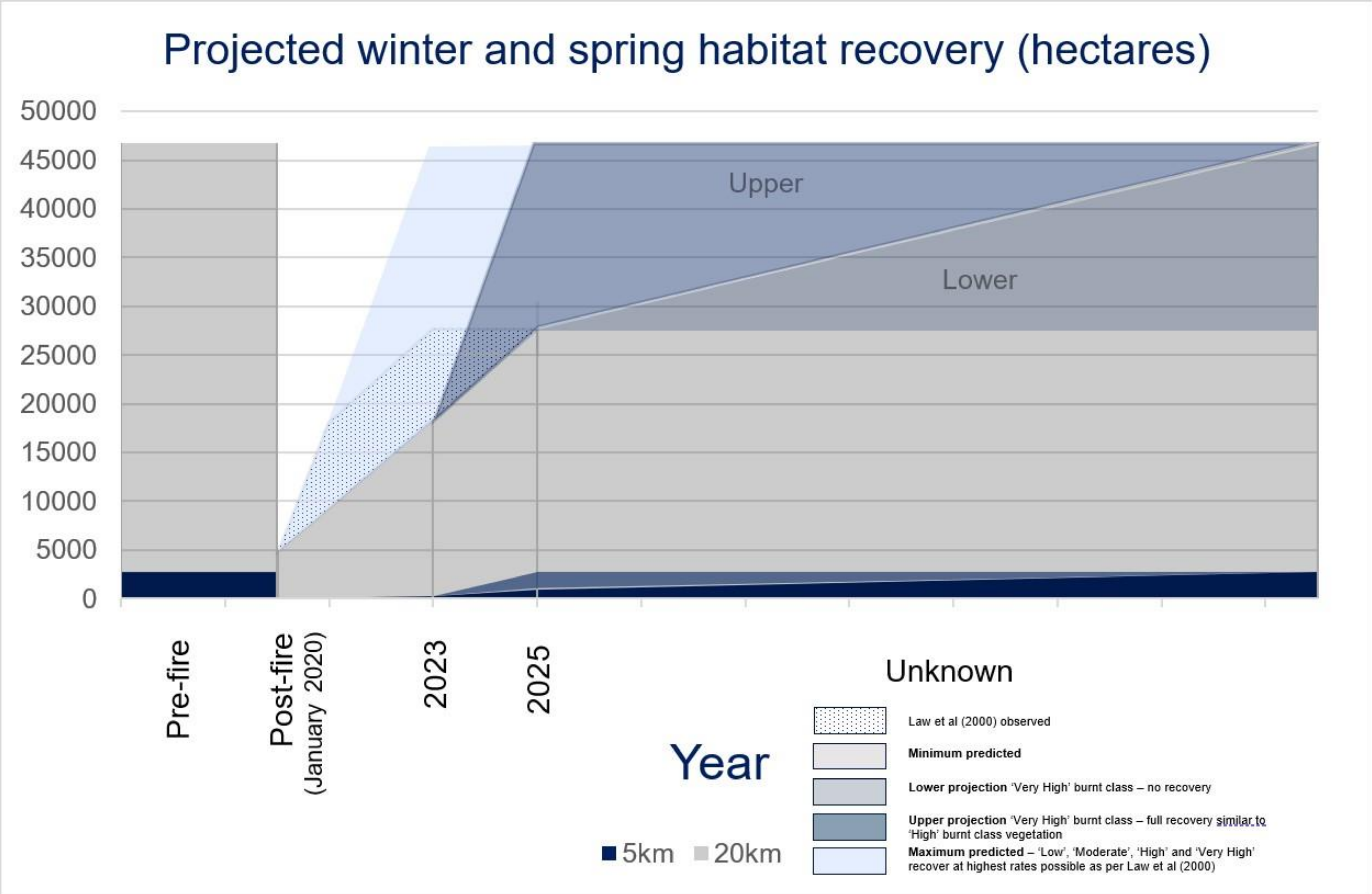


Figure 3.14: Projected habitat recovery – all ranked June-November GHFF foraging habitat within 20 km of Yatteyattah camp and within 5 km of site

3.6 Winter and spring foraging habitat use by region

The most highly productive winter and spring foraging habitats occur in coastal lowlands, plateaux and coastal ranges of Upper North East NSW and Lower North East NSW (Eby and Law 2008). In these regions, the number of flowering diet trees and the range-wide index of productivity do not vary from late autumn to mid-winter (June-July), but changes occur in the distribution of feeding habitat across these areas. Productive areas are concentrated in South East Queensland and northern NSW. More extensive forest and woodland types dominated by Spotted Gums are productive in northern South East Queensland and coastal South East NSW. While Spotted Gum dominated vegetation types have high nectar productivity scores, they score poorly for reliability and are expected to be productive in <30% of years.

The GHFF Draft Recovery Plan (DoEE 2017b) (Section 2.10.1) describes seasonal foraging patterns as follows:

‘***During spring, Grey-headed Flying-foxes are uncommon south of Nowra in New South Wales****, but widespread in other areas of their range. In summer they are widespread throughout their range and in autumn they occupy coastal lowlands and are uncommon inland. In winter they congregate in coastal lowlands north of the Hunter Valley and are occasionally found on the south coast of New South Wales (associated with flowering Spotted Gum Corymbia maculata) and the northwest slopes (generally associated with flowering White Box Eucalyptus albens or Mugga Ironbark E. sideroxylon) (Eby and Law 2008).* [emphasis added]*’*

Overall, South East NSW is not a consistent area of productive habitat, and in particular is not a centre of productive habitat in winter, with the exception of winters during which Spotted Gum flowers, of which <30% of years are expected to have productive flowering events of Spotted Gum. Therefore, the occurrence of GHFF in the region in winter is likely to be lower generally, and when GHFF do occur, they are expected to be in the area in large numbers only during the years when Spotted Gum is in flower.

Eby and Law (2008) (Section 10.3.2.1) describe winter foraging habitat in the SE NSW Region as follows:

*‘Although vegetation types dominated by Swamp Mahogany and Coastal Banksia achieve bi-monthly wt p*r scores that are among the highest in the region, these types have highly restricted distributions and primarily occur as remnants <50 ha.*

The Spotted Gum forests in the Batemans Bay area are an exception*. This species is widely distributed on the coastal plains in this area and can secrete substantial amounts of nectar over several months (Law and Chidel 2007). Forests that contain Spotted Gum are known to support populations of Grey-flying-foxes that exceed 100,000 individuals. However, annual reliability is poor and highly productive flowering occurs approximately one year in five (Pook, Gill and Moore 1997).* [emphasis added]*’*

Regarding the range-wide threats to the species, the GHFF Draft Recovery Plan (DoEE 2017a) (Section 3.1) concludes:

*'The processes that threaten Grey-headed Flying-foxes are most prevalent in **coastal areas north from the Sydney Basin,** which support the greatest natural diversity of food plants and the most consistent presence of the species outside metropolitan areas*. [emphasis added]'

Despite recent observations of wider ranging foraging behaviour outside the species' typical winter refugia in Upper Northeast NSW and Queensland, these wider ranging movements have remained in northern NSW, generally north of Sydney, so that the GHFF continues to be rare south of Nowra even in the context of the wider winter foraging extent observed from 2010-2019 (Eby 2019; DAWE 2021a,b). **Attachment A** shows a comparison of post-bushfire GHFF distribution (camp counts) to pre-bushfire GHFF distribution (DAWE 2021b). Note that November data is not yet available for 2020, so comparison of camp occupation pre and post-bushfire is not possible for this survey period. GHFF are uncommon south of Nowra during August camp counts, and are even less common in the south of their range post-bushfire (one year of data), as can be seen in **Attachment A**. Most of the southerly camps occupied in winter are urban camps, and it is well-known that an increasing number of urban camps are becoming permanently occupied, including in places as far south as Melbourne.

The *National Recovery Plan for the Grey-headed Flying-fox 'Pteropus poliocephalus'* (DAWE 2021a) maintains that:

*'**During spring, Grey-headed Flying-foxes are uncommon south of Nowra in New South Wales,** but widespread in other areas of their range.* [emphasis added]'

The National Recovery Plan (DAWE 2021a) also maintains:

'*The processes that threaten Grey-headed Flying-foxes are most prevalent in **coastal areas north from the Sydney Basin***. [emphasis added]'

Local ecologists have observed that key food sources in the region include Spotted Gum, Red Bloodwood, Morton Bay Fig (*Ficus macrophylla*), Superb Fig (*Ficus superba*), Swamp Mahogany, Coast Banksia, Old Man Banksia, and exotic Cocos Palms (*Arecastrum romanzoffianum*) (Gaia Research 2007), and that the GHFF is a summer migrant to the area (OMVI Ecological 2020).

The broad pattern of regional movements of GHFF in the winter and spring months is that Upper North East NSW and QLD are the primary winter and spring refuge for the species, with South East NSW being significant only in years when Spotted Gum forests flower en masse. The tree species found on the site are not significant in the context of the species' occasional winter movements into South East NSW.

3.6.1 Yatteyattah flying fox camp

The Department considered that the foraging habitat on site is more important due to its proximity to the Yatteyattah nationally important flying fox camp, which the Department considered to be permanently occupied. The Yatteyattah camp is not permanently occupied.

In each of the past 8 years recorded, the camp has been vacated (0 individuals recorded) during at least one of the four yearly surveys (February, May, August, November), and unoccupied during 21 out of 30 total survey events (DAWE 2021b). The camp was unoccupied over the entire surveyed period from May 2015 until August 2016, and again from

May 2019 until August 2020 (DAWE 2021b). During winter and spring (August and November surveys), the camp has been unoccupied in 7 out of 9 years (DAWE 2021b). Both of the two years of winter or spring occupation (2012 and 2016) corresponded with mass flowering of Spotted Gum (flowers April to July) and Forest Red Gum (flowers August to November) which also brought large numbers of Swift Parrots to the coastal forests north of Bateman's Bay. In 2016, the lowest record category, 1-499 GHFF individuals, was present at Yatteyattah. Spotted Gum flowered in the South Coast region in 2016 (Ingwersen et al 2016).

Historically, the Yatteyattah camp was more frequently occupied in winter-spring. GHFF were present concurrently with local mass flowering of Spotted Gum, and when present later in the year (October), they were observed foraging in a restricted area of remnant Forest Red Gum in the vicinity of the Yatteyattah camp (Parry-Jones 1993). All October-November records during this study, from 1985 to 1990, were of the lowest non-zero occupation category recorded – 10,000 individuals – while very large numbers were present in some winters (June-July) – possibly up to 100,000 individuals. Diet studies recorded only stamens in the scat of GHFF at the camp during these winters, concurrent with mass flowering Spotted Gum. Parry-Jones (1985) observed that this camp is either occupied or deserted in winter in a manner determined by the availability of blossom from the key tree species Spotted Gum.

All previously documented large movements of GHFF into the South Coast, including the Yatteyattah camp, were associated with mass flowering of either Spotted Gum or Forest Red Gum. When GHFF have previously been recorded in large numbers at the Yatteyattah camp concurrently with the flowering period of Turpentine (October-November), GHFF have been observed foraging on Forest Red Gum near the camp (Parry-Jones 1993).

Refer to **Figure 3.15** and **Figure 3.16** for recorded occupancy of the Yatteyattah GHFF camp (DAWE 2021b).

Figure 3.17 shows the historic occupancy of the Yatteyattah camp, as recorded by Parry-Jones (1993). Note that census methods used in this study differ from DAWE (2021b). Parry-Jones (1993) summarised this figure by stating that, excluding the very large winter colonies associated with mass flowering Spotted Gum and Forest Red Gum, the basic pattern at that time was that a small colony became established in late October or early November and peak numbers occurred from January to April.

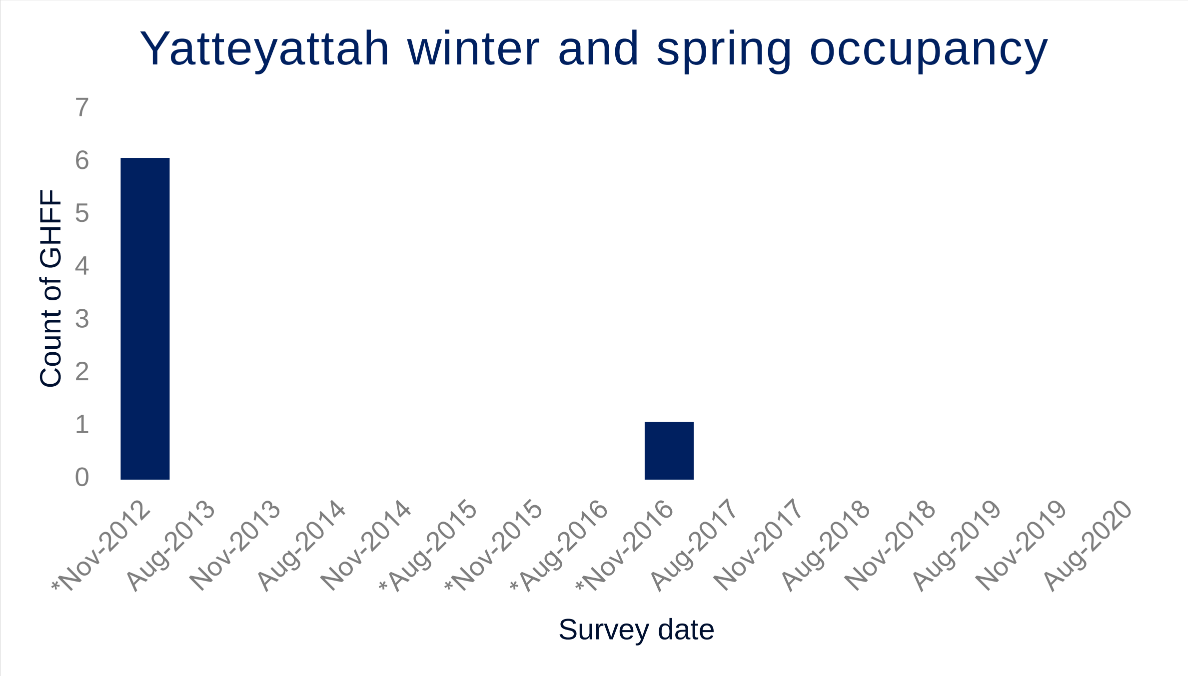


Figure 3.15: Winter and spring occupancy of the Yatteyattah GHFF camp (DAWE 2021b)

*years of known mass flowering events

Count: **1**= 1 to 499; **2**= 500 to 2,499; **3**= 2,500 to 9,999; **4**= 10,000 to 15,999; **5**= 16,000 to 49,999; **6**= 50,000+

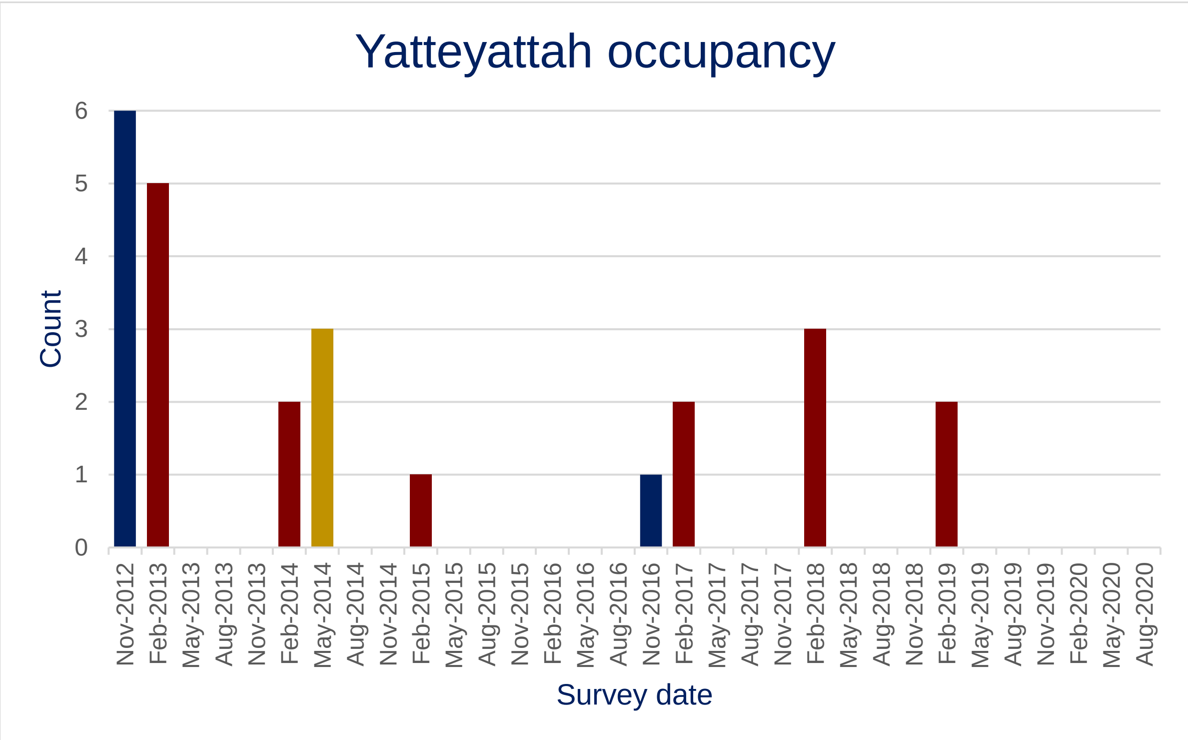


Figure 3.16: Yatteyattah GHFF camp occupancy (DAWE 2021b)

Count: **1**= 1 to 499; **2**= 500 to 2,499; **3**= 2,500 to 9,999; **4**= 10,000 to 15,999; **5**= 16,000 to 49,999; **6**= 50,000+

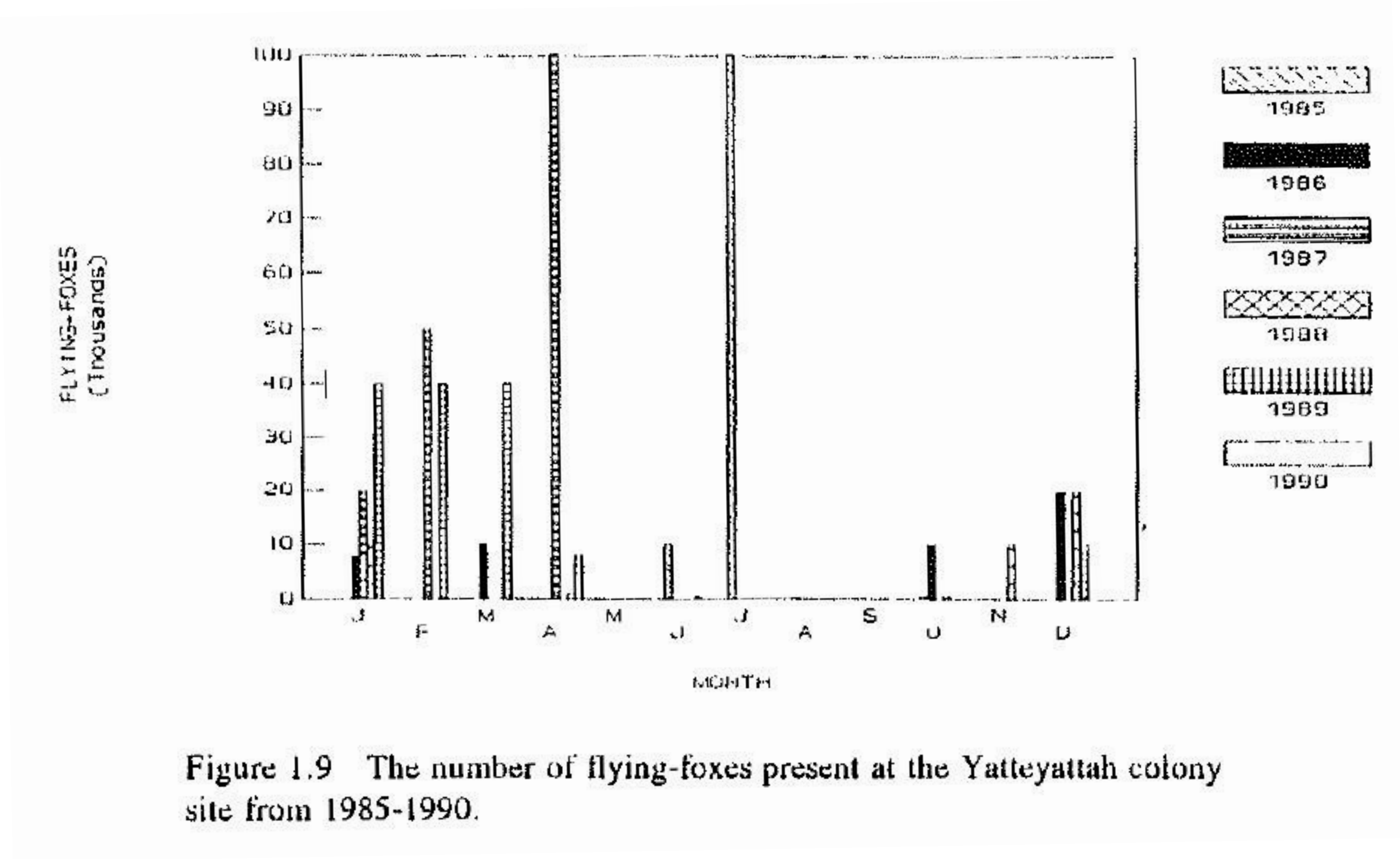


Figure 3.17: Yatteyattah GHFF camp occupancy 1985-1990 (Parry-Jones 1993)

3.6.2 Nationally-important flying-fox camps

At the time of Referral, the Yatteyattah flying-fox camp was listed as a nationally important camp because it meets the criteria of being occupied by ≥10,000 GHFF in more than one year, and not because it is occupied permanently or seasonally every year (>2,500 GHFF/year). The last time it had ≥10,000 GHFF is now more than 10 years, and it therefore not considered to be a Nationally-important Flying Fox camp any longer (see National Flying Fox Viewer; DCCEEW 2023).

The Department considered that potential GHFF foraging habitat on site is more important because of its proximity to the Yatteyattah camp, which the Department considered to be permanently occupied, and because GHFF forage more frequently within 20 km of the camp. Therefore, the frequency of occupation of the camp and the frequency of foraging activity were considered to be key elements of the habitat significance of the site, as the Department considered that the Turpentine, Grey Ironbark, and Coast Banksia on the site would be utilised far more often than if they were not located in such close proximity to a supposedly permanently occupied nationally important flying fox camp.

The Yatteyattah flying-fox camp is not permanently occupied and is not frequently occupied in winter and spring (DAWE 2021b; Eby 2002; Eby et al 1999). Historically, it was occupied more often (Parry-Jones 1993, 1985), likely due to greater prevalence of Spotted Gum and Forest Red Gum in the area at that time, but was still rarely occupied between the months of June and November, with only low numbers (ca. <10,000 individuals) recorded in the months of October and November (Parry-Jones 1993).

The reason for Yatteyattah's listing as a nationally important camp is that it has hosted very large numbers (possibly ≥100,000) of GHFF during the years when mass flowering events of Spotted Gum and/or Forest Red Gum occur. When mass flowering events of Spotted Gum occur, nectar appears not to be a limiting resource in the landscape (Law and Chidel 2007). Absent a mass flowering event, the camp is seldom occupied, especially in winter and spring.

3.6.3 Summary

The Department considered that the camp is frequently occupied and that due to its proximity to the site, the site would be more frequently visited. The available data indicates that the site would be visited infrequently by GHFF in winter or spring.

The Department considered that the site provides 17.18 ha of important winter-spring foraging resources which will be cleared. Additional survey has found that the site contains 0.22 ha of winter-spring foraging habitat (food bottleneck period) and 1.24 ha of spring foraging habitat (important period in reproductive cycle).

The data from the Yatteyattah camp and from the South Coast more generally highlights the importance of Spotted Gum. When GHFF appear in winter, it is for Spotted Gum. When they have appeared in Spring, it is for Forest Red Gum. Absent flowering of these species, GHFF don't come. They remain north of Nowra, as reported in the GHFF Recovery Plan.

The seasonal pattern has not changed post-2010 or post-bushfire, and it appears unlikely that GHFF would come to the area in winter or spring with greater frequency or in greater numbers when there is less food in the region post-bushfire and when in the past they only ever came to the area when there was an abundance of food. Post-bushfire winter foraging appears to skew even more towards unburnt parts of the GHFF's range in South East Queensland, based on the one year of data available.

In summary, Yatteyattah camp is used in winter-spring, sometimes by very large numbers of GHFF, only when certain key tree species flower en masse producing a practically unlimited nectar resource. Otherwise, Yatteyattah is a frequently occupied summer camp, supporting some GHFF in most but not all years.

3.7 Conclusion of habitat assessment

The winter and spring GHFF habitat on site is summarised as follows:

June-July August-September (food bottleneck)

Coast Banksia
- Four flowering-size individuals found.

Grey Ironbark
- 0.22 ha of canopy impacted.
- Canopy trees (DBH 25 – 70 cm)

- 0.020% of unburnt canopy habitat within 20 km of Yatteyattah camp
- 0.0000062% of range-wide habitat

October-November (late gestation/ birth/ early lactation)

Grey Ironbark
- 0.22 ha of canopy impacted.
- Canopy trees (DBH 25 – 70 cm)

Turpentine
- 1.02 ha impacted.
- Subcanopy trees
  - 75% small-medium trees (DBH 20-40 cm)
  - 25% large trees (DBH >40 cm)

- 0.0073% of unburnt canopy habitat within 20 km of Yatteyattah camp
- 0.000022 % of range-wide habitat

The summer and autumn GHFF habitat on site are summarised as follows:

- 5.39 ha impacted (calculated as 50% Blackbutt/Red Bloodwood canopy of NCSSFF)
- 0.54 ha impacted (calculated as 10% Blackbutt canopy of BMWOF)
- 0.090% of unburnt canopy habitat within 20 km of Yatteyattah camp

Avoidance

The proposed action will avoid and permanently retain approximately 3.45 ha of potential summer foraging habitat (2.26 ha of NCSSFF and 0.88 ha BPW) within which 0.36 ha is also potential spring foraging habitat (Turpentine) for GHFF within the site. Refer to **Section 6.1**.

Mitigation

Up to 0.16 ha of GHFF winter and spring foraging habitat will be cleared in Stage 1. Up to 0.21 ha of foraging habitat which would have been cleared in this stage will be avoided via updates to site CC plans and management plans. This is a 60% reduction in clearing in Stage 1.

Landscape Plans and incentive schemes for the site will be updated to incorporate planting GHFF winter and spring diet plants, including Grey Ironbark, Turpentine, Coast Banksia, and Swamp Mahogany. Due to the spacing of planted trees in the streetscape and on lots, the nectar production per tree (refer OEH 2016), and projected total amount of nectar produced on the site as a whole, is expected to be greater than the winter and spring forage currently available on the site. Refer to **Section 6.2**.

Seasonal Movements of GHFF

Yatteyattah camp

- Occupied winter or spring in 22% of recent years
- Occupied during mass flowering of
  - Spotted Gum (April-May June-July)
  - Forest Red Gum (August-September October-November)

South Coast south of Nowra

- Rare in winter or spring, except when Spotted Gum flowers
- Still rare in winter and spring post-2010, despite less concentrated occupation of usual winter refuge in south east Queensland
- Even more rare in south of range post-bushfire (1 year of data)
- Local ecologists (OMVI Ecological 2020; Gaia Research 2007) have observed that GHFF is a summer migrant to the area.

Post-bushfire context – Winter and spring

17% range-wide overlap of fire with winter and spring GHFF habitat.

19,278 ha (39%) unburnt canopy winter and spring habitat remaining within 20 km of Yatteyattah

Projected cumulative habitat removal on site relative to bushfire:

- 34 months 0.16 ha
- 3-5 years 0.18 ha
- 5-6 years 0.32 ha
- 7 years 1.25 ha

Projected recovery of flowering

- Banksia 2-5 years
- Eucalypts (Low-Moderate) 1-3 years
- Eucalypts (High) 3-5 years
- Eucalypts (Very High) 3-unknown

Projected area of winter and spring flowering vegetation recovered within 5 km of site.

- 1-3 years 213 ha recovered
- 3-5 years 892 ha recovered

- 5-10 years
    - upper 2,791 ha recovered
    - lower 892 ha recovered

Projected area of winter and spring flowering vegetation recovered within 20 km of Yatteyattah.

- 1-3 years 13,406 ha recovered
- 3-5 years 22,653 ha recovered
- 5-10 years
    - upper 41,862 ha recovered
    - lower 22,653 ha recovered

Post-bushfire context – Summer and autumn

24,146 ha (31%) unburnt canopy summer and autumn habitat remaining within 20 km of Yatteyattah

Projected cumulative habitat removal on site relative to bushfire:

- 34 months 2.02 ha
- 3-5 years 2.71 ha
- 5-6 years 3.48 ha
- 7 years 5.93 ha

Projected recovery of flowering

- Low-Moderate burnt class = 1-3 years
- High burnt class = 3-5 years
- Very High burnt class = 3-unknown

Projected area of winter and spring flowering vegetation recovered within 5 km of site.

- 1-3 years 549 ha recovered
- 3-5 years 1,384 ha recovered
- 5-10 years
    - upper 3,430 ha recovered
    - lower 1,384 ha recovered

Projected area of winter and spring flowering vegetation recovered within 20 km of Yatteyattah.

- 1-3 years 17,523 ha recovered
- 3-5 years 31,932 ha recovered
- 5-10 years
    - upper 70,550 ha recovered
    - lower 31,932 ha recovered

3.8 Impact Assessment

The updated information requested by the Department supports the conclusions of the assessment of significance referencing the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* provided in the Ecoplanning (2020a) MNES Assessment (Section 6.6). A brief update to the significant impacts assessment is provided below.

3.8.1 Population significance

An 'important population' is defined under the *Matters of National Environmental Significance: Significant impact guidelines 1.1* as a population that is necessary for a species' long-term survival and recovery. The guidelines list criteria for determining an important population, which are considered below in relation to GHFF:

- *populations identified as such in recovery plans*

The GHFF Recovery Plan does not identify 'important populations'. The entire population of the GHFF, estimated to be between 300,000 to 900,000 individuals, is considered to be a single, mobile population distributed across the species entire range (Westcott et al. 2015; DAWE 2021a).

- *key source population for either breeding or dispersal*

The site is only used infrequently by foraging individuals, mostly in summer, and therefore does not support a key source population for either breeding or dispersal.

- *populations that are necessary for maintaining genetic diversity, and/or*

The entire population of Grey-headed Flying-foxes within Australia is likely to exchange genetic material owing to the species high dispersal capability, and the site is not likely to support a population that is necessary for maintaining genetic diversity of this species.

- *populations that are near the limit of the species range.*

The site is located near the centre of this species range.

3.8.2 Habitat critical to survival of species

The site contains 0.22 ha of habitat critical to the survival of GHFF (food bottleneck) and 1.61 ha of important winter and spring foraging habitat, when subcanopy Turpentine is included, of which 1.25 ha of important winter and spring foraging habitat is located within the impact area. An estimated 8.19 ha of summer and autumn foraging habitat is located within the site, of which 5.93 ha is located within the impact area. An assessment against criteria under the *Matters of National Environmental Significance: Significant impact guidelines 1.1* for habitat critical to the survival of the species is provided below (for winter and spring habitat only):

- *necessary for activities such as foraging, breeding, roosting, or dispersal;*

The habitat available on site is not necessary for breeding, roosting, or dispersal. The foraging habitat available on site potentially productive between the months of June and November (winter-spring bottleneck, and spring late gestation/ birth/ early lactation period) is likely to be rarely utilised (refer **Section 3.6**) and represents 0.0064% of the available June to November habitat within 20 km of the Yatteyattah flying-fox camp (refer **Section 3.2.4**).

- *necessary for the long-term maintenance of the species or ecological community (including maintenance of species essential to the survival of the species or ecological community, such as pollinators);*

The site contains intermittently used summer foraging habitat for any individuals present in the locality and is not necessary for the long-term maintenance of the species (refer **Section 3.3** and **Section 3.6**).

- *necessary to maintain genetic diversity and long term evolutionary development, or*

The site is not necessary for maintaining the genetic diversity and long term evolutionary development of this highly mobile, broadly ranging species.

- *necessary for the reintroduction of populations or recovery of the species or ecological community;*

The site does not contain habitat necessary for the reintroduction or recovery of this species. The site is not necessary for the recovery of the species post-fire. With few exceptions, winter and spring foraging behaviour, which overlaps with critical food shortages and important life history events, occurs in the area north of the Sydney Basin, and the primary threats to the species are in the area north of the Sydney Basin (GHFF Recovery Plan).

1.25 ha of potential winter and spring foraging habitat is found on the site. Range-wide, between 2,216,622 and 5,746,606 hectares of GHFF foraging habitat constitutes potentially productive habitat during this period, of which the 2019-2020 bushfire overlap is approximately 17% (refer **Table 3.3**).

- *habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or*

1.25 ha of habitat identified as occurring within 20 km of flying-fox camp, productive either during the food bottleneck or late gestation/ birth/ early lactation period, and containing the food tree species Grey Ironbark, Turpentine, or Coast Banksia is found on the site. The area of Turpentine within this total, which is 1.02 ha, is subcanopy, not canopy which is what the GHFF Recovery Plan indicates is GHFF habitat. Small subcanopy eucalypts are considered to represent 'low-quality' foraging habitat for GHFF.

- *habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.*

No areas of critical habitat for this species are listed on the Register of Critical Habitat.

3.8.3 Impact assessment

Under the EPBC Act, an action is considered likely to have a significant impact on a 'vulnerable' species if there is a real chance or possibility that it will impact an 'important population' (refer **Section 3.8.1**). A response to the impact criteria of the *Matters of National Environmental Significance: Significant impact guidelines 1.1* is provided below.

- *Lead to a long-term decrease in the size of an important population of a species*

A population of this species does not occur on the site. The proposed action does not have potential to lead to a decrease in the size of the population (ca. 300,000 to 900,000 individuals) via either starvation caused by loss of food during a food bottleneck period, or failure of female GHFF to raise young to weaning via loss of condition during gestation or nursing.

The loss of 0.22 ha of habitat, which is 0.0000062% of the total range-wide habitat in the food bottleneck period, is not considered likely to lead to a long term decrease in the size of the population.

The loss of 1.24 ha of habitat, which is 0.000022% of the total range-wide habitat available during the late gestation/ birth/ early lactation period, is not considered likely to lead to a long term decrease in the size of the population.

The foraging habitat on site is likely to be utilised infrequently, and mostly in summer months.

- *Reduce the area of occupancy of an important population of a species*

The proposal is not anticipated to permanently reduce the area of occupancy of the species, as mitigation measures proposed (refer **Section 6.2**) are anticipated to increase the nectar production of the site in the long term once street tree plantings with unconstrained canopies are established (refer **Section 3.3** and **Appendix C**). Refer **Plate C1** vs **Plate C2** and **Plate C5** showing the difference between the unconstrained canopy of a street tree compared to subcanopy trees. The proposed action will not reduce the area of occupancy of the species.

- *Fragment an existing important population into two or more populations*

The proposed action will not fragment the population of this highly mobile and wide ranging species.

- *Adversely affect habitat critical to the survival of a species*

The proposed action will impact 0.22 ha of habitat potentially productive during the food bottleneck period. The proposed action will impact 1.24 ha of important foraging habitat when subcanopy spring-flowering Turpentine is included in the total, which may be productive during an important period in the reproductive cycle of the GHFF. An estimated 5.93 ha of summer-autumn foraging habitat (Blackbutt and Red Bloodwood) will be cleared over the 9 year (or greater) staged development period, which is estimated to <0.01% of the equivalent habitat within the locality during that period.

- *Disrupt the breeding cycle of an important population*

The clearing of 1.24 ha of potential habitat during the spring period in the reproductive cycle of the GHFF is not anticipated to disrupt the breeding cycle of the species. This represents 0.0073% of the intact unburnt canopy habitat within 20 km of the nearest flying-fox camp (Yatteyattah), and 0.000022% of the range-wide habitat for the species. GHFF rarely occur on the South Coast during the period which coincides with important events in the breeding cycle of the species, and when they have occurred during this period their appearance has coincided with mass flowering in Spotted Gum-Ironbark forests or Forest Red Gum dominated vegetation communities.

On this basis, the proposed action will not disrupt the breeding cycle of the GHFF.

- *Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*

The proposed action will remove a negligible amount of the available habitat for this species and is extremely unlikely to cause the species as a whole to decline. The total number of GHFF that could possibly be sustained by foraging habitat on the site which is productive during important periods in the life cycle of the species is very small.

In order for GHFF to be affected by this clearing, Grey Ironbark and/or Turpentine would need to be flowering synchronously, such that most of the 1.25 ha of potential habitat on site is productive, and also would need to be flowering at all, which happens in <40% of years. GHFF would also need to be present in the locality, which has occurred in winter or spring in 22% of recent years, while also facing a shortage of available foraging resources. During the years when GHFF have visited the locality in winter and spring, their occurrence has coincided with mass flowering events of Spotted Gum, which when flowering produces large volumes of nectar and may not constitute a limited foraging resource in the landscape.

The possibility for the species as a whole to decline, which is remote, would be related to the death of individuals or of unweaned young due to the lack of availability of forage. Between a low of 1,891,656 ha (April-May) and up to 6,637,529 ha (December-January) of forage, with an approximate reduction of 17% post-bushfire, is available to the species throughout its broad range. The movement patterns of this species also reflect a consistent tendency to utilise available foraging habitat in parts of its range north of the Sydney Basin in the winter and spring months (see **Attachment A**), where the GHFF Recovery Plan has noted the primary threats to this species occur. Moreover, the scale of any potential decline would be measured in the context of a population size of between 300,000 and 900,000 individuals. Any potential for impact to even one individual GHFF would be insignificant, and even more so in the context of the species' population size.

On this basis, the proposed action is extremely unlikely to decrease the availability of habitat such that the species as a whole is likely to decline.

- *Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat*

The proposal has the potential to result in the spread of weed species into retained areas of this species' habitat on site (the retained Reserve containing the Bangalay Paperbark Woodland EEC). The Flora and Fauna Management Plan (Ecoplanning 2021a) has been prepared to mitigate this impact. Notwithstanding, the impact of introduced weed species on this species or its habitat is minimal.

- *Introduce disease that may cause the species to decline, or*

The proposal is unlikely to result in the introduction of disease that may cause decline of

GHFF. There is potential for disease caused by the soil-borne plant pathogen *Phytophthora cinnamomi* to occur within the site as a result of the proposal. This pathogen could impact on the retained vegetation that could support foraging habitat for this species. Control of transportation of the pathogen will occur via control of soil transportation into the study area. The Environmental Management Plan (Ecoplanning 2021b) and Flora and Fauna Management Plan (Ecoplanning 2021a) include measures to reduce the risk of introduction of soil-borne pathogens into the site. The proposal is not likely to introduce disease that may cause this species to decline.

- *Interfere substantially with the recovery of the species.*

The removal of a total of 17.18 ha of habitat, of which a total of 1.25 ha may produce forage during important periods in the life cycle of the GHFF, will not interfere substantially with the recovery of the GHFF.

The total area of foraging habitat productive for this species varies from 1,891,656 ha (April-May) to 6,637,529 ha (December-January) (Eby and Law 2008), of which it is estimated that the 2019-2020 bushfires have overlapped with 17% (DAWE 2021d). In this context, the area cleared contains a small proportion of significant foraging habitat, of which a large proportion of the 1.25 ha cleared consists of immature subcanopy trees which could not produce significant amounts of nectar. An estimated 5.93 ha of summer-autumn foraging habitat (Blackbutt and Red Bloodwood) will be cleared over the 9 year (or greater) staged development period, which is estimated to <0.01% of the equivalent habitat within the locality

The number of GHFF that could potentially be sustained by the winter and spring forage produced on the site at any one time could not be considered ecologically significant with reference to current estimates of population size of the species (300,000 to 900,000 individuals) and current estimates of the range-wide foraging habitat area available to the species even within the context of the 17% overlap of fire extent with the species' range. The possibility that this small area of low quality foraging habitat remaining available could have significance for the species recovery, even in the context of the 2019-2020 bushfires, is very remote.

3.8.4 Cumulative impacts

The proposed action will be carried out in the context of concurrent and proposed future development in the Manyana area. The majority of land within 5 km of the Manyana site is zoned for environment protection, largely within Conjola National Park, or rural production, with smaller areas zoned for residential development and recreation. Most current development approvals in the vicinity are for various forms of small-scale tourist development, including a small number of cabins and caravan parks. Most of this development is to the south and to a lesser extent northeast of the site, away from Conjola National Park and any areas of mapped winter and spring GHFF habitat (refer **Figure 3.8**).

The cumulative impacts of the proposed action, when considered in conjunction with other development possibilities in the vicinity, will not be significant for the same reasons the impacts on the site considered alone will not be. When GHFF forage in the area during the winter and spring period, it is during years of mass flowering of Spotted Gum, and nectar availability is likely not a limiting factor when these mass flowering events occur. The cumulative impacts do not affect this conclusion. When the proposed action is considered in conjunction with the development planned for the area, it still represents a small and relatively low-quality fraction of the habitat available to GHFF across its range, and is unlikely to lead to a decrease in its population or interfere substantially with the GHFF's recovery.

Two planning proposals to the north east of the site have potential to result in residential development, and thus removal of native vegetation, within a vegetated area totalling up to 92 ha of summer and autumn foraging habitat (refer **Figure 3.11**). Blackbutt, however, flowers during summer when the greatest land area and total nectar production would be available for foraging GHFF and as a result, the cumulative impact to the GHFF from future surrounding development is negligible.

4 Swift Parrot

The Department in the Request for Additional Information states:

> *The Department considers the potential important foraging resources for Swift Parrot in the proposed action area have been understated given that a known feed tree for the species, Eucalyptus pilularis, was recorded on site.*

The Department requested additional information on Swift Parrot impacts and provided further comment after the Species Workshop in December 2020 (Ecoplanning 2020b).

Based on the additional assessment and analysis requested by the Department and information and analysis in the original Matters of National Environmental Significance Assessment (Ecoplanning 2020a), it is considered that Blackbutt (*Eucalyptus pilularis*) does not represent important potential foraging habitat for Swift Parrots in the region. The key points in support of this are:

- Blackbutt flowers in summer months on the site (Eby and Law 2008), while Swift Parrots are present in the region in autumn, winter and spring (Saunders and Tzaros 2011),
- Important foraging areas in the non-breeding range of the Swift Parrot are locations where large numbers have been observed foraging, or locations where birds forage with site fidelity or site persistence (Saunders and Tzaros 2011), and
- The primary threats to the Swift Parrot are habitat loss and nest predation within its breeding range in Tasmania (Saunders and Tzaros 2011).

Table 4.1 below provides brief responses to each of the Department's requests for additional information on Swift Parrot impacts and the Department's comments provided after the Species Workshop in December 2020. The remainder of the chapter provides information and analysis supporting the conclusion and key points above.

Table 4.1: Responses to Department requests for information and comments on the Swift Parrot

Information requested by the Department in its preliminary documentation requirements*	Response
Additional justification for your assessment that the quality and extent of potential foraging habitat for the Swift Parrot in the proposed action area are low.	The *National Recovery Plan for the Swift Parrot (Lathamus discolor)* excludes Blackbutt as a key tree species in the South Coast region and does not flower in winter on the South Coast when Swift Parrots are present. Refer to **Section 4.1**.
A breakdown (by PCT) of the extent of unburnt habitat within 5 km of the proposed action area that provides habitat for the Swift Parrot.	The Swift Parrot record on site is the only record in the region that does not occur in an area of mapped winter-spring foraging habitat and is an outlier in this regard. Refer to **Section 4.3**. The extent of unburnt habitat currently present within 5 km of the site is approximately 812 ha, with recovery projected as per **Section 3.5.3**.
Based on the above, an updated assessment of significance of impacts referencing the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance and criteria for a critically endangered species.	Refer to the assessment provided in Section 9 of Ecoplanning (2020a) MNES Assessment. More accurate information with regard to flowering phenology of Blackbutt (*Eucalyptus pilularis*) in the region is provided in **Section 4.1** below and **Section 3.2.3**, however, this does not affect the conclusions of the previous habitat assessment (Section 9.3 of the MNES Assessment) which formed the basis of the assessment of significant impacts. The previous assessment notes the significance of site fidelity and site persistence when assessing the importance of foraging habitat, as well as the key tree species on the South Coast – Spotted Gum, Forest Red Gum, and Swamp Mahogany – which do not occur on the site.
As required, proposals to avoid and mitigate impacts to the Swift Parrot and where necessary compensate for residual significant impacts to the species.	No residual significant impacts to the Swift Parrot will occur as a result of the proposed action; accordingly, no compensatory measures to avoid and mitigate impacts are proposed. Notwithstanding, Swift Parrots will benefit from the planting of winter flowering Swamp Mahogany in the development area, as this tree species does not presently occur on site.

* Note: No additional comments were provided by the Department after the Species Workshop in December 2020

4.1 Blackbutt

The *National Recovery Plan for the Swift Parrot (Lathamus discolor)* (**Swift Parrot Recovery Plan**) (Saunders and Tzaros 2011) separates key tree species into regions, and excludes Blackbutt as a key tree species in the South Coast region. It is likely excluded for the same reason that Blackbutt is not considered important foraging habitat for the Grey-headed Flying-fox in the South East NSW Region. Blackbutt does not flower in winter on the South Coast (refer to **Table 3.3**, **Table E.1**, and **Appendix E**). Swift Parrots are present in mainland Australia during the winter months.

Blackbutt is listed as a key tree species only in the Coastal (Hunter – Central Rivers, Northern Rivers, Hawkesbury – Nepean) region (refer to Table 1 of the Swift Parrot Recovery Plan) which does not include the site. By contrast, Spotted Gum (*Corymbia maculata*) is listed as a key tree species in the Coastal (Southern Rivers, Hunter – Central Rivers, Northern Rivers, Sydney Metro, Hawkesbury – Nepean) region, which includes the natural resource management region where the site is located (being the Southern Rivers).

4.2 Seasonal movements

All Swift Parrot records in the NSW BioNet were sorted by month, and are displayed in **Table 4.2** and **Figure 4.1**.

Table 4.2: SP records

Month	# of records
January	37
February	10
March	28
April	219
May	721
June	394
July	334
August	471
September	169
October	38
November	12
December	3

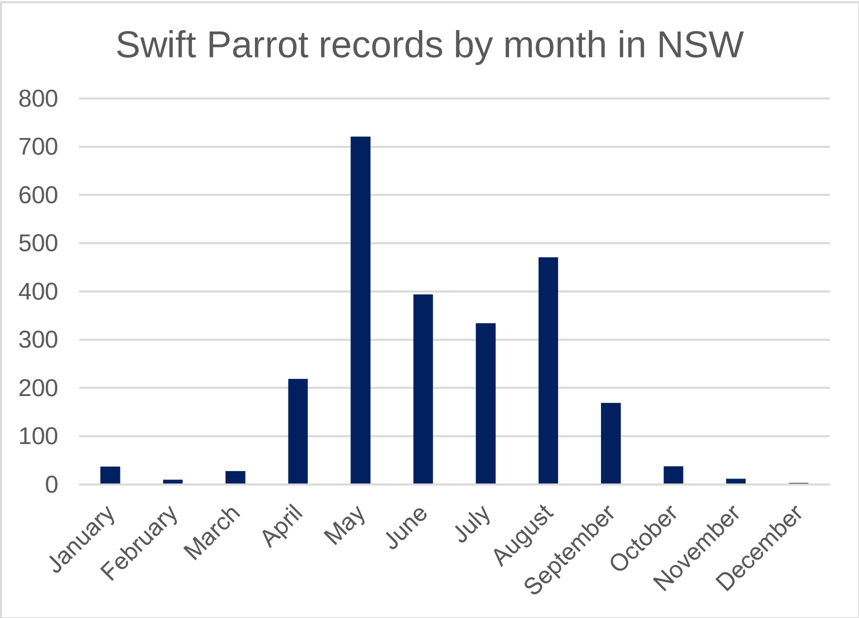


Figure 4.1: Swift Parrot records by month, all years (NSW Bionet)

Peaks in May and August correspond with annual surveys conducted by Birdlife Australia. Swift Parrots can be present in NSW during any month of the year. Most birds are not detected on the mainland until April or May when they come to their wintering habitats, and most of the population has returned to Tasmania by October (Saunders and Tzaros 2011).

4.3 Regional distribution

The regional distribution of the Swift Parrot in the area between Nowra in the north and Batemans Bay in the south is shown in **Figure 4.2** and **Figure 4.3** (BioNet records – all years). GHFF foraging habitat mapping during the months when Swift Parrots are present on the mainland (April through September) is a good proxy for Swift Parrot habitat in the South Coast region because in the South Coast the habitat rankings used to produce these map layers during the months from April-September are based largely on nectar production of trees on which Swift Parrots forage (Spotted Gum, Forest Red Gum, and Swamp Mahogany, per Table 2 of Saunders and Tzaros 2011). The Swift Parrot record on site is the only record in the region that does not occur in an area of mapped foraging habitat during these months. The Swift Parrot record on site is an outlier in this regard. Ecoplanning (2020a) MNES Assessment report contains further discussion of unusual records of EPBC Act listed species submitted during the period in early 2017 when the development site was advertised for sale. All of these submissions are outliers either:

- spatially (Swift Parrot (BioNet record User Key SJJSI0292382 recorded on 25/3/2017) – only record outside mapped April-September foraging habitat in South Coast region, only record within 5 km of Manyana, and one of only twenty-eight March records of Swift Parrot in all of NSW); or
- temporally (Greater Glider (BioNet record User Key SJJSI0292383 recorded on 15/4/2017) – only record in Manyana for nearly 10 years and in the wider locality for 5 years. Regional surveys for Greater Glider in 2021 confirm that this record is extremely anomalous (Gaia Research 2021)); or
- both spatially and temporally as well (Southern Brown Bandicoot (BioNet record User Key SJJSI0292385 on the approximate date 24/3/2017) – never recorded in Manyana before, disappeared from the wider region in the 1990s).

NSW Office of Environment and Heritage (OEH) was contacted regarding the above record of Southern Brown Bandicoot (refer **Appendix I**). The local expert officer at OEH believed that the record needed proper scrutiny because of its association with development. Accountable officers for the data holder of the BioNet Atlas, NSW OEH, then changed the source code of this record from '*sighting to possible ID*'.

The records of Swift Parrot and Greater Glider appear to be associated with the Southern Brown Bandicoot record due to sequential BioNet record User Key numbers.

Local ecologists have observed that Swift Parrot migrations apparently do not occur through the region (OMVI Ecological 2012).

Figure 4.4 displays the regional area of April-September productive foraging habitat over the GEEBAM, red and orange areas correspond to burnt canopy while green and yellow areas have intact canopy.

4.4 Key threats

As noted in the MNES Assessment (Ecoplanning 2020a), the site is unlikely to support Swift Parrots in large numbers, or with site fidelity and site persistence. In their non-breeding range, important foraging habitat areas are considered to be areas where large numbers have been seen (>40 birds observed, per the NSW Government BAM Important Area map), where there is site fidelity (>5 Swift Parrots foraging in 2 or more years, per the BAM Important Area map), or site persistence (Swift Parrots observed foraging over a period of weeks or months, per Saunders and Tzaros 2011). The site has not been identified as an important area on the BAM Important Area map and is unlikely to be identified as an important area in the future due to the lack of any of the known South Coast important food trees – Spotted Gum, Forest Red Gum, or Swamp Mahogany (Saunders and Tzaros 2011).

The primary threats to the Swift Parrot population are within its breeding range in Tasmania where increased nest predation by introduced Sugar Gliders (*Petaurus breviceps*) and clearing of Tasmanian Blue Gum (*Eucalyptus globulus*) food/nest trees threaten the species' reproductive success (Saunders and Tzaros 2011).

4.5 Assessment of significant impacts

The conclusions of the assessment of significance referencing the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* provided in the Ecoplanning (2020a) MNES Assessment (Section 9.4) remain unchanged. Tree phenology information cited in that report has been clarified in this Preliminary Documentation Submission, and more accurate data has been provided regarding range-wide phenology of the species in question, Blackbutt. However, the updated assessment in this report also leads to the conclusion that the proposed action will not have a significant impact on the Swift Parrot. A cumulative impacts analysis does not change this result, as the minimal impact of the proposed action considered on its own does not take on added significance when considered in conjunction with potential development of similar nearby sites. Nearby sites are likewise mapped as lacking potentially productive foraging habitat between April and September (refer **Figure 4.2** and **Figure 4.3**).

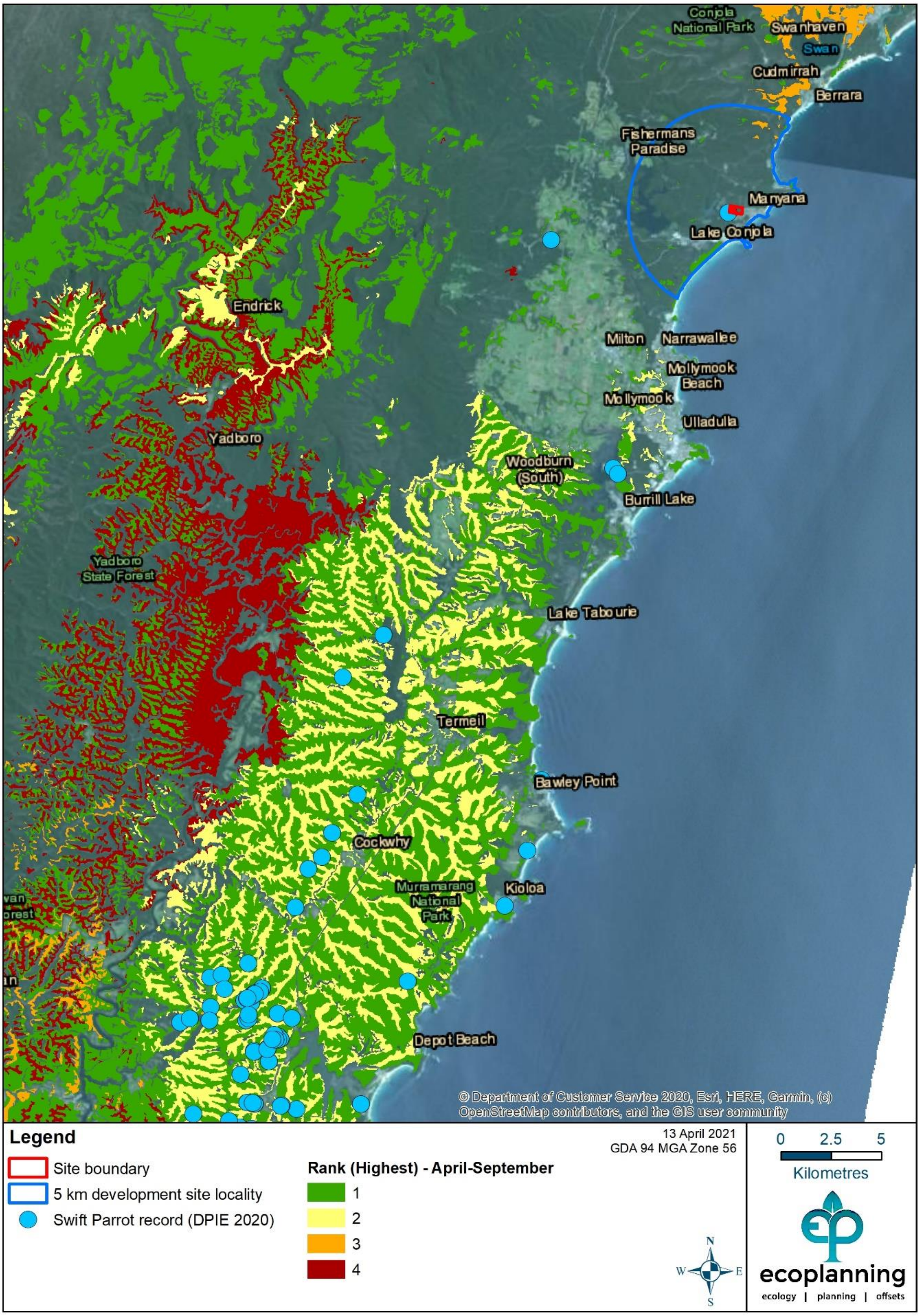


Figure 4.2: Swift Parrot records south of site

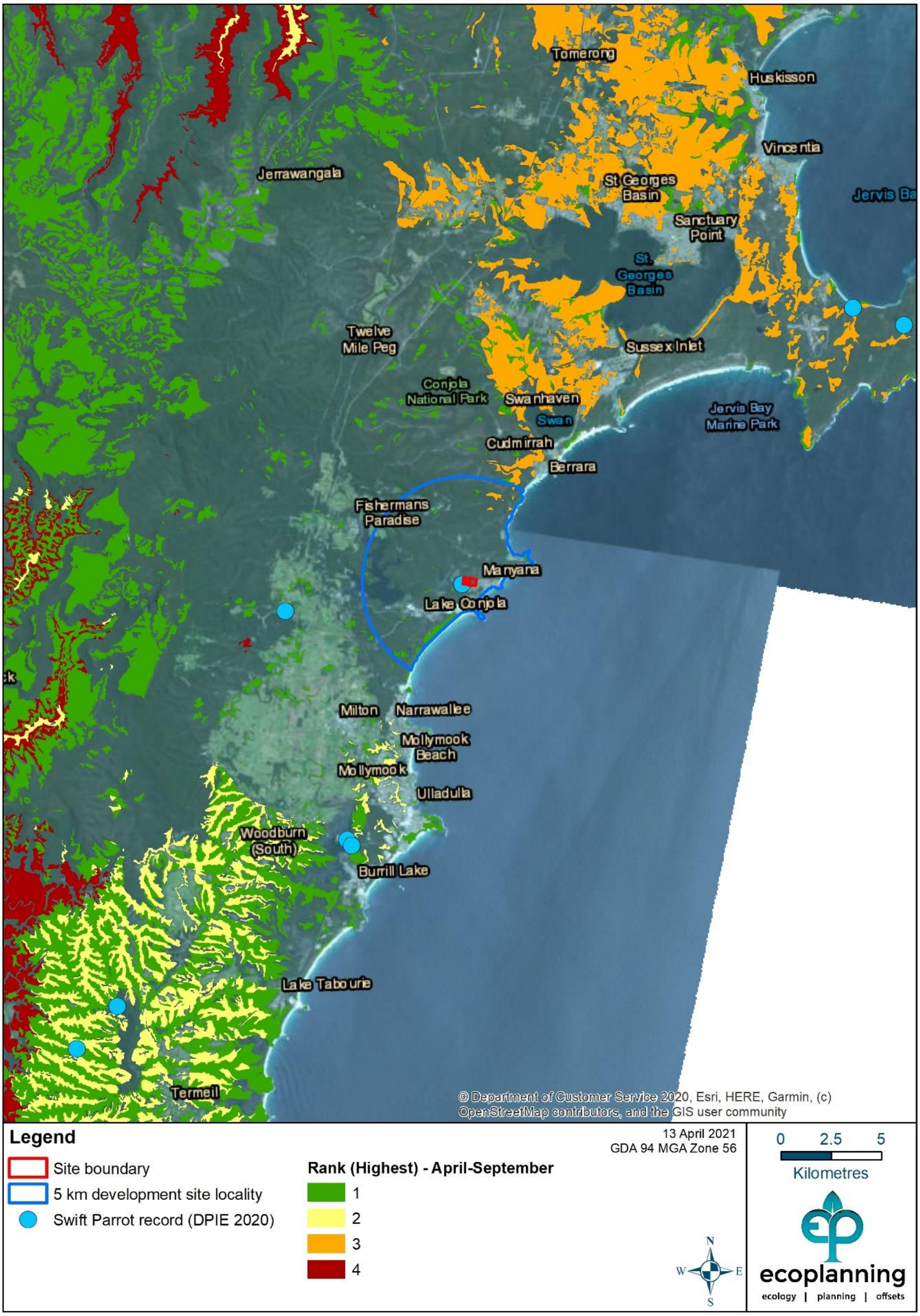


Figure 4.3: Swift parrot records north of site

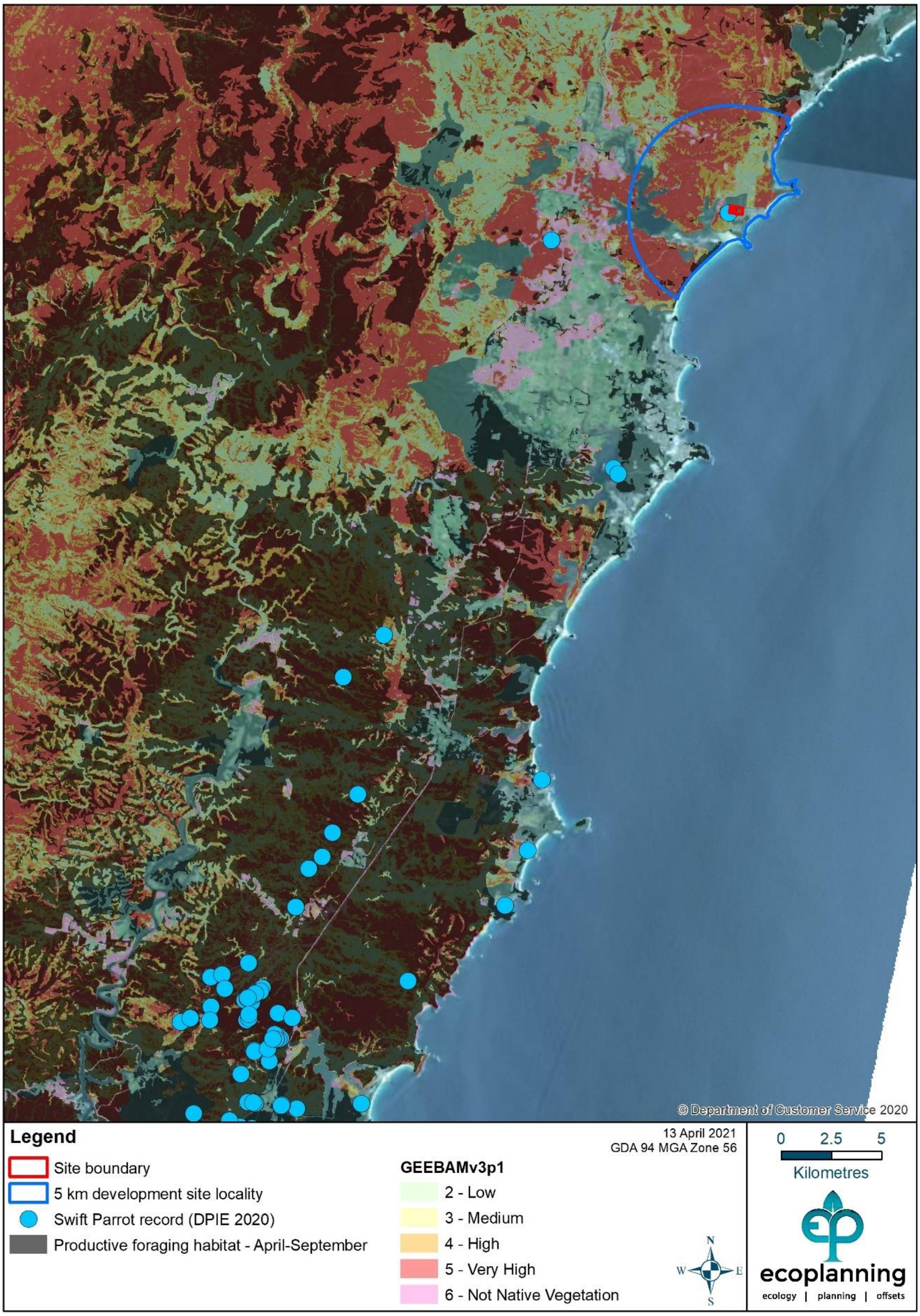


Figure 4.4: Swift Parrot records, habitat (April to September) over GEEBAM

5 Greater Glider

The Department in the Request for Additional Information stated:

> '[T]here *are uncertainties regarding your assessment of the quality of Greater Glider habitat in the proposed action area and adequacy of surveys for the species.'*

The Department requested additional information on Greater Glider impacts and provided further comment after the Species Workshop in December 2020 (Ecoplanning 2020b).

Based on the additional assessment and analysis requested by the Department and information and analysis in the original Matters of National Environmental Significance Assessment (Ecoplanning 2020a), and accounting for the attributes of forest types which support high densities of Greater Gliders compared to forest types where Greater Gliders are present at lower densities, it is considered that the site is a low-quality area of habitat which could support a low density of Greater Gliders if the species were present in the locality. There is considerable evidence, including surveys from 2021 prepared at the request of the Department, that suggests Greater Gliders are not present at the site (Gaia Research 2021). The key points in support of this are:

- Surveys conducted on the site in May-June 2020 showed that the species is absent from the site.
- Based on survey adequacy estimates used by the Department to specify post-fire survey requirements (Wintle et al 2005; Southwell 2020), the probability of a false absence (i.e. that Greater Gliders are there, but have not been detected) is estimated at <0.05.
- Surveys conducted for the Department in March 2021 along 25 transects in the area of Conjola National Park and including several on or close to the Manyana site discovered no Great Gliders at or adjacent to the site and only two Greater Gliders over the entire survey area, both at a single location approximately 10 km from the site (Gaia Research 2021).
- Based on recent regional surveys, Greater Gliders are unlikely to disperse into the site for many years, possibly decades (Gaia Research 2021; Daly 2023).

Table 5.1 below provides brief responses to each of the Department's requests for additional information on Greater Glider impacts and the Department's comments provided after the Species Workshop in December 2020. The remainder of the chapter provides information and analysis supporting the conclusion and key points above.

Table 5.1: Responses to Department requests for information and comments on the Greater Glider

Information requested by the Department in its preliminary documentation requirements	Response
Additional justification (including references to the scientific literature) for your assessment that habitat within the proposed action area represents 'poor-quality denning habitat' incorporating information from the report of the Department's independent expert which states that Greater Gliders are known to utilise hollows >7cm. *Based on the above, provide an updated assessment of the Greater Glider habitat in the proposed action area as habitat critical to the survival of the species, particularly in the context of the 2019/2020 bushfires.*	Assertions made by the Department's independent expert conflict with the published literature, the submissions of Dr David Lindenmayer, and the Department's approved conservation advice (refer to **Table 5.2** for literature review). The tree hollow data has been re-assessed (**Section 5.2.1**) and photos of all potential hollows on site can be found in **Appendix J**. The updated assessment supports the conclusion that the site contains poor-quality Greater Glider habitat (refer to **Section 5.2.1**) and is therefore not habitat critical to the survival of the species regardless of the context of the 2019-2020 bushfires. The surveys on site are sufficient to confirm that the species is absent from the site (refer to **Section 5.2.2**).
A breakdown (by Plant Community Type (PCT)) of the extent of unburnt habitat within 5 km of the proposed action area that provides habitat for the Greater Glider. *Please provide a map showing the extent of unburnt Greater Glider habitat within 5 km of the proposed action area.[1]*	The extent of 'unburnt', 'low' and 'moderate' GEEBAM burnt class field validated vegetation within 5 km of the site, which contains unburnt canopy, is approximately 812 ha (refer to **Figure 5.1**). This is the minimum area within which Greater Gliders could have survived at the time of the Currowan fire. At present, epicormic growth has returned to all areas, including 'high' and 'very high' burnt class vegetation, meaning that an estimate of foraging habitat, or habitat into which the surviving Greater Gliders could disperse, is approximately 4,000 ha, including 3,000 ha in conservation reserves (refer to **Section 5.2.3**). All of the Plant Community Types (**PCTs**) within 5 km of the proposed action area, with the exception of those found on coastal headlands and dunes, provide habitat. The total area of unburnt canopy refuge within 5 km is 812 ha. Greater Glider could have also survived the fire in refugia within GEEBAM mapped 'High' and 'Very High' burnt class areas, subject to the availability of large hollows in large old-growth trees for refuge. Of the PCTs mapped within

Information requested by the Department in its preliminary documentation requirements	Response
	5 km of the site, PCT 1283, PCT 694, PCT 1082, PCT 659, PCT 1232, PCT 1206, PCT 662, PCT 1326, PCT 1236, and PCT 1061 represent habitat for the Greater Glider.
Additional justification (including references to the scientific literature, and the reports of the Department's independent expert and Dr David Lindenmayer) as to the adequacy of field surveys for the Greater Glider carried out on site to date. *Based on the above, an updated assessment of significance of impacts referencing the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance and criteria for a vulnerable species relating to habitat critical to the survival of a species and an important population*	The field surveys for the Greater Glider carried out on the site are sufficient to determine with >0.95 probability that Greater Gliders do not occur on the site (refer to **Section 5.2.3**). The assessment of significant impacts provided in Ecoplanning (2020a) MNES Assessment has been updated (refer to **Section 5.3**).
As required, proposals to avoid and mitigate impacts to the Greater Glider and where necessary compensate for residual significant impacts to the species.	No residual significant impacts to the Greater Glider will occur as a result of the proposed action. Notwithstanding this, nest boxes that constitute suitable habitat for Greater Gliders will be installed in adjacent Crown Land and within the retained Reserve on site as part of the conditions of the development approval for the project.

[1] Note: Additional comment provided by the Department after the Species Workshop in December 2020

5.1 Literature review

A review of submissions to the Department and relevant peer-reviewed literature is provided in **Table 5.2**. The information reviewed relates to matters where the Department considered that uncertainties remain regarding the assessment of the Greater Glider provided in the Referral documentation. Passages are underlined to aid comparison between peer-reviewed scientific literature and assertions made by the Department's independent expert. **Section 5.2** contains a discussion of the literature review. As the discussion is a synthesis of the studies presented in **Table 5.2**, the source of each claim or conclusion discussed is not cited separately, however, where a source not found in the table has informed the discussion, these are cited.

Table 5.2: Greater Glider – literature review

The Department's independent expert peer review	Dr David Lindenmayer's submissions	Approved Conservation Advice (TSSC 2016)	Literature cited in the Department's expert peer review	Other relevant scientific literature
1) Tree hollow size/ denning habitat: '*Greater Gliders have occasionally been detected using nest boxes. Menkhorst (1984) reported a Greater Glider used a nest box with an entrance of 8 cm. Goldingay et al. (2020) reported detections of Greater Gliders in three nest boxes. Two of these had entrances of 7–10 cm. Most hollow-using mammals prefer hollow entrances just wide enough for them to enter, which appears to reflect a general approach to exclude competitors and predators.'*	Dr Lindenmayer letter dated 13 May 2020: *During the day it shelters in tree hollows, it shows a preference for large hollows in large, old trees (Henry 1984; Kehl & Borsboom 1984; Lindenmayer et al. 2013; Smith, Mathieson & Hogan 2007; Goldingay 2012).*	*'During the day it shelters in tree hollows, with a particular selection for large hollows in large, old trees (Henry 1984; Kehl & Borsboom 1984; Lindenmayer et al. 2013; Smith, Mathieson & Hogan 2007; Goldingay 2012).'* *'The species is particularly susceptible to threats because of its slow life history characteristics, specialist requirements for large tree hollows (and hence mature forests), and relatively specialised dietary requirements (Woinarski et al., 2014).'*	Menkhorst (1984): Two individual Greater Gliders utilised the same nest box, one in May 1979 and one in November 1979. The box was located on the edge of a mature eucalypt forest that had been heavily logged recently. The entrance diameter of this nest box was 8 cm, the interior dimensions were 28cm (depth), 682 cm^2 (cross-sectional area), 0.03 m^3 volume. Goldingay et al (2020): Of the three records of nest box occupation in this study, the interior dimensions of the boxes occupied were approximately 25 x 30 x 50 (cm).	Kehl and Borsboom (1984) A total of 67 den entrance observations (for Greater Glider), recording a mean estimated entrance diameter of 18cm ± 3cm (standard deviation) '*hollows tend to occur in the taller and larger diameter trees and that gliders selected dens in a sub-set containing the largest of the hollow trees*' Kavanagh and Wheeler (2004) Median den tree diameter 130cm, range 71-193cm (31 trees) '*Trees of this size were among the very largest in the study area.'* Lindenmayer (2002) '*Deep hollows with a large internal cavity volume are significantly more likely to be used than small shallow ones. This is particularly true for the larger species such as the Yellow-bellied Glider and Greater Glider*' Gibbons (1999) *'Hollows were more likely to be deeper - or at a more advanced stage of decay - if they had a large entrance width and occurred on a large, dead or partly dead branch'* Gibbons and Lindenmayer (2002) *It has been suggested that smaller species show a preference for hollows with an entrance dimension only slightly larger than body size, apparently in response to factors such as predation and competition (McComb & Noble 1981; Tidemann & Flavel 1987). While the smaller species in our study (agile antechinus, feathertail glider and sugar glider) occupied hollows of all entrance dimensions, they predominantly occupied hollows with smaller dimensions. The larger species occupied only hollows with the larger entrance dimensions.* *The internal dimensions of hollows, particularly hollow depth, appeared to have the greatest influence on occupancy compared with the other measured variables. In the few studies of Australian fauna in which the internal dimensions of natural hollows were measured, dimensions such as depth and internal width have been significant (e.g. Saunders, Smith & Rowley 1982; Tidemann et al. 1992; Inions, Tanton & Davey 1989a). We found that hollows only greater than around 20 cm deep were occupied in greater proportion than their availability (Fig. 2). Calder et al.* (1983) *reported an identical result for nest boxes.* *'reflects the requirement of all species to have sufficient space to adopt a sleeping or nesting position, build a nest, or sleep as part of a group.'* Goldingay (2012) '*The greater glider and common ringtail possum in eastern Australia and common brushtail and western ringtail possums (Pseudocheirus occidentalis) in Western Australia used dens with entrances of 16–18-cm diameter (Table 1). Recognising the different size classes of hollow entrances preferred by different species is important in order to evaluate the capacity of forest and*

<table>
<tr><th>The Department's independent expert peer review</th><th>Dr David Lindenmayer's submissions</th><th>Approved Conservation Advice (TSSC 2016)</th><th>Literature cited in the Department's expert peer review</th><th>Other relevant scientific literature</th></tr>
<tr><td></td><td></td><td></td><td></td><td>woodland areas to cater for the needs of different species. It is likely that the choice among smaller species (<1 kg) of tight-fitting entrances serves to exclude both competitors and predators (e.g. Menkhorst 1984; Traill & Lill 1997).'
Note: Adult Greater Gliders weigh >1kg.

Menkhorst and Knight (2010)
'Requires large tree hollows for shelter'

McLean et al (2018)
'Only hollows at least 2 cm deep and 2 cm in width (i.e. a visual cavity) were counted; this provided an index of the availability of HBTs, since we could not guarantee that every hollow was visible and because P. volans use larger-sized hollows for denning and shelter.'

Eyre et al (2004)
Hollow-bearing trees were recorded from each of the 74 sites, within 400 × 50 m transects. Live hollow-bearing trees, defined as any living stem >20 cm dbh with an observable hollow >10 cm diameter entrance, were identified to species and classified into 10 cm dbh classes. The 10 cm diameter entrance threshold was based on studies by Kehl and Borsboom (1984) who found that hollows used by Greater Gliders were characterized by a mean diameter entrance of 18 cm, and Mackowski (1984), who suggested that hollows with entrance diameters of 8-15 cm were suitable for use by both Yellow-bellied and Greater Gliders.

Smith et al (2007)
'Dens occurred mainly in older, large 'late mature' and 'overmature' live trees (dbh 50+ cm) and stags. It is the dead stags and the larger, older live trees that are more likely to contain hollows, owing to their age and extent of decay. Use of larger and older trees within forest stands by greater gliders has been reported elsewhere (e.g. Davey 1989; Lindenmayer et al. 1991b; Kavanagh & Wheeler 2004; Kehl and Borsboom (1984)'</td></tr>
<tr><td>2) Hollow-bearing tree density/ habitat:
'Whilst Greater Gliders are dependent on tree hollows for shelter it is inaccurate to imply that a large number of hollows is required per individual. Some tracked Greater Gliders have used only 1–2 dens (Goldingay 2011). It is a point debated in the literature.'</td><td>Dr Lindenmayer letter dated 26 May 2020:
The Greater Glider is dependent on hollow-bearing trees (Gibbons et al. 2002)and individual animals need access to cavities in a range of different trees as part of den-swapping behavior (Kehl & Borsboom 1984; Lindenmayer & Hobbs 2004).</td><td>'It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows (Andrews et al., 1994; Smith & Smith 2016; Kavanagh & Kavanagh 2000; Eyre 2004; van der Ree, Bennett & Gilmore 2004; Vanderduys, Kutt & Kemp 2012).'
'In the Grafton/Casino FMA, the greater glider was absent from surveyed</td><td>Goldingay (2012)
Table 1
Number of dens (tree hollows) used:
<table><tr><th>Ref #</th><th>3</th><th>4</th><th>5*</th><th>6</th><th>7</th><th>2</th></tr><tr><td>Mean</td><td>7.4</td><td>5.1</td><td>3.1</td><td>4.3</td><td>11</td><td>-</td></tr><tr><td>Range</td><td>4-18</td><td>4-6</td><td>1-7</td><td>2-13</td><td>4-20</td><td>-</td></tr></table>*Ref 5 = Kavanagh and Wheeler (2004)
Six studies reviewed
444 observed den trees in total</td><td>Smith et al (2007)
'The greater glider has one of the highest known demands for hollows of any of the arboreal marsupial species that inhabit the sclerophyll forests of eastern Australia, utilising up to 20 hollows per 2 ha of home (Kehl & Borsboom 1984; Eyre 2002).'
'While suitable food availability is likely to be an important determining factor of greater glider density, it is likely that den trees, at densities as low as 0.8 trees ha–1, have become a limiting resource in Barakula'

Kavanagh and Wheeler (2004)
Median den tree diameter 130cm, range 71-193cm (31 trees)
'Trees of this size were among the very largest in the study area.'

McKay (2008)</td></tr>
</table>

The Department's independent expert peer review	Dr David Lindenmayer's submissions	Approved Conservation Advice (TSSC 2016)	Literature cited in the Department's expert peer review	Other relevant scientific literature
		sites with fewer than six tree hollows per hectare (Smith, Moore & Andrews 1994). In southern Queensland, greater gliders require at least 2-4 live den trees for every 2 ha of suitable forest habitat (Eyre 2002).' *'the species is highly dependent on forest connectivity and large mature trees.'*		'*The abundance of the Greater Glider in undisturbed forest is in strong contrast to its absence from pine plantations and its paucity is regenerated forest which lacks old trees with hollows suitable for nesting*.' Goldingay (2012) *'All mammal species used a mean of more than one tree hollow per individual (Table 1). Mean values for the greater glider varied from 3.1 to 11 and for the common brushtail possum from 2.2 to 12.'* McLean (2018) *'The effect of logging may relate to its propensity to reduce hollow density (McLean et al., 2015), with previous correlations having been identified between the densities of tree hollows and of P. volans (Lindenmayer et al., 1990b; Eyre, 2006).'* *Previous studies have identified hollow-bearing tree density and the percentage cover of the forest canopy as key habitat features required to maintain high density populations of P. volans (Kavanagh & Kavanagh 2000; Eyre 2006).* *It is important to note, however, that the minimum densities of hollow-bearing trees in this study (8/ha in WSF and 12/ha in DSF) were likely to have exceeded the minimum requirements for occupancy by this species (Kavanagh & Wheeler 2004b; Kehl & Borsboom 1984).* Lindenmayer (2002) In a sample of 200 trees, tall, large diameter trees were most likely to be den sites. Greater Gliders use multiple dens, show den swapping behaviour, and may occupy all suitable available hollows within 1-2ha habitat. Pp. 67 Figure 6.5 – predicted number of Greater Gliders increases with number of tree hollows per three hectares, from 5 trees with hollows/3ha = 0.6 x Greater Gliders, to 20/3ha = 1.4 x Greater Gliders. In SE Qld, Greater Gliders are often absent from sites supporting <6 HBTs/ha
3) Dispersal ability/ local population post-fire recovery: *The species has been detected dispersing up to 3–7 km (Tyndale-Biscoe & Smith 1969; Taylor & Goldingay 2009) so dispersal into or out of the subject site is possible. A metapopulation simulation study that employed a model with a mean dispersal distance of 2 km closely predicted the observed number of patches occupied by Greater Gliders out of 39 patches embedded within an exotic pine plantation (McCarthy, Lindenmayer & Possingham 2001).*	Dr Lindenmayer letter dated 26 May 2020: *Greater Gliders may also be sensitive to fragmentation partly because of their low dispersal ability (Eyre 2006; McCarthy & Lindenmayer 1999; Taylor & Goldingay 2009). Notably, individuals of the Greater Glider are killed when their habitat is destroyed (Tyndale-Biscoe & Smith, 1969) – animal do not move outside of the home range at this time.*	*Notwithstanding relatively small home ranges, but in part because of low dispersal ability, greater gilders may be sensitive to fragmentation (Eyre 2006; McCarthy & Lindenmayer 1999; Taylor & Goldingay 2009)*	Taylor et al. (2007) '*The other was a subadult caught in patch 1908, 7-km distant through pine plantation from patch f2 in which both its assigned parents resided*.' '*its conversion to an exotic Pin. radiata plantation where animals cannot persist*.' *'Although one long distance dispersal event to a remote patch was inferred in this study (f2 to 1908), the generally low degree of admixture in such isolated patches suggested that long distance dispersal events through pine are rare*.' Tyndale-Biscoe &Smith (1969)	Pope et al (2004) '*The P. radiata plantation surrounding the eucalypt patches provides few feeding or denning opportunities for P. volans*' '*One individual from this study travelled over 1 km from patch 276b to Patch E3.*' Eyre (2006) *'The glider feeds predominantly on eucalypt foliage, a low nutrient and highly toxic diet which influences the sedentary and solitary socio-ecological traits of the species (Kavanagh & Lambert, 1990; Foley et al., 2004).'* Taylor and Goldingay (2009) *'greater gliders may be vulnerable to death during the passage of fire. Furthermore, the loss of the greater glider's eucalypt foliage food resource for*

The Department's independent expert peer review	**Dr David Lindenmayer's submissions**	**Approved Conservation Advice (TSSC 2016)**	**Literature cited in the Department's expert peer review**	**Other relevant scientific literature**
			'needs to be emphasized here that it was an area of forest isolated on nearly all sides from other forest by farmland and pine plantations' *'Of the 164 adult and immature animals released in the northern half, sixteen were recaptured in the southern half but, except for one animal which traversed a distance of 2 miles (3.2 km), these were all recoveries in adjacent blocks after a short interval of time. This result therefore supports the hypothesis that most animals die in situ without migrating out of their original home range.'* *'the few ultimate survivors were generally those whose immediate habitat had not been entirely destroyed'* *'survival depends on the chance of a part of the home range being left undisturbed'* *'It was concluded from this that the displaced gliders die in situ rather than emigrate to occupied forest and die there through failure to become established.'* McCarthy et al (2001) *'Because hollow development in eucalypt trees relies on fungal decay of the wood, such cavities take more than 100 years to develop and are absent from the pine plantation'* *'The ALEX models for the four species of arboreal marsupial predicted that the population densities in the* [pine plantation] *patches would be lower than in continuous forest, and hence, patch occupancy rates would also be lower. This qualitative prediction only received conclusive support from the field data for greater gliders.'* *'any model can only be a good approximation in certain circumstances'*	*at least a week following fire may lead to some mortality. We expect that the nutritional stress caused by this for surviving individuals would result in a decline in reproduction in the following year.'* McLean et al (2018) '*Thus, direct effects of fire appear critical in determining the abundance of P. volans. Such direct effects may have several causes, with the most likely being high mortality as a response to lethal heating during fires (Lindenmayer et al. 2013; Lunney 1987; Goldingay & Kavanagh 1991; Bradstock et al. 2005). If mortality is high, maintenance of populations will be dependent on reproductive rates and opportunities for dispersal and recolonisation (Bradstock et al., 2005; Chia et al., 2016). P. volans has a low reproductive rate, with only a single offspring being produced each year, with not all females breeding in any given year (Tyndale-Biscoe & Smith, 1969).*' *'The results from McLean et al. (2015) suggest that fires may be used to assist the production of additional tree hollows, however an important caveat is that the suitability for occupation by fauna of hollows created by fire is currently unknown. The importance of topographic refugia in providing a source population from which recolonization can occur after fire also requires further investigation.'* Berry et al (2015) '*The greater glider and the mountain brushtail are the only species known to persist in burnt mountain ash forests, the former within or near areas of intact canopy and the later in burnt areas presenting intact tree hollows (Lindenmayer et al. 2013). Therefore, it is likely that these species may be able to recolonise the burnt landscape from in situ refuges*.' Lindenmayer et al (2013) *A paucity of food also may explain the Greater Glider's decline from sites burnt at high-severity. The Greater Glider has a diet comprised exclusively of eucalypt leaves (Hume 1999) but few trees survived on our sites subject to high severity fire. In addition, the Greater Glider is a temperature-sensitive organism (Rubsamen et al. 1984) and high temperatures may have led to substantial levels of mortality on sites subject to high severity fire.* Gibbons (2002) *Trees under physiological stress are predisposed to forming hollows because of an increased instance of wounds that expose heartwood (e.g. through branch shedding) and a reduced capacity to occlude such wounds (Gibbons et al. 2000). Trees with a fire scar also contained hollows occupied by fauna in greater proportion than expected. Fire is known to predispose trees to attack by decay-causing organisms such as fungi and termites (McCaw 1983). Fire can also directly excavate hollows. For example, the number of trees used as den sites by the western ringtail possum Pseudocheirus occidentalis and common brushtail possum on one site in Western Australia increased from 82 before, to 254 three years after, a wild-fire (Inions, Tanton & Davey 1989b).*

The Department's independent expert peer review	Dr David Lindenmayer's submissions	Approved Conservation Advice (TSSC 2016)	Literature cited in the Department's expert peer review	Other relevant scientific literature
				Hollow formation can also be instigated in trees by stochastic processes (e.g. fire), and therefore hollows can develop in young trees (Gibbons et al. 2000)
4) Detection probability: *'The study area used in that study contains areas that have supported relatively <u>high densities of Greater Gliders</u> (0.3–1.3/ ha; Kavanagh 1984). The question that arises is whether the detection probability derived in one geographic area in one year can be applied indiscriminately in other geographic areas and in any year.'* *'Although the density of Greater Gliders in the coastal area surrounding Manyana is unknown the relative dearth of records suggests it is a <u>low density area</u>. This may produce a <u>lower detection probability</u> than estimated elsewhere.'*	No reference to detection probability in Lindenmayer submissions dated 13 May or 26 May 2020. Dr Lindenmayer Expert Report dated 10 June 2020 *'Whilst the Greater Glider is the most detectable of the various species of nocturnal arboreal marsupials (Lindenmayer 2002), it is nevertheless readily missed in spotlighting surveys, even by highly experienced observers <u>(Lindenmayer et al. 2001)</u>.'*	Southwell (2020) 5 nights spotlighting survey to achieve detection probability of 0.97	Dr Lindenmayer's Expert Report (10 June 2020) cites: <u>Lindenmayer et al (2001)</u> Patch C3 in this study was 20.1 ha. The transect survey method used in this study was similar to ANU surveys of the Manyana site (which is 20.4 ha) in May-June 2020. The study compared spotlighting detection success of known radio-tracked Greater Gliders (the person spotlighting was not told the location of radio collared Greater Gliders). Patch C3 was surveyed over 3 nights, the Manyana site was surveyed 10 nights. One observer surveyed patch C3. Two to six observers surveyed the Manyana site. 3 x 600m transects were established at patch C3. 6 x 300 m transects were surveyed at the Manyana site. The possibility of detecting a Greater Glider known to be in a patch on a given night was 26% across the whole study. Given the Greater Glider location was known, the probability that a person spotlighting on the transect passing by the radio-collared Greater Glider and detecting that animal on that pass was 8%. The number of passes undertaken on each transect on each night by Ecoplanning (2020a) was not recorded. Given that 2 to 3 teams (2 observers per team) walked 6 transects over a period of 5.5 – 6.5 hours each night on three of the nights (31 May to 2 June), completing each transect in 15 to 30 minutes, approximately 20 to 80 passes would have been completed on each night, with double the number of observers per pass. Lindenmayer et al (2001) completed a total of 45 transect passes of a single observer during the entire 5-night study. Ecoplanning (2020a) per night detection probability is therefore likely to be far greater than the 26% per night probability reported in Lindenmayer et al (2001) due to more passes, more transects, and more observers. Ecoplanning (2020a) per pass detection probability is likely to be greater due to two observers per pass instead of one.	Wintle et al (2004) Table 2 – Detection probability model for Greater Glider: logit(d) = -1.85 + 0.08T + 3.74H Variable H = habitat quality; T = ambient temperature *'habitat quality may affect the density of individuals present'* *'We expected areas of high habitat quality to support higher numbers of individual animals, making it more likely that we would observe at least 1 individual in a given survey. We found habitat quality, represented by the variable H, to influence the detectability of 2 species (Table 2), probably through its role in mediating animal abundance.'* *'Increasing the duration of visits to a site may improve the likelihood of detecting a species with small home ranges that are fully contained within the area of interest, such as the greater glider.'* *'Spotlighting was used primarily for the detection of greater gliders and common ringtails, though we occasionally found the other gliders in this way. We covered the area of spotlighting by walking 80 m to the 4 cardinal points on the edge of the plot, returning to the centre of the plot in an arc on each occasion. If owl or glider calls were heard during the spotlighting period, we recorded the species as present. <u>We spent 65 minutes at each site</u>.'* The model of detection probability allows for the possibility of lower quality sites resulting in lower density of animals and lower detection probability. The duration of Ecoplanning (2020a) surveys (up to 6 observers surveying for up to 6 hours) is very likely to have increased the detection probability above that estimated by Wintle et al (2004). The single-visit detection probability for Greater Glider reported in Wintle et al (2004) is 0.41±cl for 65 minute spotlighting survey within a ~2 ha area. Wintle et al (2004) detection probabilities are derived from approx. 0.5 person-hours survey per hectare per night (65 minutes ÷ 2 ha ÷ 1 night); Ecoplanning (2020a) undertook approx. 0.5 person-hours of survey per hectare per night (114 person hours ÷ 20 ha ÷ 10 nights). Victoria Department of Sustainability and Environment (2011) *Approved Survey Standards: Greater Glider Petauroides volans* '*Where Greater Glider surveys are conducted under optimal conditions (high habitat quality, warm temperatures with no rain, fog or bright moonlight) a minimum of 2 repeat visits is recommended for a 40 min / 2 ha transect (sensu Wintle et al. 2005). In areas containing lower quality habitat and/or under colder temperatures, five or more repeat visits of the 40 min / 2 ha transect are needed to provide an equivalent probability of detection of Greater Gliders (Wintle et al. 2005).*'

5.2 Discussion

5.2.1 Habitat

Tree hollow size

The Department's independent expert has asserted that hollows as small as 7 cm entrance size should be considered denning habitat for the Greater Glider. This assertion is based on observations of three den sites, all in nest boxes. Nest boxes are far more likely to contain significantly larger interior dimensions than entrance dimensions (for example, 7 cm diameter nest box entrance opening into a much larger, ca. 25 cm diameter cavity) when compared to natural tree hollows. Any application of 7 cm entrance diameter as a standard for suitable tree hollows would have to include only hollows which could potentially open to a large interior cavity. In some instances, it is impossible that a 7 cm diameter entrance hollow could accommodate a Greater Glider, because the hollow is located in a branch not much larger than 7 cm in diameter. In other instances, hollows >7cm open vertically in the main trunk of a tree or stag which is also open at the base, and therefore would not be used by a Greater Glider as the hollow would lack a floor on which the glider could rest. Notably, the abundance of observations in peer-reviewed literature of Greater Gliders occupying very large hollows (Goldingay 2012) conflicts with the Department's expert's suggestion that the species would prefer hollow entrances just wide enough to enter, and where this preference has been observed, it has been in small (<1 kg) arboreal mammals and not in larger (>1 kg) species such as the Greater Glider (Goldingay 2012).

The hollow bearing tree data used in the Ecoplanning (2020a) MNES Assessment has been re-assessed. **Appendix J** contains photos of all 34 tree hollows in the >7 cm size class recorded on the site. The 34 trees counted as potential den sites include a number of hollows in less suitable conditions, such as at the top of dead stumps or located 3 or 4 m above ground level. Detailed measurement of the interior dimensions of these hollows is not possible until after the trees are felled, but as shown in the photos, it is doubtful that many of these hollows could accommodate an animal the size of a Greater Glider, or in the case of vertical entrances at the top of a tree's main stem, whether these hollows would be suitable for occupation.

Using 7 cm as a minimum as suggested by the Department's independent expert, trees were classed as likely, possible, and unlikely on the basis of whether the hollow could contain interior dimensions large enough to accommodate a Greater Glider and whether the position of the hollow (height in tree, vertical opening) would be suitable. All 34 trees on site with >7 cm diameter entrance hollows are shown in **Appendix J** (**Plate J1** – **Plate J36**). Note that this classification does not relate to the likelihood that the hollows could be used by Greater Gliders, only the likelihood of the hollows being of a size capable of containing a Greater Glider. On the basis of the literature reviewed (**Table 5.2**), all hollows on site, even those classed in **Appendix J** as 'likely', would be unlikely to be utilised by Greater Gliders as none of the hollows on site conform with what has been reported in the literature as preferred den sites, being large (>15 cm diameter) hollows in large (>100 cm dbh) old (>150 years) trees.

Examples of additional trees in the >7 cm size class, but which are definitely not suitable as well as some trees in the <7 cm size class are shown in **Plate J37** – **Plate J38**. Generally, the site contains some large hollows which are clearly not suitable (**Plate J7**), some hollows which are >7 cm but in small branches (**Plate J1**), and many hollows which are very unlikely to have developed large interior cavities owing to the young age of the tree (**Plate J11**) or the obviously young age of the hollow due to its occurrence in a recently broken branch (**Plate J12**).

Denning habitat

If only trees in the >7 cm range which are likely to be capable of occupation by Greater Gliders are included in the total, then the total number of suitable dens on the site is 19, or 0.9 per hectare. Even so, the figure cited in Ecoplanning (2020a), which is 0.75 per ha, is likely to be more accurate.

Notwithstanding the above outlined likelihood of Greater Gliders actually using the hollows <15 cm found on site (see **Table 5.2**), applying the standard suggested by the Department's independent expert results in 34 potential den sites within 20.4 ha, or 1.7 hollows per hectare.

All of the above figures are at the lower end of the range of hollow bearing tree densities documented in areas occupied by Greater Gliders. Many studies have not classed denning habitat by hollow entrance diameter (likely due to the difficulty of locating, estimating size, and classifying hollow attributes from ground level), but instead have recorded diameter at breast height (DBH) and species of den trees. Of the tree hollows recorded on site, only one occurred in a living tree >100 cm DBH, and the majority occurred in trees between 30cm DBH and 70cm DBH. This is at the smaller end of the range of tree sizes where Greater Glider dens have been recorded (refer to Table 1 of Goldingay (2012)). Many studies have noted that the trees chosen by denning Greater Gliders are among the largest found in the study area (refer **Table 5.2**). The peer-reviewed literature reviewed for this PD and the Department's conservation advice indicates that not only large hollows are preferred for denning, but large mature ('late-mature' or 'overmature') trees. Most of the hollows on site are in smaller mature trees, which would be referred to as 'mature regrowth' in arboriculture or forestry. Smaller, younger trees are less likely to have developed hollows with sufficient interior dimensions because the process of hollow formation is likely to be less advanced.

The conclusion that the site represents 'poor-quality denning habitat' is based on all of the above factors, summarised as follows:

- Relatively low number of suitable hollows per hectare (0.75/ha)
- Relatively small size of hollow bearing trees (one >100 cm, majority 30 – 70 cm DBH)
- Generally poor condition of many tree hollows observed, being either recently formed (at base of recently broken branch), low height (<6 m), opening vertically, or in small branches

Habitat quality

The habitat quality of the site is characterised more broadly below, accounting for denning habitat, foraging habitat, landscape topography, vegetation structure, interspecific competitors, and population viability of the previously occurring Greater Glider(s) on site.

The low to moderate density of suitable hollows (depending on which metrics are used to determine suitability), low fertility sandy soil, coastal low altitude forest (11.9 ha of forest on site) and woodland (5.32 ha on site) habitat which is not in the vicinity of major drainage lines or within a sheltered topography, together support the categorisation of the site as a 'low-quality' habitat area. Additionally, high densities of Common Brushtail Possums were observed during surveys of the site – up to 13 individuals in one night. Increased food availability within surrounding residential areas, as well as feeding stations within the site set up by local residents, have likely to contributed to greatly elevated numbers of this species on the site compared to the surrounding forests. Common Brushtail Possums are a known nest competitor for large hollows (Olsen and Trost 2009) and could exclude Greater Gliders from available hollows.

The broad characterisation of the site as 'low quality' habitat is further supported by observations of Braithwaite et al (1983) that Greater Gliders were distributed along a nutrient gradient, with greater densities of gliders in areas with higher foliage nutrient concentrations. Davey (1984) likewise found that foliage biomass was a predictor of the density of Greater Gliders. These studies would suggest that the sandy (tertiary sedimentary) soils of the site, occurring on gently sloping land away from any large drainage lines, would be unlikely to sustain vegetation with nutrient concentrations and foliar biomass that would sustain high densities of Greater Gliders. A large portion of the site (5.39 ha) is an open woodland structure which would also provide poor quality habitat due to the Greater Glider's preference for forests with interconnected canopy that enable economical movement between trees (Kavanagh and Wheeler 2004). The Department's independent expert likewise asserts that the area surrounding Manyana may have always supported only low-density populations of Greater Gliders. Habitats capable of supporting lower densities of individuals would naturally be considered lower quality than habitats supporting high densities.

The site, when it was utilised by Greater Gliders, was more likely a marginal area of habitat into which juveniles might disperse and where animals could perhaps become established during times when a local population is in good condition (higher fecundity), environmental conditions are favourable (e.g. an extended period of above average rainfall; few predators such as Powerful Owls present), and animals are expanding into the limits of potential occupancy. As evidenced by the disappearance of Greater Gliders from the site pre-fire, the site is definitely not a source population for the locality, is unlikely to have supported a stable population over the past 20 years, and is highly likely to have been a population 'sink' wherein deaths exceed births of resident individuals. This is empirically true because Greater Gliders were present on site previously, and now they are not present; therefore, deaths/ emigration exceeded births/ immigration within the site in the recent past.

The presence of Greater Gliders, when they occurred on the site in the recent past, was likely supported by immigration from surrounding areas, and is unlikely to have contributed to net migration out of the site, due to the low availability of hollows, reduced habitat quality along the urban interface (including competition for hollows with abundant Common Brushtail Possums), position in the landscape and relative quality of foraging resources. The preservation of an area of habitat which has demonstrably not served as a source population for Greater Gliders in the wider landscape in the past 20 years would do little to facilitate the recovery of the local population presently or in the near future.

The site is very unlikely to be capable of supporting a viable population of multiple breeding individuals at all. BES (2006) noted the following in relation to the habitat quality on site:

- *'there are only a few large, mature trees'*
- *'approximately 36 hollow bearing trees that provide potential roosting and denning habitat for a range of common fauna species. Tree hollow roost or nest sites suitable for threatened owls, cockatoos, gliders and microchiropteran bats are very limited in the study area and represent relatively low quality resources for these species.'*
- *'Whilst the study area is relatively undisturbed there are few old-growth elements, and the vegetation appears to have been affected by historic selective logging, wildfire and prescribed fire.'*
- *'The study area appears to support a relatively low abundance of prey species for the Powerful Owl which is probably the result of the relatively low abundance of tree hollows.'*

The Ecoplanning (2020a) MNES Assessment included a habitat assessment (Section 5.3 and 5.5) which is consistent with the observations of BES (2006).

ANU researchers have also conducted a habitat assessment of the site on behalf of the Environmental Defenders Office (EDO) but have not reported the results of this habitat assessment, nor has this habitat assessment been provided to the Department or to the proponent. Habitat surveys were undertaken by ANU researchers at five locations along six 300 m long transects, each parallel transect was ca. 75 m apart. These surveys quantified the number of large trees (30-50 cm and >50 cm) in a 20x20 m (0.04 ha) quadrat. Data from this habitat assessment has not been provided to Ecoplanning, but it is assumed to be used to determine the age class and habitat suitability for targeted fauna, in particular the Greater Glider.

The forests found on site would be referred to in arboriculture or forestry as 'mature regrowth' as the site would have been cleared at some stage in the past century, and the trees which have returned to the logged site have reached mature age – most are likely to be between 40 and 100 years old. None of the trees anywhere on site could be described as 'old-growth', and none are similar to the old-growth tree pictured in **Plate 2**.

All of the factors described above were considered when the site was characterised as a 'low quality' habitat area by Ecoplanning (2020a).

Habitat values of burnt forests

The effects of fire on the landscape-wide availability of foraging and denning habitat for Greater Gliders are discussed below.

<u>Forage</u>

The evidence from peer-reviewed literature, as well as the contemporary observations of Greater Gliders among epicormic growth in burnt forests in the region (Craven and Daly 2020; Gaia Research 2021) and elsewhere (Cornwell et al 2021), is that fire impacts Greater Gliders via direct mortality in the fire, followed by starvation in the weeks or month immediately following the fire when no foliage is available on which to feed (Taylor and Goldingay 2009;

Lindenmayer et al. 2013; McLean et al. 2018). Foraging habitat returns when epicormic growth returns to the areas of burnt forest. Severe famine can occur immediately following fires, but Greater Gliders can survive in the post-fire environment in unburnt, lightly burnt, and regenerating trees (Lunney 1987). Smoke may induce prolonged torpor in some glider species, potentially allowing for survival in some burnt landscapes (Nowack et al 2017; Stawski et al. 2017). Regarding the status of Greater Gliders at burnt sites, Lindenmayer et al (2008) observes:

'They [the population declines] *are unlikely to be related to shortages of food because observed declines encompassed both burnt and unburnt areas. Moreover, rapid growth of epicormic shoots characteristic of many species of trees and shrubs in burnt areas would have provided a substantial amount of food for these folivorous, or partially folivorous, species of arboreal marsupials'*

Dens

The relationship between fire and the creation/destruction of tree hollows is complex. Tree hollows are often excavated by fire, and the damage to trees caused by fire can provide entry points for cavity excavating organisms (fungi, termites) to enter the heartwood of the tree (Gibbons 1999). Increased fire frequency can increase the availability of hollows in the landscape (McLean et al 2015). Greater Gliders have been observed in 'high' and 'very high' burnt class forests where no unburnt denning refuge would have been available (Cornwell et al 2021; Gaia Research 2021) and previous studies of Greater Glider response to bushfire have not assumed that fire removes denning habitat from the landscape, instead assuming that burnt areas provide habitat for Greater Gliders as soon as epicormic growth returns to the canopy (Lindenmayer et al 2008; McLean et al. 2015).

While the passage of fire may destroy some hollows, fire does not remove denning habitat from the landscape. Fire is an important part of the process of creating new hollows, both through direct excavation of hollows and by creating entry points for hollow excavating organisms (Inions et al. 1989b; Gibbons 1999; Gibbons et al. 2002; McLean et al. 2015).

Greater Gliders are slow to recolonise burnt areas (Lindenmayer et al 2011; Kavanagh 2004). This is due to the species' low reproductive rate, small home range, and low dispersal ability, and not because burnt areas are slow to recover to a condition suitable for Greater Glider occupation. Greater Gliders are capable of utilising regenerating forest as soon as the foliage returns to burnt trees (Lindenmayer et al 2008). Where Greater Gliders are extirpated from an area due to mortality in high intensity canopy fires, the species is slow to return because it takes many years for offspring from surrounding source populations to disperse into the fire affected areas – and not because of the habitat attributes of the burnt sites themselves. From the Approved Conservation Advice (TSSC 2016):

'Reoccupation of burnt sites in subsequent years is likely to be a slow process due to the small home ranges (1−2 ha) of the species and its limited dispersal capabilities (L. Lumsden pers. comm., cited in Vic SAC 2015).'

It assumed for the purposes of this assessment that all areas burnt at 'high' and 'very high' burnt class do not harbour viable, surviving Greater Glider populations, though anecdotal reports exist of Greater Gliders surviving within fire grounds far from unburnt refugia (Cornwell et al 2021; Gaia Research 2021). A Greater Glider in this situation may have survived the fire by sheltering in a hollow insulated from the passing fire (see **Plate 3**). Recent surveys of Conjola National Park conducted by Gaia Research have also located Greater Gliders within the fire grounds and far from unburnt refugia (see **Figure 5.2**, **Figure 5.3**, **Plate 2** and **Plate 4**). All areas of regenerating forest, which total approximately 4,000 ha within 5 km surrounding the site, have potential to provide both foraging habitat and denning habitat for Greater Gliders.

All ‘low’ and ‘medium’ burnt class forests represent places where Greater Gliders would have survived the passage of fire, as tree canopies and often understorey shrubs remain unburnt in these areas, as confirmed by ground-truthing surveys (Ecoplanning 2020a). Greater Gliders would not have suffered direct mortality through lethal heating in these areas. There is no evidence in the literature that arboreal mammals suffer mortality by smoke inhalation alone during the passage of fire. Studies have found that some glider species respond to smoke by extending torpor, which may allow them to survive through the post-fire landscape until food resources return (Stawski et al 2017; Nowack et al 2017). Foliage was present in the ‘low’ and ‘medium’ burnt class areas immediately post-fire and would have provided forage for Greater Gliders. If a population had persisted in the 812 ha of unburnt canopy surrounding the site, dispersing individuals from this population could now reoccupy the surrounding regenerating forests. Refer to **Figure 5.1** showing the extent of Greater Glider habitat within 5 km of the site. Note that, with regard to the Currowan fire, the area shown in green in this figure greatly underestimates, the actual area within Greater Gliders are capable of having survived the fire.

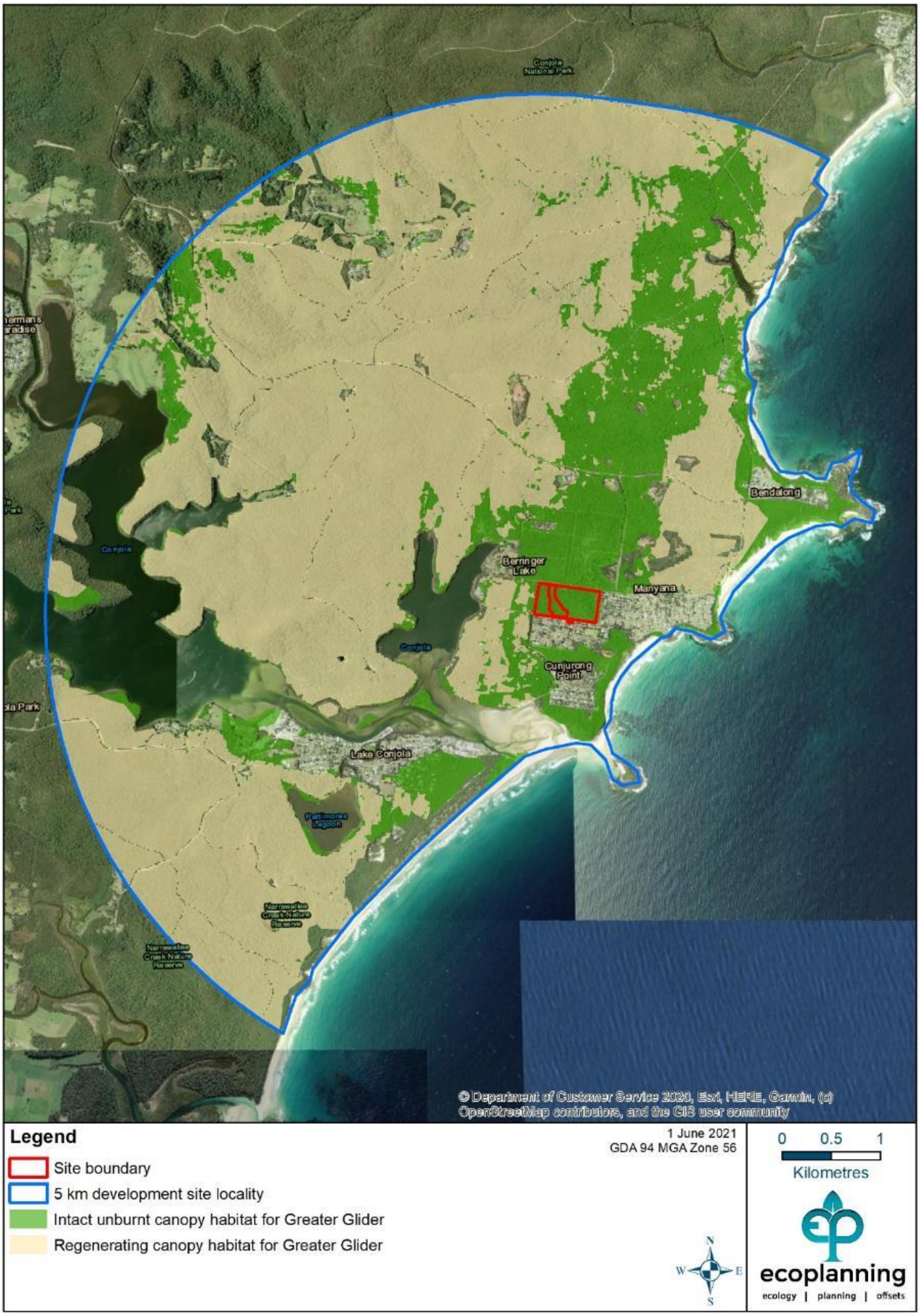


Figure 5.1: Greater Glider habitat

Regional record after the Currowan fire

At least one Greater Glider has survived the passage of the Currowan fire at a location approximately 10 kilometres north of the site, which was found by Gaia Research. This location is GEEBAM mapped 'High' burnt class surrounded by 'Very High' burnt class vegetation (refer **Figure 5.2**).

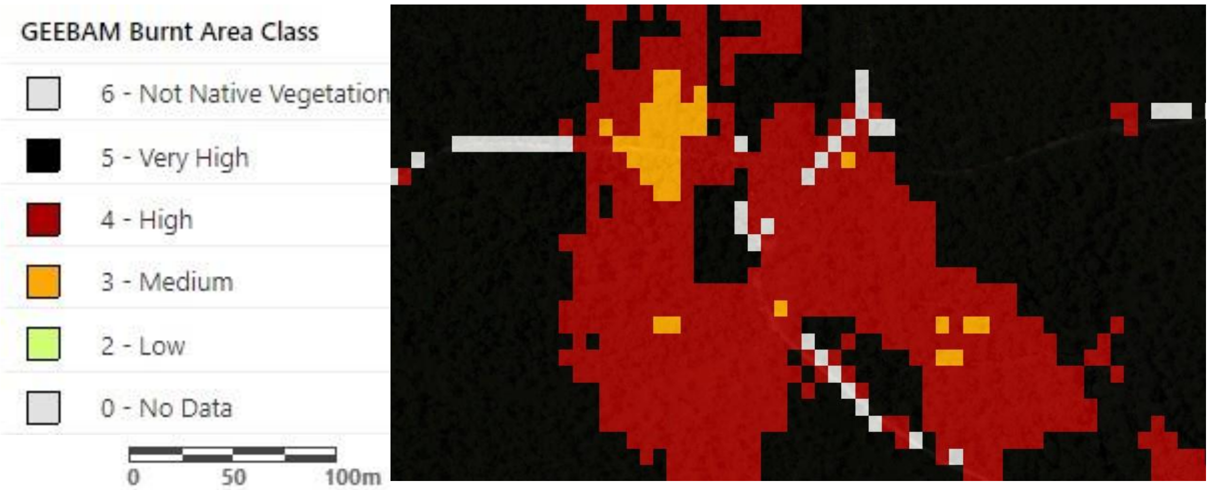


Figure 5.2: GEEBAM mapping of location where Greater Glider survived the Currowan fire; Tree in Plate 2 is mapped 'High' burnt class

Extensive regional surveys undertaken by Gaia Research at the request of the Department detected Greater Gliders only at this location, which is approximately 10 kilometres north of the site. No Greater Gliders were detected in either unburnt or burnt forests anywhere within a survey area extending from Cunjurong Point in the south to north of Mondayong and to just west of the Pacific Highway (including Manyana and Bendalong), apart from at this location.

This finding highlights the extreme importance of preserving old-growth elements within native forests. Trees such as the Blackbutt pictured in **Plate 2,** Gaia Research has noted is up to 1.6 m DBH, provide unique and irreplaceable ecosystem values during rare stochastic events which could be a critical factor enabling the survival of individuals or whole populations within the landscape.

The key element in the survival of the Greater Glider at this site was not a large unburnt patch of forest, but possibly a single very large old-growth tree. The area surrounding this tree was burned at high intensity (refer **Plate 4**; **Figure 5.2** and **Figure 5.3**). The Greater Glider that survived at this location would have had no access to unburnt forest anywhere within its home range. The fire did not destroy hollows. The fire did not remove forage. Based on the glider's position among epicormic growth when observed, it is likely that this individual is foraging on foliage produced by epicormic shoots. The post-fire 'refugium' in this instance could possibly have been a few scorched trees (refer **Appendix K**).

It is far more likely that Greater Gliders in the region have survived the 2019-2020 bushfires in this way – within higher quality habitats such as large, creek lines with larger trees and higher moisture levels – than within larger unburnt patches in poorer quality habitat areas such as the proposed action area. Areas such as the large (4th order) creek line in **Figure 5.3** and **Plate 5** with large old-growth trees would have been more likely to support higher-density Greater Glider populations pre-fire than regrowth forests on sandy coastal hills adjacent to residential back yards such as within the proposed action area. The quality of the habitat pre-fire – in particular the old-growth trees – was far more likely to have been a factor in the survival of the Greater Glider at this location than the particulars of the fire impacts, such as number of hectares of totally unburnt vegetation within the Greater Glider's home range, burn intensity at or surrounding the location, proximity to totally unburnt areas of vegetation, etc. The habitat condition at the location where at least one Greater Glider survived the Currowan fire can be seen in **Figure 5.3** and **Plates 2 – 5**.

Figure 5.3: Location where Greater Glider was recorded and may have survived the Currowan fire. Green canopy overhanging road is tree in Plate 2

Plate 2: Very large, old-growth Blackbutt where Greater Glider may have survived the passage of fire; the canopy of this tree is several metres taller than the surrounding forest canopy

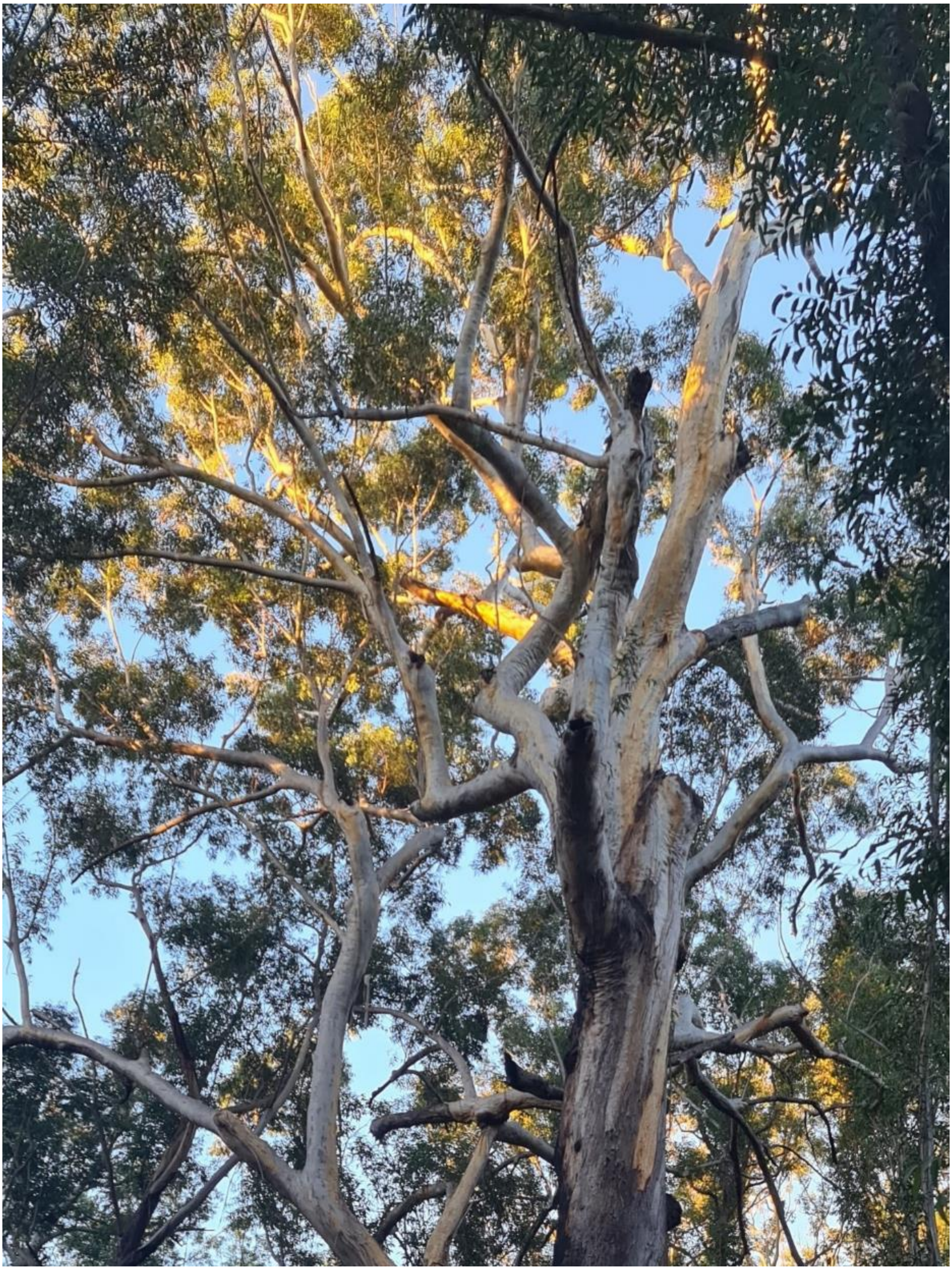


Plate 3: Several large hollows which could have provided insulated refuge for Greater Glider

Plate 4: Vegetation condition near where Greater Glider was found (April 2021)

Plate 5: Large watercourse near tree in Plate 2 (April 2021)

Figure 5.4: Greater Glider amongst epicormic foliage in GEEBAM 'Very High' burnt class location

5.2.2 Dispersal ability and post-fire population recovery

Dispersal

The Department's independent expert suggested that individual Greater Gliders may disperse into the site from areas of occupation up to 3 to 7 km distant from the site. By asserting that a Greater Glider is capable of dispersing 3 to 7 km across *pine plantations* in order to imply that dispersal of 7 km across *native eucalypt forest* is possible, the Department's independent expert is describing a scenario which is technically and theoretically possible however would be extremely unlikely to occur in nature. Greater Gliders have very limited energy budgets due to being a folivore and therefore it is very important that they travel the minimum distance necessary. The Greater Glider is likely near the limit of its energy budget due to poor nutrition of food, i.e. Eucalyptus leaves (Lindenmayer 2002). Generally, Greater Glider movements are very economical, with animals using the minimum number of trees necessary to get to desired feeding sites and often walking along interconnecting horizontal branches rather than gliding (Kavanagh and Wheeler 2004). Greater Gliders carry very little body fat, and most animals would not survive long distance movements (Lindenmayer 2002).

The examples cited by the Department's independent expert were long distance movements within pine plantations. Essentially, a Greater Glider began dispersing out of a remnant eucalypt patch, and once the animal began moving through the pine plantation, it could not stop dispersing until it reached another eucalypt patch or returned to the one from which it came. Dispersing a short distance and remaining within the pine plantation was not an option in those instances, because the dispersing animal would have neither food nor shelter to survive. Notably, all the examples of long distance movement cited by the Department's expert are highlighted as outliers within their respective studies, with each study going on to conclude that Greater Gliders do not move such long distances generally, and that the results are only applicable to similar environments where eucalypt forest is embedded within a pine plantation (refer **Table 5.2**).

Any Greater Glider dispersing from a fire refuge up to 7 km distant from the site would encounter suitable foraging habitat long before arriving at the site, and the energy cost as well as heightened predation risk would discourage any animals from travelling greater distances than necessary across the fire-affected landscape. An extensive area (ca. 812 ha) of unburnt canopy stretches to the north and northeast from the site, and this unburnt canopy vegetation would be encountered by any dispersing animals prior to arriving at the Manyana development site from any distant fire refuges. As such it appears to be extremely improbable that a Greater Glider would seek out and encounter the Manyana development site by chance after travelling a great distance across burnt landscape and continuing to disperse despite encountering foraging habitat to the site's north. Habitats surrounding the site retain suitable foraging habitat, and are apparently either unoccupied or occupied by a low-density population (due to lack of recent records despite survey), and therefore can support any dispersing individuals without competition from conspecifics.

Notwithstanding the above, studies of Greater Gliders in lands cleared for forestry have found that even when a glider's home range is destroyed, the animal does not disperse great distances into available habitat, generally only surviving if a portion of its existing home range is conserved (Tyndale-Biscoe and Smith 1969). The reasons for this appear to be that animals have a poor ability to adapt to new locations outside of their established home range.

The peer-reviewed literature indicates that Greater Gliders do not disperse great distances, and that the examples cited by the Department's independent expert of dispersal up to 7 km are outliers which occurred in very specific circumstances and which do not apply to the site at Manyana (refer **Table 5.2**). The studies where these movements were observed noted the long distance dispersal events as outliers, while concluding that Greater Gliders do not disperse great distances (Tyndale-Biscoe and Smith 1969; Taylor et al. 2007).

5.2.3 Survey adequacy

The estimate of survey adequacy cited in the Ecoplanning (2020a) MNES Assessment is correct. The Department's independent expert's assertion that surveys of the site may be inadequate due to the possibility of a low density population occurring in the locality does not reflect the findings of Wintle et al (2005). This study, which the Department has used as the basis for its published guidelines for post-fire survey effort, accounts for variations in species' density, which is mediated in the study's models by a variable for habitat quality. The Greater Glider detectability model therefore accounts for variation in population density. The probability curve provided in Wintle et al (2005) and reproduced in the Ecoplanning (2020a) MNES Assessment is suitable for use in both high-density and low-density areas. Even allowing for a scenario in which Ecoplanning surveys were undertaken in the worst detection conditions (low-density population and poor weather conditions), which Table 5.1 of the Ecoplanning (2020a) MNES Assessment demonstrates they were not, the probability that surveys could have missed a Greater Glider (false absence) under these conditions is <0.25 (refer to curve 'c' of Figure 2 of Wintle et al (2005)).

Survey effort within and adjacent to the site amounts to 114 person-hours over 10 nights during a six week period within a 20 hectare area. By any measure, survey effort for Greater Gliders on the site exceeds the survey effort conducted in relevant published studies of Greater Glider detectability (refer **Table 5.2**) – e.g. Wintle et al (2005); Lindenmayer et al (2001). The detection probabilities reported in these studies would be underestimates of the actual detection probability for the surveys conducted on the site. On this basis, the survey as reported in the Ecoplanning (2020a) MNES Assessment is sufficient to confirm that Greater Gliders are absent from the Manyana development site.

5.2.4 Local population

The imperative to conserve the vegetation on site relates to its importance as a refuge for animals which have survived the fire. The significance of the site as a refuge is greatest in the immediate post-fire time period when no foliage is available in 'high' and 'very high' burnt class areas, and much less so once regrowth has returned to areas of burnt forest. As confirmed by contemporary surveys, no Greater Gliders have sought refuge on the site in the period following the Currowan fire. The site is not a post-fire refugium for this species.

Adjacent unburnt habitats

The Department's independent expert has suggested that Greater Gliders might be present in the area around the site, however, none were detected by surveys. The scenario suggested by the Department's expert would be one in which a low-density population occurs in the area, one or more individual Greater Gliders have home ranges which overlap with the site, and the Greater Gliders with home ranges including the site were all outside the site over the six week survey period. While possible, this is extremely unlikely. Moreover, the significance of the site would be lesser in this scenario than if the site supported all or most of the home range of a Greater Glider.

Greater Gliders have small home ranges (Lindenmayer 2002). Assuming that Greater Gliders in the locality have home range sizes at the higher end of the range recorded in similar coastal forests, approximately 4 ha, even the largest home ranges would be no greater than 0.5 km across. This results in a very small potential area adjacent to the site where a Greater Glider utilising the site could have been residing while undetected by site surveys.

The only possible (though unlikely) impact of the proposed action would be removing unburnt habitat into which Greater Gliders, most likely juveniles, could disperse as their populations recover. In such a scenario, the dispersing juveniles (with parents living in the area just north of the site) would also have suitable unburnt available habitat directly to the north and east of their parent's home range, and would also have habitat available in burnt areas to the west, southwest, and much farther to the north in Conjola National Park where eucalypt foliage regrowth is already advanced and sufficient to provide forage.

Wider locality

As the Department's expert has noted: '*It is worth highlighting that the Greater Glider may be absent from or occur at low density in some coastal forests*.' Greater Gliders may now be absent from the Manyana locality, as suggested by recent regional surveys, or else may be present at low density, in which case the potential utilisation of the site and the potential significance of the habitat on the site is less than it would be for a high-density population, as a lower number of individual Greater Gliders could possibly be impacted by the proposed action. Without question, a viable source population for repopulating the surrounding forests is not found on the site currently, and given the species low reproductive rate (one offspring per litter; one litter per year; juveniles disperse about one year after birth), a source population could not possibly occupy the site for many years or decades.

The Department's expert has disputed the inference from BioNet database records of a possible decline in the Greater Glider population in the Manyana-Bendalong area (refer Section 5.2.2 of Ecoplanning 2020a). However, in discussing the status of the Greater Glider in NSW, the Conservation Advice (TSSC 2016b) uses the same approach to infer that a population decline may have occurred in the Blue Mountains:

'Anecdotal reports, including from local ecologists, indicated similar declines elsewhere in the lower Blue Mountains, and the NSW Bionet Atlas confirms a marked drop in records in the region (Blue Mountains National Park: 357 records 1990−2004, 8 records 2004−2014. Blue Mountains LGA: 142 records 1990−2004, 1 record 2004−2014) (Smith pers. comm., 2015).'

Within a 5 km radius of the site, the BioNet Atlas contains 15 Greater Glider records from 2001-2011 and 2 records from 2011 to the present date. The Department's expert asserts that:

'The data in Bionet do not allow any real insight into the status of the Greater Glider.'

Recent survey in the area from Cunjurong Point to Sussex Inlet has confirmed that Greater Gliders have in fact disappeared from areas where they have previously been recorded in the BioNet (Gaia Research 2021), such as the area west of North Bendalong. These surveys confirm that previous inferences of population decline based on a drop in BioNet records in both burnt and unburnt areas pre-fire (Ecoplanning 2020a) are correct. Greater Gliders are very likely to have disappeared from the locality within 5 km of the site.

Gaia Research (2021) concludes:

'*On its own, the site is too small to sustain a viable population. … Our surveys indicate the closest known population of Greater Glider to the Manyana site is approximately 10km. The current status and distribution of the Conjola population does not suggest viability in the long-term. If the Greater Glider no longer persists on the Manyana site, the probability of animals recolonising this patch is remote, as the Conjola population has crashed.*'

Conclusion

There is no evidence to suggest that the site could represent a core area of habitat from which a viable, breeding population of Greater Gliders could repopulate other areas. In the only possible scenario under which Greater Gliders may have been undetected by survey, only a low-density population would be present in the area, in which case the site would not support enough individuals to constitute a viable population. Assuming a low-density population, the relative importance of the habitat on site would be lower, as it would represent, at most, part of a glider's home range. Moreover, the evidence of recent surveys and peer-reviewed studies of Greater Glider response to fire confirm that the estimate provided in the Ecoplanning (2020a) MNES Assessment of at least 812 ha of contiguous habitat within 5 km of the site remaining as a refuge within which Greater Gliders could have survived the passage of the Currowan fire is accurate, and that there may now be up to 4,000 ha of habitat within 5 km of the site.

5.2.5 Metapopulations

Following the species workshop, the Department considered that surveys of the regional Greater Glider population were warranted to identify ‘patches’ of vegetation, both burnt/ unburnt, and determine whether these patches were occupied/ unoccupied by Greater Gliders. The Department considered that assessment of the proportion of the potential Greater Glider habitat, including ‘occupied patches’ and ‘unoccupied patches’, is relevant to the assessment of the conservation importance of the proposed action area in the context of the regional Greater Glider population. The Department’s consideration of patch occupancy follows on from concerns relating to metapopulation persistence raised at the species workshop, and also raised in an expert report submission provided by the Environmental Defenders Office (EDO) to the Department in a report dated 10 June 2020.

Relevant assertions of this submission are:

10. *The presence of the Greater Glider in forests adjacent to the Manyana development site and persistence of unburned areas at the site itself suggest that the Greater Glider may exist as a patchy population in the broader area. That is, its distribution occurs in a series of temporally occupied and temporally unoccupied suitable areas of forest habitat, with the ensemble of patches needed to ensure medium to long-term persistence in a landscape (Hanski 1998, 1999). Such patchy populations have been termed meta-populations (Hanski 1998, 1999) and habitat patches that are unoccupied at a given time can soon after be re-occupied with landscape-level and regional persistence dependent on the maintenance of all patches in an ensemble of patches, especially larger intact patches (Possingham et al. 1994).*

   …

11. ***The key issue is that all patches of relatively intact forest in the broader landscape including the area that encompasses the Manyana development site will likely be needed to remain intact for persistence of the Greater Glider.***

   …

The application of metapopulation theory to the assessment of the regional Greater Glider population is unfounded.

Theory

> *‘…the classical metapopulation theory and its spatially realistic version are most useful for examining the dynamics of metapopulations living in highly fragmented landscapes (Harrison and Taylor (1999a), Hanski (2001)). By the latter I mean landscapes in which the suitable habitat for the focal species accounts for only a small fraction of the total landscape area, typically only a few percent, and where the habitat occurs as discrete fragments.’ Hanski (2004)*

> *‘If a population is actually panmictic (patchy) rather than a CM* [metapopulation]*, this would suggest focusing on different spatial scales …. Wrong assumptions about spatial population structure may thus lead to unnecessary spending of resources that would be much better invested elsewhere, and incorrect conservation concepts with potentially fatal consequences, such as loss of biodiversity. We thus advise more care when using the term ‘‘metapopulation.’’ Often, ‘‘spatially structured population’’ may be more appropriate.’ Fronhofer et al (2012)*

> *'One misunderstanding is that the use of the metapopulation concept in conservation requires or implies the conservation or management of species as multiple populations. In some cases, maintaining more than one population does increase the persistence of the species as a whole, but this is neither universal, nor a necessary result of using a metapopulation approach. Thus, what conservation needs is not necessarily metapopulations per se, but the metapopulation approach and concepts, which permit assessment of the persistence of a species that happens to exist in a metapopulation, either naturally or due to habitat loss and fragmentation.' Akçakaya et al (2007)*

Organisms that occupy discrete habitat patches exhibit a continuum of spatial population structures. These range from essentially panmictic populations, where individuals move freely among habitat patches to isolated subpopulations where interpatch movement occurs too infrequently to influence metapopulation persistence (Harrison 1994). Although the original model of metapopulation dynamics focused on the middle of this continuum (Levins 1970), metapopulation designation is now often applied to any species occupying a system of habitat patches connected by dispersal (Hanski and Gilpin 1997; Simberloff 1997). The combined effects of juvenile and adult dispersal, demographic characteristics of the subpopulations, and subpopulation persistence, determine how metapopulation theory applies to a specific system.

Metapopulation theory is often misapplied to describe population systems that should not be described as metapopulations, and this can lead to poor conservation decisions (Baguette 2004; Hanski and Gilpin 1997; Akçakaya et al. 2007; Fronhofer et al. 2012). Conservation priorities for metapopulations differ from conservation strategies suited to more typically observed spatially structured populations. Relevant to the current assessment, metapopulations may require conservation of unoccupied habitat patches, while other spatially structured populations often do not. Classical metapopulation theory is most appropriately applied to species living in highly fragmented landscapes (Hanski 2004), and with particular life history attributes (Fronhofer et al. 2012; Baguette 2004).

Metapopulation systems are characterised by relatively rapid and asynchronous extinction/ recolonisation turnover of discrete habitat patches, which necessitates maintenance of all occupied/ unoccupied patches in order for the entire focal population to persist. Classical metapopulations exist only within a narrow parameter space, and the imperative to conserve unoccupied patches derives from the particular conditions within these narrow parameters. Below Figure 4 excerpted and modified from Fronhofer et al (2012) provides a visual representation of this parameter space.

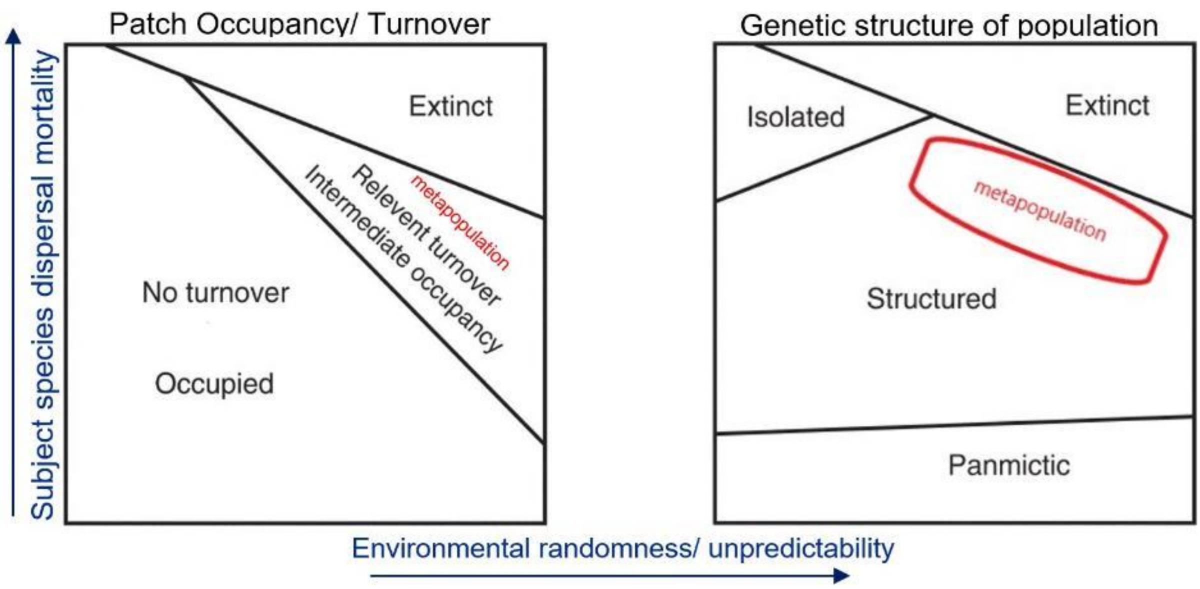


Figure 5.5: Figure 4 of Fronhofer et al (2012)

Only within the narrowly defined band in parameter space characterised by intermediate occupancy, relevant turnover, and spatial structure, would one find a metapopulation system. These parameters are most often found in fragmented landscapes, and among invertebrates.

Theory applied to Greater Gliders in Manyana

In Manyana, it is far more likely that Greater Gliders either occupy an area, in which case conservation of the area should be considered; or, Greater Gliders do not occupy an area, in which case conservation of the area for Greater Gliders would achieve little to facilitate the species recovery. With reference to the above, the Greater Glider population in the area is likely spatially structured (denser in better habitats, less dense but still present in poorer habitats), has a low turnover of patch occupancy, exists as one large 'patch' east of the Pacific Highway, and is panmictic (breeding and genetic exchange across the whole local population).

The expert report submitted by the EDO drew parallels between wood production forests (e.g. pine plantations) and the Manyana landscape. The landscapes studied in Possingham et al (1994), Lindenmayer and Lacy (1995), McCarthy and Lindenmayer (1999), McCarthy and Lindenmayer (1999) and Todd et al (2016) are different from the landscape surrounding Manyana in many aspects relevant to the spatial structure of the local Greater Glider population. These studies examined Greater Glider populations in a network of fragmented eucalypt patches surrounded by unsuitable habitat where inter-patch dispersal is rare. These studies are not instructive for directing conservation priorities for Greater Gliders in the Manyana area.

The landscape surrounding Manyana, stretching between the Pacific Highway and the Pacific Ocean, is one contiguous forest block. Habitat fragmentation is not a concern for the proposed action, which sits adjacent to existing residential areas of Manyana. Thus, many of the conservation issues informed by metapopulation theory, such as reduced connectivity between sub-populations in occupied/ unoccupied patches, the preservation of a constellation of habitat patches in the landscape, etc., are not relevant to the current assessment.

Moreover, the ecology of the Greater Glider, including characteristics of dispersal, fecundity, generation time, and response to disturbance, does not lend itself to the application of metapopulation concepts. Where metapopulation theory has been applied to the species, it has been in areas where distinct, clearly defined habitat refuges have persisted in a modified landscape where the landscape surrounding each habitat refuge (each sub-population) was clearly unsuitable – either young regrowth from logging, or pine plantation – yet still allowed for between-patch dispersal of this wholly arboreal species. In any native forest landscape not subject to such regular forestry activity, the space between putative 'patches' would be suitable for some level of occupation by Greater Gliders. Such native forests, including the area surrounding Manyana, would fail the pre-requisites of a metapopulation as described in the previous section.

The site, and the contiguous forested area surrounding it, exists as a single habitat 'patch' for Greater Gliders. While certain areas within this large contiguous patch may be more or less suitable as habitat, resulting in a patchy population (more/ higher density of Greater Gliders in high quality patches such as along large drainage lines; fewer/ lower density of Greater Gliders in low quality patches such as dry sclerophyll forests on hill tops and flats in-between drainage lines), this 'patchy' population is certainly panmictic. The Greater Glider population in this landscape could not be described as a metapopulation. Moreover, metapopulation systems are rare among mammals, existing only in very specific circumstances where a range of landscape and life-history parameters are met, and therefore should not be assumed without a compelling reason.

Extensive population-wide survey is not necessary to confirm the above characterisation of the Greater Glider population in the Manyana area. The observable habitat attributes – e.g. aerial imagery showing the presence of native forest across the whole landscape – and the known ecology of the species are alone sufficient to rule out the presence of a Greater Glider metapopulation system in the Manyana area.

5.3 Assessment of significance of impacts

Based on the literature review and analysis of the Department's expert's assertions provided above, the conclusions of the assessment of significance referencing the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* provided in the Ecoplanning (2020a) MNES Assessment (Section 5.6), there are no significant impacts. Despite the uncertainties raised by the Department's experts, the claims and conclusions of Ecoplanning (2020a) are well supported based on reasonable inferences made from extensive contemporary survey. A brief update to the significant impacts assessment is provided below.

5.3.1 Population significance

An 'important population' is defined under the *Matters of National Environmental Significance: Significant impact guidelines 1.1* (Department of Environment 2013) as a population that is necessary for a species' long-term survival and recovery. The guidelines enumerate several criteria for determining an important population, which are considered below in relation to the Greater Glider:

- *populations identified as such in recovery plans*

A recovery plan for the Greater Glider has not been published.

- *key source population for either breeding or dispersal*

The site does not contain a source population of Greater Gliders (refer **Section 5.2.3**). The site is unlikely to have supported a source population of Greater Gliders in the past 20 years (refer **Section 5.2.1**). The disappearance of Greater Gliders from the site in the past 20 years strongly suggests that the site is more likely to be a population 'sink'.

- *populations that are necessary for maintaining genetic diversity, and/or*

Genetic analysis over a limited number of sample sites supports splitting the Greater Glider (*Petauroides volans*) in to three distinct species – *Petauroides volans*, *Petauroides minor*, and *Petauroides armillatus* (McGregor et al 2020). Jackson (2015) has named these the Southern Greater Glider, Northern Greater Glider, and Central Greater Glider respectively. McGregor et al (2020) did not collect samples of *Petauroides volans* sensu lato from NSW; however, Jackson (2015) recognises *Petauroides volans* sensu novo as occurring throughout NSW and Victoria, with the other two species found in northern and central Queensland.

The Greater Gliders in the Manyana region are found in the centre of the range of the broadest ranging of the three species. No population of Greater Gliders occurs on site. Based on the location of the site in the centre of the range of *Petauroides volans* sensu lato, and the application of elementary concepts of evolutionary ecology and biogeography (i.e. the absence of geographic features in the broader landscape which might restrict gene flow and facilitate speciation or the evolution of genetically distinct population segments of this species – see Pianka 1974) it is highly unlikely that a genetically distinct population segment of Greater Gliders occurs in the region surrounding the site.

- *populations that are near the limit of the species range.*

The site is not near the limit of the species range.

5.3.2 Habitat critical to the survival of species

Habitat critical to the survival of a species or ecological community is defined under the *Matters of National Environmental Significance: Significant impact guidelines 1.1* (Department of Environment 2013) using a number of criteria, which are considered below in relation to the Greater Glider:

- *necessary for activities such as foraging, breeding, roosting, or dispersal*

Habitat on site is not currently used for foraging, breeding, roosting, or dispersal of this species. Foraging, breeding, and roosting habitat is abundant in the surrounding locality (refer **Section 5.2.1**).

- *necessary for the long-term maintenance of the species or ecological community (including maintenance of species essential to the survival of the species or ecological community, such as pollinators)*

The site is not currently occupied by Greater Gliders (refer **Section 5.2.3**). The site may not be occupied by Greater Gliders for many years (refer **Section 5.2.1**). Extensive areas of unburnt (812 ha) or regenerating forest habitat in the surrounding Conjola National Park currently provide habitat for the long-term maintenance of the species in the locality.

- *necessary to maintain genetic diversity and long term evolutionary development, or*

Any Greater Gliders in the area east of the Pacific Highway, south of Sussex Inlet, and north of Lake Conjola are likely to exist as a single local population within which genetic exchange is possible, as this area contains a single contiguous forest block. The site does not contain a population of Greater Gliders (refer **Section 5.2.3**). The site is not necessary for maintaining the genetic diversity of a local population, if one is extant. The local population is not necessary for maintaining the genetic diversity of the species as a whole.

- *necessary for the reintroduction of populations or recovery of the species or ecological community.*

Reintroduction programs are not likely to be undertaken for this species in relation to post-bushfire recovery.

The habitat on site, while unburnt, is not necessary for the recovery of the local population, or the species as a whole (refer **Section 5.2.1**). The habitat on site is not a refugium for this species (refer **Appendix K**).

- *habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or*

A recovery plan for the Greater Glider has not been published.

- *habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.*

No areas of critical habitat for this species are currently listed on the Register of Critical Habitat.

5.3.3 Impact assessment

Under the EPBC Act, an action is considered likely to have a significant impact on a 'vulnerable' species if there is a real chance or possibility that it will impact an 'important population' (refer **Section 5.3.1**). Assessment criteria are:

- *Lead to a long-term decrease in the size of an important population of a species*

A population of this species does not occur on the site. A population, were it to have occurred on site prior to the 2019-20 bushfires, would not constitute an important population as defined under Commonwealth guidelines (refer to **Section 5.3.1**). Therefore, the proposed action will not lead to a long-term decrease in the size of an important population of Greater Gliders.

- *Reduce the area of occupancy of an important population of a species*

The site is not currently occupied by Greater Gliders. The site has not previously supported an important population of Greater Gliders as defined under Commonwealth guidelines (refer to **Section 5.3.1**). Therefore, the proposed action will not reduce the area of occupancy of an important population of Greater Gliders.

- *Fragment an existing important population into two or more populations*

The proposed action will not fragment a population of Greater Gliders into two or more populations. The proposed action will increase the residential area of Manyana without creating additional barriers to movement to Greater Gliders or any other species within the wider landscape. Therefore, the proposed action will not fragment an existing population into two or more populations.

- *Adversely affect habitat critical to the survival of a species*

The site does not contain habitat critical to the survival of the species (refer **Section 5.3.2**). The proposed action will result in minimal additional edge effects which could impact any adjacent unburnt Greater Glider habitat to the site's north (refer **Section 6.3**). The proposed action will not affect habitat critical to the survival of this species.

- *Disrupt the breeding cycle of an important population*

The site is not currently occupied by Greater Gliders. The site has not previously supported an important population, nor is it likely to support one in the future (refer to **Section 5.3.1**). The site contains too few potential den sites to support enough individuals to sustain a viable breeding population of Greater Gliders. Therefore, the proposed action will not disrupt the breeding cycle of an important population.

- *Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*

The proposed action will remove approximately 17.18 ha of vegetation, comprising 5.39 ha of Bangalay Moist Woodland Open Forest and 10.79 ha of Northern Coastal Sands Shrub/Fern Forest, all of which is considered potential foraging and/or low-quality denning habitat for this species. 3.45 ha of habitat is to be retained on site. The estimated area of occupancy of this species is 1,616,400 ha (TSSC 2016). The estimated overlap of the 2019-20 summer bushfires with this species' range is 29% (DAWE 2021d). Despite the reduction in area of occupancy of this species caused by the 2019-20 summer bushfires, the removal of habitat on site is negligible by comparison to the broad extent of this species' habitat. Within a 5 km radius of the site, approximately 4,000 ha of suitable Greater Glider habitat exists currently, of which approximately 3,000 ha is within conservation reserves.

- *Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat*

The proposal has the potential to result in the spread of weed species into retained areas of this species' habitat on site (the retained Bushland Reserve containing the Bangalay

Paperbark Woodland EEC). The Flora and Fauna Management Plan (Ecoplanning 2021a) has been prepared to mitigate this impact. Notwithstanding, the potential impact of introduced weed species on this species or its habitat is minimal.

- *Introduce disease that may cause the species to decline, or*

The proposal is unlikely to result in the introduction of disease that may cause decline of Greater Glider. There is potential for disease caused by the soil-borne plant pathogen *Phytophthora cinnamomi* to occur in the study area as a result of the proposal. This pathogen could impact on the vegetation communities that could support foraging and breeding habitat for this species. Control of transportation of the pathogen will occur via control of soil transportation into the study area. The Environmental Management Plan (Ecoplanning 2021b) and Flora and Fauna Management Plan (Ecoplanning 2021a) include measures to reduce the risk of introduction of soil-borne pathogens into the site. The proposal is not likely to introduce disease that may cause this species to decline within the locality.

- *Interfere substantially with the recovery of the species.*

A population of Greater Gliders does not currently occur on the site (refer **Section 5.2.3**). The site contains only poor-quality habitat for this species (refer **Section 5.2.1**). Greater Gliders are unlikely to disperse into the site from surrounding habitats for many years or decades (refer **Section 5.2.2**). Gaia Research (2021) summarises the situation as follows:

> *'Our surveys indicate the closest known population of Greater Glider to the Manyana site is approximately 10km. The current status and distribution of the Conjola population does not suggest viability in the long-term. If the Greater Glider no longer persists on the Manyana site, the probability of animals recolonising this patch is remote, as the Conjola population has crashed*.'

The proposed action is unlikely to interfere substantially with the recovery of this species in the locality following the 2019-20 summer bushfires.

5.3.4 Cumulative impacts

The proposed action will be carried out in the context of concurrent and proposed future development in the Manyana area for various forms of small-scale tourist development, mostly to the south and northeast of the site, away from Conjola National Park and large contiguous blocks of habitat.

The cumulative impacts of the proposed action on Greater Gliders, when considered in conjunction with other development possibilities in the vicinity, will not be significant for the same reasons the impacts of the site considered alone will not be. No Greater Gliders have been found by recent surveys at the site or the locations of other proposed developments in the area. The proposed action and other potential developments are clustered in the Manyana area and would not inhibit recolonisation of southern portions of Conjola National Park from the sites where Greater Gliders have been recently recorded, unlikely though that recolonisation may be. The total area of additional vegetation cleared via these cumulative impacts is 24 ha of GEEBAM Unburnt, 'Low', or 'Medium' burnt class vegetation, based on regional mapping (GEEBAM; SCIVI) Greater Gliders are not present at the site and are unlikely to recolonise in the near future, and a cumulative impacts analysis does not affect this conclusion.

6 Avoidance and mitigation

6.1 Avoidance

The proposed action will avoid and permanently retain approximately 3.45 ha of potential summer-autumn foraging habitat for GHFF within the site, as well as 0.36 ha of potential spring foraging habitat. This area represents potential, though unoccupied, habitat for Greater Glider. No winter foraging habitat for Swift Parrots is found on site, and none is found in the areas of avoidance.

The existing approvals provide for avoidance of native vegetation within the site. Avoidance will be achieved by:

<u>Major Project Approval</u> (MP 05_0059) (**Attachment L**)

- 10-meter building setbacks on the western (Cunjurong Point Rd) and northern (Berringer Rd) edges of the site will allow greater retention of vegetation;
- the provision of larger allotments throughout the entire subdivision that will allow the greater retention of existing vegetation;
- Tree preservation zone – 10-meter setback on the southern and eastern edges of the site. Trees in this area are to be retained and protected via protective fencing throughout construction;
- The retained Reserve on site (3.45 ha) contains Bangalay Paperbark Woodland EEC and a 25 m buffer surrounding the EEC which contains Northern Coastal Sands Shrub/Fern Forest. The Reserve vegetation has a dominant canopy of Blackbutt and Bangalay, with subcanopy elements including Turpentine, Flax-leaved Paperbark (*Melaleuca linariifolia*), Black She-Oak (*Allocasuarina littoralis*), and Old Man Banksia. Ecoplanning (2021a) surveys of the Reserve, which included BioBanking Assessment Method (BBAM) quadrats, characterised this vegetation as having high resilience. The canopy and subcanopy species listed above provide potential foraging habitat for GHFF, primarily in summer months, and potential forage for Greater Gliders.

<u>Proposed</u>

- The avoidance of GHFF in the retained Reserve on site will be managed further by the identification and marking of all GHFF trees within 10 m of the Reserve boundary by an ecologist prior to development works commencing in the adjacent development stage. An arborist will then be engaged to identify Tree Protection Zones (TPZ) surrounding each tree and, if necessary, supervise any construction works in the vicinity of the retained tree to ensure the health of the tree is not impacted by adjacent development works. These additional tree protection measures are proposed for trees in the 'large' size class, which is >40 cm DBH as defined by Law and Chidel (2007), as these trees are more likely to provide significant amounts of nectar for GHFF. TPZs will not be established for any trees <40 cm DBH within 10 m of the Reserve boundary.

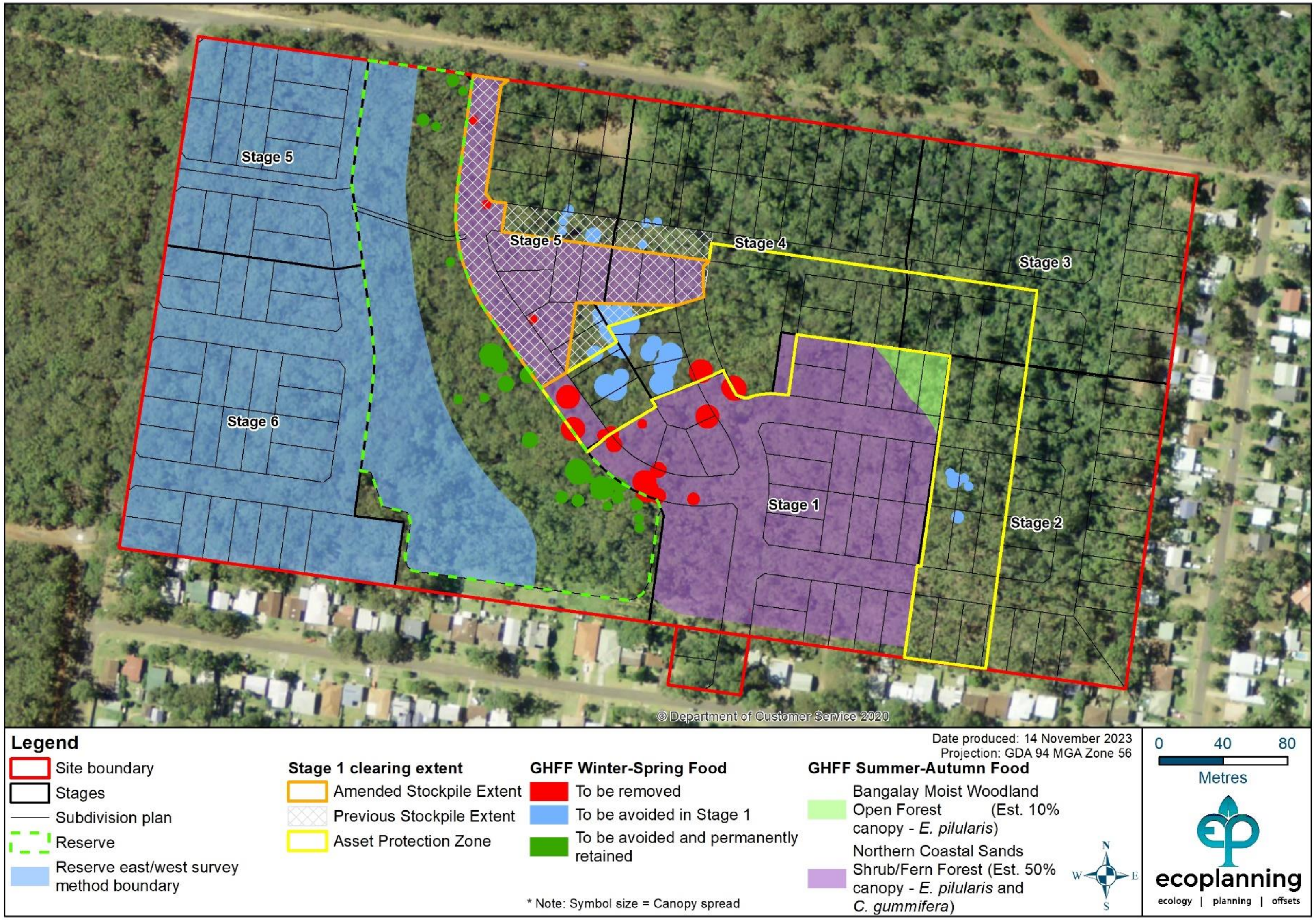


Figure 6.1: Mitigation – vegetation clearing delayed in Stage 1

6.2 Mitigation

The staging of the development (refer to **Table 2.1**) will mitigate any potential impacts on the subject species. As the surrounding bushland recovers post-fire, the relative importance of the habitat on site will decrease. Assuming the earliest projected timeline for clearing on site, a maximum of approximately 1% of the intact habitat within 5 km of the site will be cleared as development stages progress. By the time Stage 6 of the development is complete, the total clearing will have removed 0.4% of the native vegetation and potential habitat for the subject species within 5 km of the site, when accounting for the recovery of vegetation in Low, Medium, and High GEEBAM burnt class vegetation.

Any clearing of vegetation will (and must) be carried out in accordance with approval conditions of the Major Project Approval, which requires mitigation measures including preservation of trees on site, staged clearing of the development and prohibition of broad-scale clearing on site, management plans to protect fauna welfare and retained vegetation, installation of nest boxes (suitable habitat for Greater Gliders) in reserves (crown lands) adjacent to the site, and restrictions on clearing during months when some migratory MNES may be sensitive to impacts. The conditions of the Major Project Approval (MP 05_0059) are provided as an attachment to the Referral (Ecoplanning 2020c). Impacts to the subject species, though minor and unlikely to occur, will be managed by avoidance, mitigation, and monitoring.

<u>Major Project Approval</u> (MP 05_0059) (**Attachment L**)

- An incentive scheme outlined within the Draft Design Guidelines to encourage home owners to quickly establish landscaping and to landscape using selected native species for consistency and ecological grounds;
- the clearing of the site in a staged fashion in order that trees can be established on the earlier stages prior to the clearing of vegetation associated with the later stages;
- The developer will impose a restriction on the title of each allotment requiring that any dogs or cats are kept only within the curtilage of a dwelling house, however dogs may be kept outside of the curtilage if secured on a leash;
- Flora and Fauna Management Plan (FFMP) (Ecoplanning 2021a) to protect and manage threatened species habitat within the retained Reserve, including removal of weeds and monitoring retained vegetation condition over a period of at least 3 years.
- Environment Management Plan (EMP) (Ecoplanning 2021b) to manage impacts to adjacent vegetation, including management of erosion and sediment, retained trees, retained vegetation, water quality.

<u>Proposed</u>

- Early (prior to Stage 1 commencement) planting of GHFF important food trees in suitable areas within the 10 m tree preservation zone along the southern (Stage 1, 2, and 6) and eastern (Stage 2 and 3) boundary of the site;
- Plantings will be established and maintained prior to/ during Stage 1 in the tree preservation zone, as per updated site Landscape Plans;
- Incentive scheme within the Draft Design Guidelines will be modified to require home owners to plant GHFF important food trees within residential lots;
- Landscape Plans will have reference to GHFF important food trees best suited to microhabitats within the site, which are evident from the existing distribution of

important food trees on the site. For example, Swamp Mahogany will be planted in the vicinity of drainage lines and proposed stormwater basins, Coast Banksia will be planted near or within the tree preservation zone as existing individuals of this species occur in or near the tree preservation zone, elsewhere Coast Banksia would be suited to streetscapes or residential allotments (via incentive scheme) and Grey Ironbark will be planted along the Reserve boundary;

- Construction Certificate Plans – CC plans (CC18/2030) will be modified to reduce the area of Stage 1 stockpiles and avoid important food trees found in the temporary APZ (refer **Figure 6.1**);
- Retained GHFF important food trees along boundaries of Stage 1 impact area, including the trees within 10 m of the reserve boundary Reserve, all trees within the amended Stage 1 stockpile, and all trees in the temporary APZ and tree preservation zone, will be surveyed and inspected by an arborist (refer **Figure 6.1**). The arborist will determine appropriate tree protection zones (TPZ) for all GHFF important food trees in these areas and, if necessary, the arborist will supervise Stage 1 construction works in the vicinity of these trees if, for example, ground disturbance works are required within TPZ surrounding the tree. This will ensure that the health of the tree is not impacted by adjacent development works.
- It is recommended that Staging of the development is conditioned such that the development stages cannot occur earlier than projected in **Table 2.1**. This is to ensure that the majority of development impacts to GHFF habitat areas are avoided until surrounding bushland in the has recovered, per minimum projections in **Section 3.5.3**.

6.2.1 GHFF food tree plantings

Proposed plantings within the development area of GHFF diet plants which are productive during the winter-spring food bottleneck period is consistent with recommendations to ameliorate the impact of food shortages (Eby and Law 2008), and is consistent with Recovery objective 1 of the GHFF Recovery Plan (DAWE 2021a).

The planting of street trees (facilitated via Landscape Plans) and widely spaced trees on residential lots (facilitated via Design Guidelines), which will develop full canopies at maturity (see **Plate 11**), as well as the planting of trees which predictably produce greater nectar volumes, such as Swamp Mahogany or Coast Banksia, is expected to increase the total nectar productivity on the site above that which is already produced, once the plantings mature (refer OEH (2016) and Davis et al (2016) regarding productivity of street trees). Eby and Law (2008) rank Coast Banksia productivity '0.77' and reliability '1'. For comparison Turpentine is ranked '0.54-0.59' productivity and '0.60-0.80' reliability (when growing in the canopy – the productivity and reliability of the subcanopy trees on site is likely to be significantly less).

The proponent will plant GHFF food trees within the site, as presented in **Table 6.1**, and maintain these trees until such time as street trees (and roads) are transferred to Council control, after which time Shoalhaven City Council has an obligation to maintain street trees in perpetuity. It is anticipated that maintenance works, including branch lopping or even loss and replacement of trees, may occur after a period of time, likely greater than at least 5 years post-development, however, with regard to the subject species of this assessment these impacts are not considered significant. By the time trees have matured to an age where such maintenance works would likely be carried out by Council, the plantings will have matured to a size large enough to provide significant foraging resources even in the context of typical maintenance (pruning) activities, and no significant loss of foraging habitat would occur if one or a number of branches of a mature, flowering Coast Banksia, for example, were pruned. Moreover, the recovery of surrounding fire-affected vegetation will be far more advanced at such time that any maintenance activities undertaken by Council may occur.

Further to the above, the proponent commits to additional outlays (over 50% above the cost of planting and maintenance alone) of installing tree guards around street trees which will improve the survivorship of GHFF important food tree plantings while these plantings become established. Plantings of 75 litre size have been selected as this size has proven to be the most likely to establish and flower at the fastest rates (Southern Habitat, pers comm). Larger plantings (100 litres or greater) are less able to adapt to local conditions and thus take longer to establish, and thus ultimately to flower. Smaller planting sizes would take longer to reach flowering size than 75 litre plantings. Refer to **Table 6.1** for estimated cost of plantings. These costings include maintenance for up to two years prior to transfer of assets to Council, although this may occur as early as within 6 months of planting.

Table 6.1: GHFF food tree plantings within the site

Stage	Coast Banksia (Street trees)	Coast Banksia (in lots and pathways)	Grey Ironbark	Swamp Mahogany	Spotted Gum	Total number of trees planted/ Total cost
1	61	16	8	11	0	96
Cost	$96,380	$15,600	$12,640	$10,725	$0	$135,345
2	31	82	0	0	0	113
Cost	$48,980	$79,950	$0	$0	$0	$128,930
3	25	24	0	0	0	49
Cost	$39,500	$23,400	$0	$0	$0	$62,900
4	19	23	11	0	7	60
Cost	$30,020	$22,425	$17,380	$0	$6,825	$76,650
5	35	0	17	0	7	59
Cost	$55,300	$0	$26,860	$0	$6,825	$88,985
6	32	20	8	0	0	60
Cost	$50,560	$19,500	12,640	$0	$0	$82,700
Total	368 Coast Banksia		44 Grey Ironbark	11 Swamp Mahogany	14 Spotted Gum	437 trees $576,510

Plate 6: Recent Coast Banksia street planting which has flowered

Plate 7: Similar size Coast Banksia on site which has not flowered

Plate 8: Coast Banksia street tree less than 2 years after planting (Burrill Lake NSW)

Plate 9: Coast Banksia street tree less than 2 years after planting (Burrill Lake NSW)

Plate 10: Coast Banksia street tree ca. 10 years after planting (Burrill Lake NSW)

Plate 11: Mature Coast Banksia street tree plantings (Dolphin Point NSW)

Plate 12: Mature Coast Banksia in streetscape (Dolphin Point NSW)

Plate 13: Largest mature Coast Banksia on site

Plate 14: Coast Banksia street tree flowering and attracting pollinators (Burrill Lake NSW)

Plate15: Coast Banksia small street tree planting flowering and attracting pollinators (Burrill Lake NSW)

6.3 Edge effects

Management of edge effects is the main focus of the EMP (Ecoplanning 2021b) and FFMP (Ecoplanning 2021a) required under the Major Project approval. Briefly, regarding the subject species:

- Noise and light disturbance – after approximately 4 years' time, development along the site's northern boundary will commence, which will introduce noise and light pollution effects to the area north of the site across Berringer Road. These areas are subject to significant existing disturbance from the existing Berringer Road and the cleared easements surrounding it. These areas are subject to existing disturbance and fragmentation from ongoing rural land use including selective clearing of trees. The site otherwise sits adjacent to existing residential development.
- Roadkill/ trampling – none of the subject species could be affected by vehicle strike or trampling. All are arboreal, flying/gliding birds or mammals.
- Littering – potential effects are mitigated by the EMP, but none of the subject species could be affected by littering. All of the subject species live in the tree canopy.
- Weed invasion – potential effects are mitigated by the FFMP and EMP, but the subject species are all canopy species which would be minimally affected by weed invasion in all but the most extreme infestations (e.g. Cats Claw Creeper (*Macfadyena unguis-cati*) overtopping mature canopy trees) which would be prevented, at minimum, by the management actions detailed in the FFMP and EMP.
- Predation by pets – the EMP details restrictions on title limiting the potential impact of pets within the residential development, however, none of the subject species are likely to be affected by predation by domestic animals.
- Altered fire regimes – Existing fire regimes within the site have already been altered by anthropogenic fire suppression. This has resulted in more mesic elements establishing within the dry sclerophyll forests on site. The retained Reserve vegetation will continue to be affected by the existing altered fire regime.
- Altered hydrology – the EMP details extensive measures and supporting management documents that will mitigate impacts to hydrology within the retained Reserve vegetation. The site drains into the existing residential area of Manyana, and effectively acts as the headwaters of a small catchment. Thus, hydrological impacts to any threatened species outside of the proposed action area are expected to be minimal.

The impacts of edge effects on the subject species are expected to be negligible.

6.4 Offsets

No residual impacts are anticipated resulting from the proposed action. The proposed action will not result in a significant impact to any of the subject species. The impacts which may occur, which are negligible, will be further mitigated by delaying clearing of potentially important foraging habitat in later stages of the development during clearing of earlier stages. Plantings of foraging habitat are expected to increase the availability of foraging habitat for the GHFF within the site after the plantings mature. GHFF foraging activity within the site in winter and spring months is likely to increase once the development is complete.

Moreover, the mitigation plantings within the site offer equivalent, and likely greater, compensatory foraging habitat to what would be provided via an offsite offset. Any offsetting off site would be at a greater distance, likely a significantly greater distance given the surrounding land tenure, from the impact area than the mitigation plantings on the site. Planting offsets off site would also provide only equivalent, or lesser, potential foraging resources (nectar production) when compared to the nectar produced by street trees (see OEH 2016; Davis et al 2016; Birtchnell and Gibson 2006). Nothing about the mitigation plantings within the development site would result in a poorer habitat resource being made available than if the resource were provided via an off-site offset.

The level of residual impact to the subject species following avoidance and mitigation measures is expected to be negligible. Due to negligible impacts occurring, a significant residual impact assessment is not required.

7 Conclusion

Without question the 2019-2020 bushfires had a devastating impact on the populations of flora and fauna species throughout eastern Australia. Range-wide impacts to certain vulnerable species may not become clear for many years, and the legislative up-listing of some of these species will likely be warranted. In this context, action must certainly be taken to prevent further declines of the species most affected by the bushfires. Conservation actions, and in particular the preservation of parcels of land, must allocate resources efficiently and must do so in consideration of the best available science. Allocating resources to locations where these fire affected species do not occur does not serve to improve the conservation outcomes for these species post-fire.

The efficient allocation of resources where they are most needed is of paramount importance in the post-bushfire context. Focusing research efforts, public funds, and media attention to locations where none of the subject species occur has the unavoidable consequence of depriving areas of higher conservation significance of these same resources. This is a hindrance to these species' recovery.

The potential impacts to the subject species of this assessment are negligible, and summarised as follows:

- Grey-headed Flying-fox
  - Clearing 1.25 hectares of winter-spring foraging habitat potentially productive during the months of June-November. Range-wide foraging habitat available during these months is between 2,000,000 and 5,850,000 hectares, with an estimated 17% overlap of the 2019-2020 bushfires over this foraging habitat.
  - Clearing 5.93 hectares of summer-autumn foraging habitat over a 9 year period, commencing >50 months since the Currowan fire, and when the greatest land area and total nectar production would be available for foraging GHFF.
  - The foraging habitat on site is likely to be infrequently utilised given the species' rare occurrence in the South Coast during these months.
- Greater Glider
  - Greater Gliders do not occur on site. Extensive survey both within the site and in the surrounding region has detected Greater Gliders at only one location, which is 10 kilometres from the site.
  - Greater Gliders do not disperse great distances. Greater Gliders could not possibly disperse into the site from areas of known occupation for many years, possibly decades.
- Swift Parrot
  - Important areas within this species' non-breeding range on the Australian mainland are relatively well understood. The site is not an important area for Swift Parrots.
  - The site does not contain important food trees for Swift Parrots.
  - The primary threats to Swift Parrots are within their breeding range in Tasmania and not on the Australian mainland.

For the above reasons, we conclude that the proposed action does not represent a significant impact to the Grey-headed Flying-fox, Greater Glider or Swift Parrot.

References

Akçakaya, HR, Mills, G & Doncaster, CP 2007, 'The role of metapopulations in conservation', in D Macdonald & K Service (eds), *Key Topics in Conservation Biology*.

Baguette, M 2004, 'The classical metapopulation theory and the real, natural world: a critical appraisal', *Basic and applied ecology*, vol. 5, no. 3, pp. 213–224.

Bär, A, Michaletz, ST & Mayr, S 2019, 'Fire effects on tree physiology', *New Phytologist*, vol. 223, pp. 1728–1741.

Benson, RP, Roads, JO & Weise, DR 2008, 'Chapter 2 Climatic and Weather Factors Affecting Fire Occurrence and Behavior', *Developments in Environmental Science*, vol. 8, pp. 37–59.

Berry, L. E, Banks, S, Lindenmayer, D, & Driscoll, D. A 2015, 'The use of topographic fire refuges by the greater glider, Petauroides volans and the mountain brushtail possum, *Trichosurus cunninghami* following a landscape-scale fire', *Australian Mammalogy*, vol. 37, no. 1.

Birdlife Australia 2014, *Swift Parrots and Regent Honeyeaters in the Lake Macquarie City Council area New South Wales: An Assessment of Status, Identification of High Priority Habitats and Recommendations for Conservation*. Prepared by Birdlife Australia for Lake Macquarie City Council

Birtchnell, MJ & Gibson, M 2006, 'Long-term flowering patterns of melliferous Eucalyptus (Myrtaceae) species', *Australian Journal of Botany*, vol. 54, pp. 745–754.

Bradstock, R, Bedward, M, Gill, A & Cohn, J 2005, 'Which mosaic? A landscape ecological approach for evaluating interactions between fire regimes, habitat and animals', *Wildlife Research*, vol. 32, pp. 409–423.

Bradstock, RA, Hammill, KA, Collins, L & Price, O 2010, 'Effects of weather, fuel and terrain on fire severity in topographically diverse landscapes of south-eastern Australia', *Landscape Ecology*, vol. 25, pp. 607–619.

Bradstock, RA, Williams, JE & Malcolm, AG (eds) 2002, *Flammable Australia: the fire regimes and biodiversity of a continent*, Cambridge University Press.

Braithwaite, LW, Dudzinski, ML & Turner, J 1983, 'Studies on the arboreal marsupial fauna of eucalypt forests being harvested for woodpulp at Eden, N.S.W. 11. Relationship between fauna density, richness and diversity, and measured variables of the habitat.', *Australian Wildlife Research*, vol. 10, pp. 231–247.

Brundrett, M & Longman, V 2015, 'Recovery of banksia woodland after fire', *Wildlife Society of Western Australia Newsletter*.

Burrows, GE 2013, 'Buds, bushfires and resprouting in the eucalypts', *Australian Journal of Botany*, vol. 61, no. 5.

Bushfire and Environmental Services (BES) 2006, *Flora and Fauna Assessment – Proposed Subdivision, Lot 172 DP 755923 & Lot 823 DP 247285 Berringer Road and Cunjurong Point Road, Manyana.*, St Georges Basin.

Calder, TG 1983, *Management for Arboreal Species in the Wombat State Forest. Environmental Report*, Graduate School of Environmental Science, Monash University, Melbourne.

Chia, EK, Bassett, M, Leonard, SW, Holland, GJ, Ritchie, EG, Clarke, MF & Bennett, AF 2016, 'Effects of the fire regime on mammal occurrence after wildfire: site effects vs landscape context in fire-prone forests', *Forest Ecology Management*, vol. 363, pp. 130–139.

Clarke, PJ, Lawes, MJ, Midgley, JJ, Lamont, BB, Ojeda, F, Burrows, GE, Enright, NJ & Knox, KJE 2013, 'Resprouting as a key functional trait: how buds, protection and resources drive persistence after fire', *New Phytologist*, vol. 197, pp. 19–35.

Cornwell, W, Kirchhoff, C, & Ooi, M 2021, '5 remarkable stories of flora and fauna in the aftermath of Australia's horror bushfire season', *The Conversation*, accessed from <https://theconversation-com.cdn.ampproject.org/c/s/theconversation.com/amp/5-remarkable-stories-of-flora-and-fauna-in-the-aftermath-of-australias-horror-bushfire-season-155749>.

Cowles, HC 1899, 'The Ecological Relations of the Vegetation on The Sand Dunes of Lake Michigan. Part I.- Geographical Relations of the Dune Floras', *Botanical Gazette*.

Craven, P and Daly, G 2020, *Post-fire fauna surveys in coastal national parks of the Shoalhaven Area, NSW National Parks and Wildlife Service South Coast Branch; Murramarang National Park, Meroo National Park, Conjola National Park, Corramy Regional Park, May, June 2020*. Report prepared by Philip Craven and Garry Daly for the NSW National Parks and Wildlife Service, South Coast Branch July 2020.

Daly, G. 2023. Monitoring of arboreal mammals in Corramy Nature Reserve, Conjola National Park, Meroo National Park, Murramarang National Park and Seven Mile Beach National Park, NSW. Report prepared for NSW National Parks and Wildlife Service, South Coast Branch.

Davey, SM 1984, 'Habitat preferences of arboreal marsupials within a coastal forest in southern New South Wales', in *Possums and Gliders*, Surrey Beatty & Sons with Australian Mammal Society, Sydney, pp. 509–516.

Davis, A, Major, RE & Taylor, CE 2016, 'Do trees flower longer in the city? A comparison of flowering eucalyptus trees in streets, remnants and continuous forest and their association with nectarivorous birds', *Urban Ecosystems*, vol. 19, pp. 735–747.

Department of Agriculture Water and the Environment (DAWE) 2020, *Rapid analysis of impacts of the 2019-20 fires on animal species, and prioritisation of species for management response*. Report prepared for the Wildlife and Threatened Species Bushfire Recovery Expert Panel 14 March 2020

Department of Agriculture Water and the Environment (DAWE) 2021a, *National Recovery Plan for the Grey-headed Flying-fox*.

Department of Agriculture Water and the Environment (DAWE) 2021c, 'Species Profile and Threats Database (SPRAT).'.

Department of Agriculture Water and the Environment (DAWE) 2021d, *Conservation Advice for the Coastal Swamp Sclerophyll Forest Of New South Wales And South East Queensland*.

Department of Agriculture, Water and the Environment (DAWE) Wildlife And Threatened Species Bushfire Recovery Expert Panel 2021d, *Rapid analysis of impacts of the 2019-20 fires on animal species, and prioritisation of species for management response and supporting information*, accessed from <https://www.environment.gov.au/biodiversity/bushfire-recovery/priority-animals on 26 May 2020>.

Department of Agriculture, Water and the Environment (DAWE) Wildlife and Threatened Species Bushfire Recovery Expert Panel 2021e, *Provisional list of animals requiring urgent management intervention*.

Department of Agriculture, Water and the Environment (DAWE) 2022, *Conservation Advice for Callocephalon fimbriatum (Gang-gang Cockatoo)*.

Department of Climate Change, Energy the Environment and Water (DCCEEW) 2023, *National Flying-Fox Monitoring Program*.

Department of Planning, Industry and Environment (DPIE) 2019, 'Flying-Fox Foraging Habitat 2019', accessed from https://www.planningportal.nsw.gov.au/opendata/dataset/flying-fox-foraging-habitat-2019

Department of Planning Industry and Environment (DPIE) 2021, 'Google Earth Engine Burnt Area Map (GEEBAM)', Google Earth Engine Burnt Area Map (GEEBAM), accessed from https://datasets.seed.nsw.gov.au/dataset/google-earth-engine-burnt-area-map-geebam

Department of Planning Industry and Environment (DPIE) 2022, NSW Bionet Threatened Biodiversity Profile Data Collection, accessed from https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/nsw-bionet/about-bionet-atlas

Department of the Environment and Energy (DoEE) 2017, *Draft Recovery Plan for the Grey-headed Flying-fox Pteropus poliocephalus*.

Eby, P 2019, 'A Case for the GER: Conserving Functional Landscapes for Nomadic', accessed from https://ger.org.au/wp-content/uploads/2020/08/Eby-2019-Conserving-Functional-Landscapes-for-Nomadic-Pollinators.pdf

Eby, P. & Law, B. 2008, *Ranking the feeding habitats of Grey-headed flying foxes for conservation management*, The Department of Environment and Climate Change (NSW) & The Department of Environment, Water, Heritage and the Arts, Department of Environment, Water, Heritage and the Arts, Canberra.

Eby, P & Lunney, D 2002, 'Managing the Grey-headed Flying-fox Pteropus poliocephalus as a threatened species: a context for the debate', *Royal Zoological Society of New South Wales*.

Eby, P, Richards, G, Collins, L & Parry-Jones, K 1999, 'The distribution, abundance and vulnerability to population reduction of a nomadic nectarivore, the Grey-headed Flying-fox Pteropus poliocephalus in New South Wales, during a period of resource concentration', *Australian Zoologist*, vol. 31, no. 1.

Eby, P, Sims, R & Bracks, J 2019, *Flying fox Foraging Habitat Mapping NSW: a seamless map for assessing temporal and spatial patterns of habitat quality for flying foxes.*, Local Government Association New South Wales.

Ecoplanning 2018a, 'Re: Response to letter from Department of the Environment and Energy, regarding 182 lot sub-division, Berringer and Cunjurong Roads, Manyana'.

Ecoplanning 2018b, 'Re: Response to the Department of the Environment and Energy requesting additional information regarding EPBC Act application to the 182 lot residential subdivision at Berringer and Cunjurong Point Roads, Manyana.'.

Ecoplanning 2020a, *Matters of National Environmental Significance Assessment – Lot 172 // DP 755923 & Lot 823 DP // 247285, Manyana, NSW*.

Ecoplanning 2020b, *Draft Preliminary Documents Submission provided prior to the Species Workshop in December 2020, Lot 172 // DP 755923 & Lot 823 DP // 247285, Manyana, NSW*.

Ecoplanning 2020c, *EPBC Act referral, 2020/8704 - Lot 172 DP 755923 Lot 823 DP247285, Manyana, NSW*.

Ecoplanning 2021a, *Flora and Fauna Management Plan, Lot 172 // DP 755923 & Lot 823 DP // 247285, Berringer Road, Cunjurong Point Road and Sunset Strip, Manyana*, Precise Planning.

Ecoplanning 2021b, *Environment Management Plan, Lot 172 // DP 755923, Lot 823 // DP 247285, Berringer Road, Cunjurong Point Road and Sunset Strip, Manyana, NSW 2539*.

Environment Protection and Biodiversity Conservation Act 1999.

EPBC Act Environmental Offsets Policy 2012.

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

Eyre, TJ 2004, 'Distribution and conservation status of possums and gliders of southern Queensland. Pp. 1-25 in', in pp. 1–25.

Eyre, TJ 2006, 'Regional habitat selection of large gliding possums at forest stand and landscape scales in southern Queensland, Australia. I. Greater glider (Petauroides volans)', in RL Goldingay & SM Jackson (eds), *Forest Ecology and Management*, Surrey Beatty and Sons, Chipping Norton, Australia, pp. 270–285.

Fairman, TA, Bennett, LT, Tupper, S & Nitschke, CR 2017, 'Frequent wildfires erode tree persistence and alter stand structure and initial composition of a fire-tolerant sub-alpine forest', *Journal of Vegetation Science*, vol. 28, pp. 1151–1165.

Foley, WJ, Lawler, IR, Moore, BD, Marsh, KJ & Wallis, IR 2004, 'Diet selection in marsupial folivores of Eucalyptus: the role of plant secondary metabolites', in RL Goldingay & SM Jackson (eds), *The Biology of Possums and Gliders*, Surrey Beatty & Sons, Chipping Norton, pp. 207–221.

Fronhofer, EA, Kubisch, A, Hilker, FM, Hovestadt, T & Poethke, HJ 2012, 'Why are metapopulations so rare?', *Ecology*, vol. 93, no. 8, pp. 1967–1978.

Gaia Research 2007, *Assessment on the impact of fauna from proposed quarrying on Lot 464 DP 1058778, Princes Highway, South Nowra*. Report prepared for South Coast Crushing and Recycling.

Gaia Research Pty Ltd 2021, *Targeted surveys for the Greater Glider Petauroides volans in the Conjola area, Nowra*. Report prepared for the Department of Agriculture, Water and the Environment.

Gibbons, P 1999, 'Habitat-tree retention in wood production forests'. A thesis submitted for the degree of Doctor of Philosophy of The Australian National University. February 1999

Gibbons, P, Lindenmayer, D, Barry, S & Tanton, MT 2002, 'Hollow selection by vertebrate fauna in forests of southeastern Australia and implications for forest management', *Biological Conservation*, vol. 103, no. 1, pp. 1–12.

Goldingay, RL 2012, 'Characteristics of tree hollows used by Australian arboreal and scansorial mammals', *Australian Journal of Zoology*, vol. 59, pp. 277–294.

Goldingay, RL & Kavanagh, RP 1991, 'The Yellow-bellied Glider: a review of its ecology, and management considerations', *Conservation of Australia's Forest Fauna*, vol. 1, pp. 365–375.

Goldingay, RL, Rohweder, D & Taylor, BD 2020, 'Nest box contentions: Are nest boxes used by the species they target?', *Ecological management and restoration*, vol. 21, no. 2, pp. 115–122.

Goldingay, RL, Taylor, BD & Ball, T 2011, 'Wooden poles can provide habitat connectivity for a gliding mammal', *Australian Mammalogy*, vol. 33, no. 1, pp. 36–43.

Hanski, I 2004, 'Metapopulation theory, its use and misuse', *Basic and Applied Ecology*, vol. 5, no. 3, pp. 225–229.

Hanski, I & Gilpin, ME 1997, *Metapopulation Biology - Ecology, Genetics, and Evolution*.

Harrison, S 1994, 'Metapopulations and conservation', In: Edwards, P. J., Webb, N. R. and May, R. M. (eds), *Large-scale ecology and conservation biology*. Blackwell, pp. 111-128.

Henry, SR 1984, *Social organisation of the greater glider (Petauroides volans) in Victoria. In Possums and Gliders* AP Smith & ID Hume (eds), Surrey Beatty and Sons, Chipping Norton.

Hume, ID 1999, *Marsupial Nutrition*, Cambridge University Press, Cambridge.

Ingwerson, D, Roderick, M, & Wilson, C, 2016, '*Swift Parrot and Regent Honeyeater Update from 2016 surveys*', Birdlife Australia.

Inions, GB, Tanton, MT & Davey, SM 1989, 'Effect of Fire on the Availability of Hollows in Trees Used by the Common Brushtail Possum, Trichosurus Vulpecula Kerr, 1792, and the Ringtail Possum, *Pseudocheirus peregrinus* Boddaerts, 1785.', *Australian Wildlife Research*, vol. 16, no. 4, pp. 449–458.

Jackson, S. M. 2015, Family Pseudocheiridae (Ringtail Possums and Greater Gliders). In *Handbook of the Mammals of the World. Volume 5: Monotremes and Marsupials* (eds Mittermeier, R. A. & Wilson, D. E.) Springer, Barcelona, pp. 654–658.

Kapoor, D, Bhardwaj, S, Landi, M, Sharma, A, Ramakrishnan, M & Sharma, A 2020, 'The Impact of Drought in Plant Metabolism: How to Exploit Tolerance Mechanisms to Increase Crop Production', *Applied Sciences*, vol. 10, no. 16, p. 5692.

Kavanagh, R. P. 1984, '*Seasonal changes in habitat use by gliders and possums in southeastern New South Wales. In 'Possums and gliders*', Eds A. P. Smith and I. D. Hume. pp. 527-543, Surrey Beatty and Sons: Chipping Norton.

Kavanagh, RP & Kavanagh, RP 2000, 'Effects of variable-intensity logging and the influence of habitat variables on the distribution of the Greater Glider Petauroides volans in montane forest, southeastern New South Wales', *Pacific Conservation Biology*, vol. 6, no. 1, pp. 18–30.

Kavanagh, RP & Lambert, MJ 1990, 'Food selection by the greater glider, Petauroides volans: is foliar nitrogen a determinant of habitat quality?', *Australian Wildlife Research*, vol. 17, pp. 285–299.

Kavanagh, R P 2004. Distribution and conservation status of possums and gliders in New South Wales. in RL Goldingay & SM Jackson (eds), *The biology of possums and gliders*, Surrey Beatty & Sons, Chipping Norton, pp. 130-148.

Kavanagh, RP & Wheeler, RJ 2004, 'Home-range of the greater glider Petauroides volans in tall montane forest of southeastern New South Wales, and changes following logging.', in RL Goldingay & SM Jackson (eds), *The biology of possums and gliders*, Surrey Beatty & Sons, Chipping Norton, pp. 413–425.

Keeley, JE 2009, 'Fire intensity, fire severity and burn severity: A brief review and suggested usage', *International Journal of Wildland Fire*, vol. 18, no. 1, pp. 116–126.

Kehl, J & Borsboom, AC 1984, 'Home range, den tree use and activity patterns in the greater glider Petauroides volans.', in AP Smith & ID Hume (eds), *Possums and Gliders*, Surrey Beatty, Sydney, pp. 229–236.

Lamont, B & Markey, A 1995, 'Biogeography of Fire-Killed and Resprouting Banksia Species in South-Western Australia', *Australian Journal of Botany*, vol. 43, pp. 283–303.

Law, B & Chidel, M 2007, 'Effects of Logging on Nectar-Producing Eucalypts Spotted Gum and Grey Ironbark'. Report prepared for the Australian Government, Rural Industries Research and Development Corporation.

Law, B, Mackowski, C, Schoer, L & Tweedie, T 2000, 'Flowering phenology of myrtaceous trees and their relation to climatic, environmental and disturbance variables in northern New South Wales', *Austral Ecology*, vol. 25, no. 2, pp. 160–178.

Levins, R. 1970, Extinction, in M. Gersten-haber (ed.) *Some mathematical problems in biology*. Mathematical Society of America, Providence, Rhodes Island, USA, pp 75-107

Leys, AJ 2021, *How is carbon stored in trees and wood products?*, Forest and Wood Products Australia.

Lindenmayer, D 2002, *Gliders of Australia: a natural history*, UNSW Press, Sydney.

Lindenmayer, D 2020, *Affidavit of Professor David Lindenmayer AO in support of application for injunction affirmed on 25 May 2020*.

Lindenmayer, DB, Blanchard, W, McBurney, L, Blair, D, Banks, SC, Driscoll, D, Smith, AL & Gill, AM 2013, 'Fire severity and landscape context effects on arboreal marsupials', *Biological Conservation*, vol. 167, pp. 137–148.

Lindenmayer, DB, Cunningham, RB, Donnelly, CF, Incoll, RD, Pope, ML, Tribolet, CR & Viggers, KL 2001, 'How effective is spotlighting for detecting the greater glider (Petauroides volans)?', *Wildlife Research*, vol. 28, no. 1, pp. 105–109.

Lindenmayer, DB, Cunningham, RB, Tanton, MT, Smith, AP & Nix, HA 1990, 'The conservation of arboreal marsupials in the Montane ash forests of the central highlands of Victoria, Southeast Australia: I. Factors influencing the occupancy of trees with hollows', *Biological Conservation*, vol. 54, no. 2, pp. 111–131.

Lindenmayer, DB, Cunningham, RB, Tanton, MT, Smith, AP & Nix, HA 1991, 'Aspects of the use of den trees by arboreal marsupials in the montane ash forests in Victoria', *Australian Journal of Zoology*, vol. 39, pp. 57–65.

Lindenmayer, DB, and Lacy, RC 1995, 'Metapopulation viability of arboreal marsupials in fragmented old-growth forests: comparison among species.' *Ecological Applications* vol. 5, pp. 183-199.

Lindenmayer, DB & Hobbs, RJ 2004, 'Fauna conservation in Australian plantation forests – a review', *Biological Conservation*, vol. 119, no. 2, pp. 151–168.

Lindenmayer, DB, MacGregor, C, Welsh, A, Donnelly, C, Crane, M, Michael, D, Montague-Drake, R, Cunningham, RB, Brown, D, Fortescue, M, Dexter, N, Hudson, M & Gill, AM 2008, 'Contrasting mammal responses to vegetation type and fire', *Wildlife Research*, vol. 35, pp. 395–408.

Lindenmayer, DB, Wood, JB, McBurney, L, MacGregor, C, Youngentob, K, and Banks, SC 2011, How to make a common species rare: A case against conservation complacency. *Biological Conservation* 144:1663-1672.

Lunney, D 1987, 'Effects of Logging, Fire and Drought on Possums and Gliders in the Coastal Forests Near Bega, NSW', *Wildlife Research*, vol. 14, pp. 263–274.

Mackowski, CM 1984, ‘The ontogeny of hollows in blackbutt, Eucalyptus pilularis, and its relevance to the management of forests for possums, gliders and timber’, in AP Smith & ID Hume (eds), *Possums and Gliders*, Australian Mammal Society, Sydney, pp. 553–567.

Martin, L, Kennedy, JH, Little, L, Luckhoff, HC, O’Brien, GM, Pow, CST, Towers, PA, Waldon, AK & Wang, DY 1996, ‘The reproductive biology of Australian flying-foxes (genus Pteropus)’, *Symposia of the Zoological Society of London*, vol. 67, pp. 167–184.

McCarthy, MA, Gill, AM & Lindenmayer, DB 1999, ‘Fire regimes in mountain ash forest: evidence from forest age structure, extinction models and wildlife habitat’, *Forest Ecology and Management*, vol. 124, no. 2–3, pp. 193–203.

McCarthy, MA & Lindenmayer, DB 1999, ‘Incorporating metapopulation dynamics of greater gliders into reserve design in disturbed landscapes’, *Ecology*, vol. 80, no. 2, pp. 651–667.

McCarthy, MA, Lindenmayer, DB & Possingham, HP 2001, ‘Assessing spatial PVA models of arboreal marsupials using significance tests and Bayesian statistics’, *Biological Conservation*, vol. 98, no. 2, pp. 191–200.

McCaw, WL 1983, ‘Wood defect associated with fire scars on Jarrah’, *Australian Forest Research*, vol. 13, pp. 261–266.

McComb, WC & Noble, RE 1981, ‘Nest-box and natural cavity use in three mid-south forest habitats’, *Journal of Wildlife Management*, vol. 45, pp. 93–101.

McGregor, IR, Helcoski, R, Kunert, N, Tepley, AJ, Gonzalez-Akre, EB, Herrmann, V, Zailaa, J, Stovall, AEL, Bourg, NA, McShea, WJ, Pederson, N, Sack, L & Anderson-Teixeira, KJ 2020, ‘Tree height and leaf drought tolerance traits shape growth responses across droughts in a temperate broadleaf forest’, *New Phytologist Foundation*.

McLean, CM, Bradstock, R, Price, O & Kavanagh, RP 2015, ‘Tree hollows and forest stand structure in Australian warm temperate Eucalyptus forests are adversely affected by logging more than wildfire’, *Forest Ecology and Management*, vol. 341, pp. 37–44.

McLean, CM, Kavanagh, RP, Penman, T & Bradstock, R 2018, ‘The threatened status of the hollow dependent arboreal marsupial, the Greater Glider (Petauroides volans), can be explained by impacts from wildfire and selective logging’, vol. 415–416, pp. 19–25.

Menkhorst, P & Knight, F 2010, *A Field Guide to the Mammals of Australia* 3rd edn.

Menkhorst, PW 1984, ‘Use of Nest Boxes by Forest Vertebrates in Gippsland: Acceptance, Preference and Demand’, *Australian Wildlife Research*, vol. 11, no. 2, pp. 255–264.

Moore, CE, Beringer, J, Evans, B, Hutley, LB & Tapper, NJ 2017, ‘Tree–grass phenology information improves light use efficiency modelling of gross primary productivity for an Australian tropical savanna’, *Biogeosciences*, vol. 14, pp. 111–129.

Murphy, BP, Bradstock, RA, Boer, MM, Carter, J, Cary, GJ, Cochrane, MA, Fensham, RJ, Russell-Smith, J, Williamson, GJ & Bowman, DMJS 2013, ‘Fire regimes of Australia: a pyrogeographic model system’, Journal of Biogeography, vol. 40, no. 6, pp. 1048-58.

Nolan, RH, Boer, MM, Collins, L, de Dios, VR, Clarke, H, Jenkins, M, Kenny, B & Bradstock, RA 2020, ‘Causes and consequences of eastern Australia’s 2019–20 season of mega-fires’, , vol. 26, no. 3, pp. 1039–1041.

Nowack, J, Stawski, C & Geiser, F 2017, ‘More functions of torpor and their roles in a changing world’, *Journal of Comparative Physiology B*, vol. 187, pp. 889–897.

Office of Environment and Heritage (OEH) 2016, '*Planting to conserve threatened nomadic pollinators in NSW*', State of NSW and Office of Environment and Heritage.

Office of Environment and Heritage (OEH) (2022a). Atlas of NSW Wildlife. Accessed from <http://www.bionet.nsw.gov.au/> Accessed September 2021

Office of Environment and Heritage (OEH) (2022b). Threatened Species Profiles. Accessed from <http://www.environment.nsw.gov.au/threatenedspecies/> Accessed May 2022

Olsen, J & Trost, S 2009, 'Common Brushtail Possum Trichosurus vulpecula Evicts Juvenile Southern Boobook Ninox novaeseelandiae from its Nest-hollow', *Australian field ornithology*, vol. 26, no. 1/2, pp. 46–52.

OMVI Ecological 2012 *Flora and Fauna Impact Assessment for a Proposed Training Camp, Little Forest*, Report prepared for David Wilson Architects.

OMVI Ecological 2020, *Review of the flora and fauna impacts assessment for MP05-0059 an approved 182 lot residential sub-division development in Manyana, NSW*.

Parry-Jones, K 1985, 'Winter Flying-fox Colonies in Southern NSW', *Australian Zoologist*, vol. 22, no. 2.

Parry-Jones, KA 1993, 'Movements of Pteropus poliocephalus New South Wales', A thesis submitted for the degree of Doctor of Philosophy of the University of New South Wales, Australia. March 1993.

Pausas, JG & Keeley, JE 2014, 'Evolutionary ecology of resprouting and seeding in fire-prone ecosystems', *New Phytologist*, vol. 204, pp. 55–65.

Pianka, ER 1974, *Evolutionary ecology*, Harper and Row, New York.

Pook, EW, Gill, AM & Moore, PHR 1997, 'Long term variation of litter fall, canopy leaf area and flowering in a Eucalyptus maculata forest on the south coast of New South Wales', *Australian Journal of Botany*, vol. 45, pp. 737–755.

Poore, M 1955, 'The Use of Phytosociological Methods in Ecological Investigations: II. Practical Issues Involved in an Attempt to Apply the Braun-Blanquet System.' *Journal of Ecology*, vol .43 no. 1, pp. 245-269.

Possingham, HP, Lindenmayer, DB & Norton, TW 1994, 'A framework for the improved management of threatened species based on Population Viability Analysis (PVA)', *Pacific Conservation Biology*, vol. 1, no. 1, pp. 39–45.

Prior, LD, Williamson, GJ & Bowman, DMJS 2016, 'Impact of high-severity fire in a Tasmanian dry eucalypt forest', *Australian Journal of Botany*, vol. 64, no. 3, pp. 193–205.

Recher, HF, Holmes, RT, Schulz, M, Shields, J & Kavanagh, R 1985, 'Foraging patterns of breeding birds in eucalypt forest and woodland of southeastern Australia', *Australian Journal of Ecology*, vol. 10, no. 4.

van der Ree, R, Bennett, AF & Gilmore, DC 2004, 'Gap-crossing by gliding marsupials: thresholds for use of isolated woodland patches in an agricultural landscape', *Biological Conservation*, vol. 115, no. 2, pp. 241–249.

Rubsamen, K, Hume, ID, Foley, WJ & Rubsamen, U 1984, 'Implications of the large surface area to body mass ratio on the heat balance of the greater glider (*Petaroides volans*: Marsupialia)', *Journal of Comparative Physiology B*, vol. 154, pp. 105–111.

Saunders, D & Heinsohn, R 2008, Winter habitat use by the endangered, migratory Swift Parrot (*Lathamus discolor*) in New South Wales', *Emu,* 108.

Saunders, D & Tzaros, C 2011, *National Recovery Plan for the Swift Parrot Lathamus discolor*, Birds Australia, Melbourne.

Saunders, DA, Smith, GI & Rowley, I 1982, 'The availability and dimensions of tree hollows that provide nest sites for cockatoos (Psittaciformes) in Western Australia', *Australian Wildlife Research*, vol. 9, pp. 541–556.

Simberloff, D 1997, 'Biogeographic Approaches and the New Conservation Biology', in *The Ecological Basis of Conservation*, pp. 274–284.

Smith, AP, Moore, DM & Andrews, SP 1994, *Fauna of the Grafton and Casino Forestry Study Areas description and assessment of forestry impacts*, State Forests of New South Wales, Austeco Environmental Consultants, Armidale.

Smith, GC, Mathieson, M & Hogan, L 2007, 'Home range and habitat use of a low-density population of Greater Glider, Petauroides volans (Pseudocheiridae: Marsupialia), in a hollow-limiting environment', *Wildlife Research*, vol. 34, pp. 472–483.

Smith, P & Smith, J 2016, Influence of fire regime and other habitat factors on a eucalypt forest bird community in south-eastern Australia in the 1980s', *Australian Journal of Zoology*, vol. 64, no. 5, pp. 312–326.

Southwell, D 2020, *Preliminary Draft - Design considerations for post natural disaster (fire) on-ground assessment of status of species, ecological communities, habitats and threats*, The University of Melbourne.

Stawski, C, Nowack, J, Kortner, G & Geiser, F 2017, 'A new cue for torpor induction: charcoal, ash and smoke', *Journal of Experimental Biology*, vol. 220, no. 2, pp. 220–226.

Taylor, AC, Tyndale-Biscoe, H & Lindenmayer, DB 2007, 'Unexpected persistence on habitat islands: genetic signatures reveal dispersal of a eucalypt-dependent marsupial through a hostile pine matrix', *Molecular Ecology*, vol. 16, no. 13, pp. 2655–2666.

Taylor, BD & Goldingay, RL 2009, 'Can Road-Crossing Structures Improve Population Viability of an Urban Gliding Mammal?', *Ecology and Society*, vol. 14, no. 2, p. 13.

Threatened Species Scientific Committee (TSSC) 2016a, *Conservation Advice Lathamus discolour Swift Parrot*.

Threatened Species Scientific Committee (TSSC) 2016b, *Conservation Advice Petauroides volans Greater Glider*.

Threatened Species Scientific Committee (TSSC) 2018, *Conservation Advice Rhodamnia rubescens Scrub Turpentine*.

Tidemann, CR & Flavel, SC 1987, 'Factors affecting choice of diurnal roost site by tree-hole bats (Microchiroptera) in south-eastern Australia', *Australian Wildlife Research*, vol. 14, pp. 459–473.

Tidemann, SC, Boyden, J, Elvish, R, Elvish, J & O'Gorman, B 1992, 'Comparison of the breeding sites and habitat of two hole-nesting estrildid finches, one endangered, in northern Australia', *Journal of Tropical Ecology*, vol. 8, pp. 373–388.

Todd, CR, Lindenmayer, DB, Stamation, K, Acevedo-Cattaneo, S, Smith, S & Lumsden, LF 2016, 'Assessing reserve effectiveness: Application to a threatened species in a dynamic fire prone forest landscape', *Ecological Modelling*, vol. 338, pp. 90–100.

Tozer, M, Turner, K, Simpson, C, Keith, D, Beukers, P, MacKenzie, B, Tindall, D and Pennay, C 2006, *Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands*. NSW Department of Environment and Conservation and NSW Department of Natural Resources, Sydney.

Traill, BJ & Lill, A 1997, 'Use of tree hollows by two sympatric gliding possums, the squirrel glider, Petaurus norfolcensis, and the sugar glider, P. breviceps', *Australian Mammalogy*, vol. 20, pp. 79–88.

Tyndale-Biscoe, CH & Smith, RFC 1969, 'Studies on the Marsupial Glider, *Schoinobates volans* (Kerr): III. Response to Habitat Destruction', *Journal of Animal Ecology*, vol. 38, no. 3, pp. 651–659.

Tzaros, C & Ingwersen, D 2012, *Swift Parrot and Regent Honeyeater survey update*, Birdlife Australia.

Tzaros, C & Ingwersen, D 2009, *Swift Parrot and Regent Honeyeater surveys in 2009*, Birdlife Australia.

Unwin, GL & Kriedman, PE 2000, *Principles and Processes of Carbon Sequestration by Trees. Technical Paper No. 64*, Research and Development Division State Forests of New South Wales, Sydney.

Vanderduys, EP, Kutt, AS & Kemp, JE 2012, 'Upland savannas: the vertebrate fauna of largely unknown but significant habitat in north-eastern Queensland', *Australian Zoologist*, vol. 36.

Vivian, LM, Cary, GJ, Bradstock, RA & Gill, AM 2008, 'Influence of fire severity on the regeneration, recruitment and distribution of eucalypts in the Cotter River Catchment, Australian Capital Territory', *Austral Ecology*, vol. 33, no. 1.

Walker LR, Walker J, Hobbs RJ, *Linking restoration and ecological succession*, Springer London; 2007.

Westcott, DA, Heersink, DK, McKeown, A & Caley, P 2015, *Status and Trends of Australia's EPBC-Listed Flying-Foxes*, CSIRO, Australia.

Whelan, RJ 2005, *The Ecology of Fire*, Cambridge University Press.

Williams, MA & Baker, WL 2012, 'Spatially extensive reconstructions show variable-severity fire and heterogeneous structure in historical western United States dry forests', *Global Ecology and Biogeography*, vol. 21, no. 10, pp. 1042–1052.

Wintle, BA, Kavanagh, RP, McCarthy, MA & Burgman, MA 2005, 'Estimating and Dealing with Detectability in Occupancy Surveys for Forest Owls and Arboreal Marsupials', *The Journal Wildlife Management*, vol. 69, no. 3, pp. 905–917.

Woinarski, CZ & Recher, JF 1997, '*Impact and response: a review of the effects of fire on the Australian avifauna*', Pacific conservation biology, vol. 3, no. 3, p. 183–.

Woinarski, J 2014, *The action plan for Australian mammals 2012*, Commonwealth Scientific and Industrial Research Organization Publishing (CSIRO Publishing), Collingwood, Victoria, Australia.

Zammit, C & Westoby, M 1987, 'Population structure and reproductive status of two Banksia shrubs at various times after fire', *Vegetatio*, vol. 70, no. 1, pp. 11–20.

Appendix A Sub-division Works Certificate

Shoalhaven City Council

Bridge Rd, Nowra NSW 2541 | 02 4429 3111
Deering St, Ulladulla NSW 2539 | 02 4429 8999

Address all correspondence to
The Chief Executive Officer, PO Box 42, Nowra NSW 2541 Australia
council@shoalhaven.nsw.gov.au | DX5323 Nowra | Fax 02 4422 1816

shoalhaven.nsw.gov.au

SUBDIVISION CONSTRUCTION CERTIFICATE NO: CC18/2030

Environmental Planning and Assessment Act, 1979, s81A(3), s109F

TO:
Ghazi Sangari
PO Box 3163
BANKSTOWN NSW 2200

being the applicant in respect of the development of the land described as follows:

LAND: Cunjurong Point Rd, MANYANA - Lot 172 DP 755923 & Lot 823 DP 247285

APPROVED USE AND OR DEVELOPMENT:	**182 Lot Subdivision - Stage 1 (30 lots and passive open space)**
DEVELOPMENT CONSENT NO:	**SF9787 (MP05_0059)**
DATE OF CONSENT:	**08-Jul-2008**

This Subdivision Construction Certificate authorises the work referred to in this Certificate in accordance with the attached, certified plans and specifications (identified by the above Subdivision Construction Certificate number) and schedule below/overleaf. This Certificate is required for the carrying out of subdivision work in accordance with the above Development Consent.

DOCUMENT	REF/SHEET NO.	PREPARED BY	DATED
Cover Sheet	PS03-A000 rev. K	Martens & Associates	14/10/2019
Development Overview Plan	PS03-A050 rev. H	Martens & Associates	24/09/2019
Town Planning and Subdivision Plan	PS03-A300 rev. F	Martens & Associates	24/09/2019
Staging Overview Plan	PS03-B100 rev. D	Martens & Associates	17/09/2019
Sediment and Erosion Control and Clearing Plan (as amended)	PS03-B300 rev. F	Martens & Associates	17/09/2019
Sediment and Erosion Control Details (Sheet 1)	PS03-B310 rev. B	Martens & Associates	27/07/2018
Sediment and Erosion Control Details (Sheet 2)	PS03-B311 rev. B	Martens & Associates	27/07/2018
Earthworks and Grading Plan of Stage 1	PS03-C100 rev. G	Martens & Associates	17/09/2019
Earthworks Cut-Fill Plan of Stage 1	PS03-C500 rev. G	Martens & Associates	17/09/2019
Earthworks Section D1	PS03-C600 rev. E	Martens & Associates	17/09/2019
Roadworks Plan of Stage 1	PS03-D100 rev. G	Martens & Associates	17/09/2019
Proposed Road 1 (21-MRC01) Longitudinal Section	PS03-D200 rev. E	Martens & Associates	17/09/2019
Proposed Road 1 (21-MRC01) and Fire Trail Typical Sections	PS03-D201 rev. B	Martens & Associates	27/07/2018

RESPECT | INTEGRITY | ADAPTABILITY | COLLABORATION

Proposed Road 2 (21-MRC02) and Footpath (21-MRP02) Longitudinal Sections & Typical Sections	PS03-D202 rev. C	Martens & Associates	21/05/2019
Proposed Road 4 (21-MRC03) Longitudinal & Typical Sections	PS03-D203 rev. C	Martens & Associates	21/05/2019
Proposed Road 5 (21-MRC05) Longitudinal & Typical Sections	PS03-D204 rev. C	Martens & Associates	21/05/2019
Road 1 (21-MRC01) & Sunset Strip Intersection Plan and Longitudinal Sections	PS03-D300 rev. F	Martens & Associates	17/09/2019
Road 1 (21-MRC01) & Road 4 (21-MRC03) Intersection Plan and Longitudinal Sections	PS03-D301 rev. C	Martens & Associates	21/05/2019
Road 1 (21-MRC01) & Road 2 (21-MRC02) Intersection Plan and Longitudinal Sections	PS03-D302 rev. C	Martens & Associates	21/05/2019
Road 1 (21-MRC01) & Road 5 (21-MRC05) Intersection Plan and Longitudinal Sections	PS03-D303 rev. C	Martens & Associates	21/05/2019
Kerb Return Set Out Tables	PS03-D310 rev. D	Martens & Associates	17/09/2019
Proposed Road 1 (21-MRC01) Stage 1 Cross Sections (Sheet 1)	PS03-D500 rev. E	Martens & Associates	17/09/2019
Proposed Road 1 (21-MRC01) Stage 1 Cross Sections (Sheet 2)	PS03-D501 rev. D	Martens & Associates	21/05/2019
Proposed Road 1 (21-MRC01) Stage 1 Cross Sections (Sheet 3)	PS03-D502 rev. D	Martens & Associates	21/05/2019
Proposed Road 1 (21-MRC01) Stage 1 Cross Sections (Sheet 4)	PS03-D503 rev. C	Martens & Associates	21/05/2019
Proposed Road 2 (21-MRC02) Cross Sections (Sheet 1)	PS03-D504 rev. C	Martens & Associates	21/05/2019
Proposed Road 2 (21-MRC02) Cross Sections (Sheet 2)	PS03-D510 rev. C	Martens & Associates	21/05/2019
Proposed Road 4 (21-MRC03) Cross Sections (Sheet 1)	PS03-D511 rev. C	Martens & Associates	21/05/2019
Proposed Road 4 (21-MRC03) Cross Sections (Sheet 2)	PS03-D512 rev. C	Martens & Associates	21/05/2019
Proposed Road 5 (21-MRC05) Cross Sections (Sheet 1)	PS03-D520 rev. C	Martens & Associates	21/05/2019
Proposed Road 5 (21-MRC05) Cross Sections (Sheet 2)	PS03-D521 rev. C	Martens & Associates	21/05/2019
Swept Path Analysis	PS03-DZ00 rev. C	Martens & Associates	29/03/2019
Shoalhaven City Council Standard Kerb & Gutter Details	PS03-DZ10 rev. C	Martens & Associates	29/03/2019
Shoalhaven City Council Standard Kerb Ramp & Vehicular Crossing Details	PS03-DZ15 rev. B	Martens & Associates	27/07/2018
Sight Distance Assessment	PS03-DZ30 rev. A	Martens & Associates	29/03/2019
Drainage Plan of Stage 1	PS03-E100 rev. H	Martens & Associates	14/10/2019
Drainage Plan Ponding Extents (1% AEP) and Drainage Details	PS03-E101 rev. E	Martens & Associates	17/09/2019
OSD / Bioretention Basin A Plans and Details (as amended)	PS03-E200 rev. F	Martens & Associates	14/10/2019
Basin A Section A1 & A2	PS03-E201 rev. F	Martens & Associates	14/10/2019

Headwall and Reno Mattress Details Signage and Ecosol GPT Details (as amended)	PS03-E202 rev. E	Martens & Associates	14/10/2019
Custom Pit Details (Sheet 1)	PS03-E203 rev. G	Martens & Associates	14/10/2019
Custom Pit Details (Sheet 2)	PS03-E204 rev. F	Martens & Associates	14/10/2019
Drainage Longitudinal Section (Sheet 1)	PS03-E300 rev. F	Martens & Associates	17/09/2019
Drainage Longitudinal Section (Sheet 2)	PS03-E301 rev. E	Martens & Associates	17/09/2019
Drainage Longitudinal Section (Sheet 3)	PS03-E302 rev. E	Martens & Associates	17/09/2019
Drainage Longitudinal Section (Sheet 4)	PS03-E303 rev. E	Martens & Associates	17/09/2019
Drainage Longitudinal Section (Sheet 5)	PS03-E304 rev. E	Martens & Associates	17/09/2019
Drainage Longitudinal Section (Sheet 6)	PS03-E305 rev. E	Martens & Associates	17/09/2019
Drainage Longitudinal Section (Sheet 7)	PS03-E306 rev. E	Martens & Associates	17/09/2019
Drainage Catchment Plan – Off Site	PS03-E400 rev. D	Martens & Associates	17/09/2019
Drainage Catchment Plan – On Site	PS03-E401 rev. A	Martens & Associates	17/09/2019
Drainage Pit Schedule (Sheet 1)	PS03-E500 rev. F	Martens & Associates	17/09/2019
Drainage Pit Schedule (Sheet 2)	PS03-E501 rev. F	Martens & Associates	17/09/2019
5 Year Hydraulics Calculations (Sheet 1)	PS03-E502 rev. E	Martens & Associates	17/09/2019
5 Year Hydraulics Calculations (Sheet 2)	PS03-E503 rev. E	Martens & Associates	17/09/2019
5 Year Hydraulics Calculations (Sheet 3)	PS03-E504 rev. E	Martens & Associates	17/09/2019
5 Year Hydraulics Calculations (Sheet 4)	PS03-E505 rev. E	Martens & Associates	17/09/2019
5 Year Hydraulics Calculations (Sheet 5)	PS03-E506 rev. E	Martens & Associates	17/09/2019
100 Year Hydraulics Calculations (Sheet 1)	PS03-E508 rev. E	Martens & Associates	17/09/2019
100 Year Hydraulics Calculations (Sheet 2)	PS03-E509 rev. E	Martens & Associates	17/09/2019
100 Year Hydraulics Calculations (Sheet 3)	PS03-E510 rev. E	Martens & Associates	17/09/2019
100 Year Hydraulics Calculations (Sheet 4)	PS03-E511 rev. E	Martens & Associates	17/09/2019
100 Year Hydraulics Calculations (Sheet 5)	PS03-E512 rev. C	Martens & Associates	17/09/2019
Pre-Development OSD Catchment Plan, Model and Results	PS03-E600 rev. C	Martens & Associates	17/09/2019
Post-Development OSD Catchment Plan, Model and Results	PS03-E601 rev. C	Martens & Associates	17/09/2019
Water Quality Catchment Plan, Model and Results	PS03-E700 rev. D	Martens & Associates	17/09/2019
Retaining Wall Plan	PS03-G200 rev. F	Martens & Associates	14/10/2019
Concrete Retaining Wall Details (Sheet 1)	PS03-G210 rev. D	Martens & Associates	14/10/2019
Concrete Retaining Wall Details (Sheet 2)	PS03-G211 rev. B	Martens & Associates	14/10/2019
Pavement, Signage and Line Marking (Sheet 1)	PS03-G400 rev. F	Martens & Associates	14/10/2019
Pavement, Signage and Line Marking (Sheet 2)	PS03-G410 rev. F	Martens & Associates	14/10/2019
Pavement, Signage and Line Marking (Sheet 3)	PS03-G420 rev. C	Martens & Associates	29/03/2019
Sunset Strip Pedestrian Crossing & Berringer Road Signage Plan and Details (as amended)	PS03-G430 rev. C	Martens & Associates	14/10/2019
General Notes (Sheet 1)	PS03-ZZ00 rev. C	Martens & Associates	07/11/2018
General Notes (Sheet 2)	PS03-ZZ01 rev. C	Martens & Associates	07/11/2018
General Notes (Sheet 3)	PS03-ZZ02 rev. C	Martens & Associates	07/11/2018
General Notes (Sheet 4)	PS03-ZZ03 rev. C	Martens & Associates	07/11/2018

Landscape Plan – Stage 1	LD03 issue D	HLS Pty Ltd	14/10/2018
Landscape Plan – Stage 1	LD04 issue D	HLS Pty Ltd	14/10/2018
General Notes & Drawing List	S200 rev. A	Dincel & Associates	22/10/2019
Kerb Inlet Pit 1A101-02 Details	S201 rev. A	Dincel & Associates	22/10/2019
Kerb Inlet Pit 1A101-03 Details	S202 rev. A	Dincel & Associates	22/10/2019
Kerb Inlet Pit 1A101-04 Details	S203 rev. A	Dincel & Associates	22/10/2019
Kerb Inlet Pit 1A101-05 Details	S204 rev. A	Dincel & Associates	22/10/2019
Junction Pit 1A103-01 Details	S205 rev. A	Dincel & Associates	22/10/2019
Junction Pit 1A103-04 Details	S206 rev. A	Dincel & Associates	22/10/2019
Kerb Inlet Pit 1A106-02 Details	S207 rev. A	Dincel & Associates	22/10/2019
Kerb Inlet Pit 1A106-03 Details	S208 rev. A	Dincel & Associates	22/10/2019
Kerb Inlet Pit 1A106-04 Details	S209 rev. A	Dincel & Associates	22/10/2019

Supporting documents:

Design Certificate – Structural Pit Design	17108	Dincel & Associates	22/10/2019
Design Certificate – Retaining Structures	P1705919JC09V01	Martens & Associates	15/10/2019
Design Certificate – OSD Structure	P1705919JC07V02	Martens & Associates	25/10/2019
Construction Management Plan	P1705919JR03V04	Martens & Associates	29/04/2019
Flora & Fauna Management Plan	2017-044 ver 2.2	Ecoplanning	26/07/2019
Arboricultural Development Assessment Report	-	Moore Trees	04/05/2018
Bushfire Management Report	CR-133-2	Sydney Bushfire Consultants	11/05/2018
Noise and Vibration Management Plan	17367 version B	Wilkinson Murray	May 2018
Construction Waste Management Plan	P1705919JR02V02	Martens & Associates	23/10/2017
Cultural Heritage Management Plan	-	Southeast Archaeology	July 2018
Department of Planning Letter of Approval of CHMP	CM9 SF 18/56589	NSW Department of Planning & Environment	03/08/2018

Note:

Prior to commencement of work, the applicant must notify Council in writing the commencement date for the subdivision work, giving at least two (2) days' notice.

SIGNED on behalf of Shoalhaven City Council:

Signature

Name	**Scott Haylett** **Development Engineering Coordinator** **Planning Environment & Development Group**	**DATED 19-Nov-2019**

Appendix B GEEBAM vegetation validation

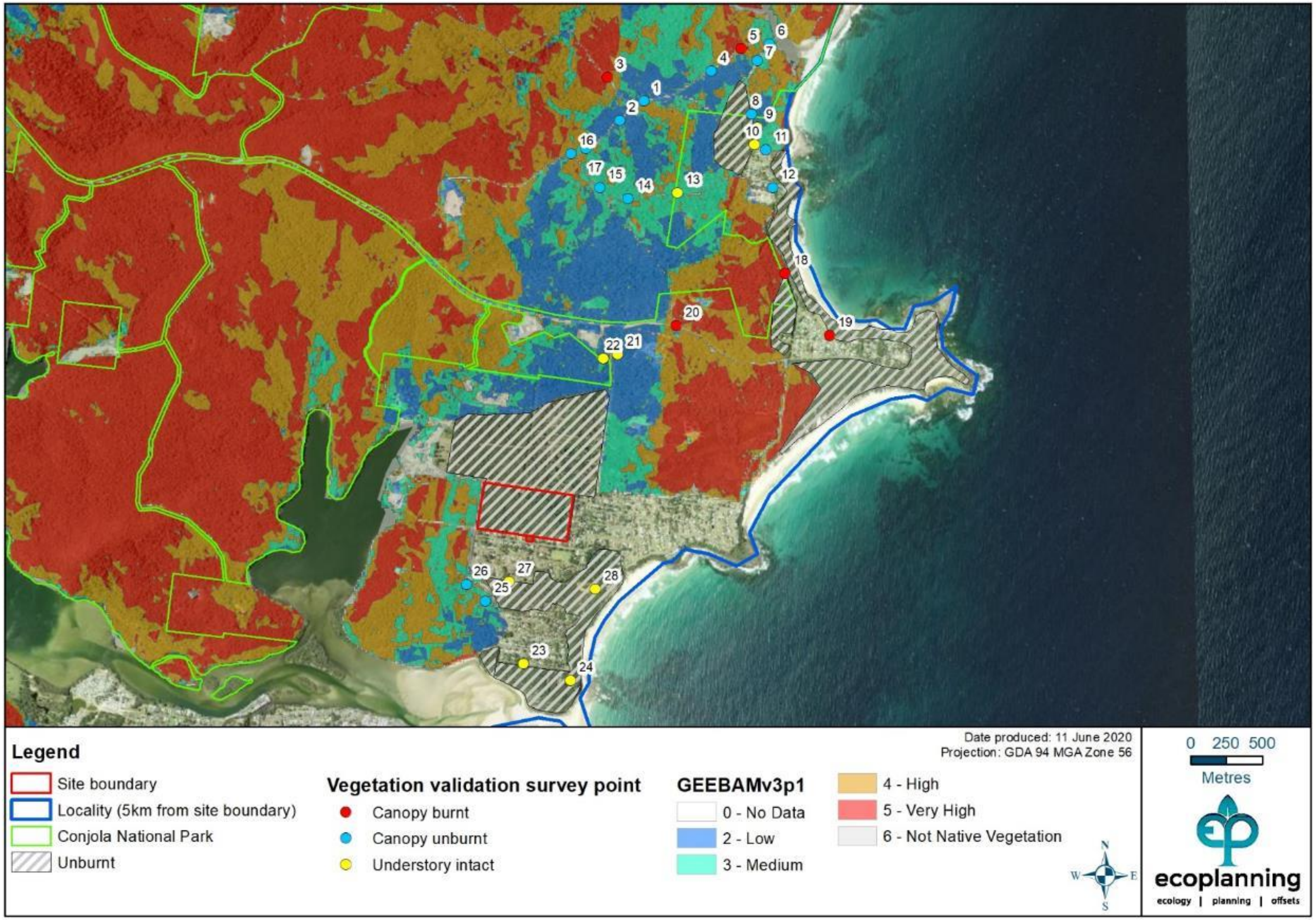
EXAMPLES OF FIELD VERIFIED VEGETATION CONDITION AS SHOWN IN APPENDIX F OF ECOPLANNING (2020A). REFER TO ECOPLANNING (2020A) FOR ALL SURVEY POINTS. ONLY EXAMPLES OF GEEBAM MAPPED 'VERY HIGH' BURNT CLASS VEGETATION ARE SHOWN IN THIS APPENDIX – THESE ARE THE HIGHEST SEVERITY BURN LOCATIONS FOR WHICH PHOTO POINTS WERE RECORDED.

Plate B1 – Unique ID 3. This assessment – Canopy scorched; GEEBAM class 5 – Very High
May 2020 (above)
April 2021 (below)

Plate B2 – Unique ID 5. This assessment – Canopy consumed; GEEBAM class 5 – Very High
May 2020 (above)
April 2021 (below)

Plate B3 – Unique ID 18. This assessment – Canopy consumed; GEEBAM class 5 – Very High
May 2020 (above)
April 2021 (below)

Plate B4 – Unique ID 20. This assessment – Canopy consumed and likely dead; GEEBAM class 5 – Very High.
May 2020 (above)
April 2021 (below)


Legend
Site boundary
Locality (5km from site boundary)
Conjola National Park
Unburnt
Vegetation validation survey point
Canopy burnt
Canopy unburnt
Understory intact
GEEBAMv3p1
0 - No Data
2 - Low
3 - Medium
4 - High
5 - Very High
6 - Not Native Vegetation
Date produced: 11 June 2020
Projection: GDA 94 MGA Zone 56
0 250 500
Metres
ecoplanning
ecology | planning | offsets

Appendix C GHFF habitat survey methods

Two observers walked parallel transects 10 to 20 m apart. Turpentine was identified by its distinctive foliage which is dark green and arranged in whorls. Grey Ironbark was identified first by deeply furrowed, rough, persistent bark, and thereafter the ground was searched for the relatively small conical/pyriform fruits which are not similar to those of other tree species found on site. Coast Banksia was distinguished from Old Man Banksia (*Banksia serrata*) by foliage – Old Man Banksia having toothed leaf margins and Coast Banksia having margins entire or with few teeth.

C.1 Data Collection

The data collected in the east of the site – Stage 1, 2, 3, 4 and part of Stage 5 east of the Reserve – differed from the method used west of the Reserve. **Figure C.1** displays survey effort. The green line in the middle of the Reserve in this figure represents the point where survey method used was changed, and the boundary between 'East of reserve' and 'West of reserve'.

East of Reserve

To enable avoidance and mitigation measures to be incorporated into the site CC plans, in particular regarding placement of stockpiles and selective removal of trees within APZs, a Trimble Geo XH 6000 differential global positioning system (D-GPS) linked to a Trupulse 360 laser range finder was used to accurately map the location of all GHFF important food trees. Terrasync software was used to record data. For each tree, the following data was recorded:

- Tree species.
- Diameter at breast height (DBH) – trunk diameter measured at 1.3 m height.
- Height (estimate) – assigned to categories <5 m, 5-10 m, 10-15 m, 15-20 m, 20-25 m, 25+ m.
- Canopy spread diameter (estimate) – the maximum crown spread visually estimated to the nearest metre from the centre of the trunk to the tips of the live lateral branches, recorded as diameter (trunk to branch tip X 2). Where canopy estimates to the nearest metre were not possible due to obstructed views, canopy spread was assigned to categories <2 m, 2-5 m, 5-10 m, 10-15 m, 15+ m. When entering values into mapping software to calculate canopy area (refer **Section C.3**), the accurate measure (to nearest metre) was used if possible, but where canopy was recorded as a category, the higher value in the category was entered. For example, '5-10' entered as '10' when calculating area of canopy.
- Location – sub-metre accuracy.
- Survey tracks – survey tracks were recorded with D-GPS in-between areas where GHFF important food trees were found in order to track survey coverage. Track recording was switched off when recording tree location data. Therefore, gaps in between line segments in **Figure C.1** represent places where tracking was switched off, and tree location points were recorded. Two observers walked parallel, but one track file was recorded, so gaps between the track as shown in **Figure C.1** may be greater than 20 m.

West of Reserve

Stage 5 west of the Reserve and Stage 6 will not be developed until at least 6 years post-fire. Avoidance and mitigation measures applied to the east of the site will be replicated in the west of the site. For the present analysis, the detailed tree location data which was recorded for the earlier stages is not necessary for these stages.

In the west of the reserve, observers walked parallel transects recording the following data:

- Tree species – only Turpentine is found west of the Reserve.
- DBH – recorded in categories 20-30 cm, 30-50 cm, 50-70 cm, and 70+ cm.
- Tally – number of trees counted in each DBH category.

C.2 Data excluded

Coast Banksia ≤5 cm DBH were excluded from the analysis. Individuals of this size were small (<2 m canopy spread; <5 m height) and lacked the distinctive woody cones which remain on the tree for many years after flowering. Trees lacking these cones would not be of flowering size and would not provide potential forage for GHFF.

All Grey Ironbark were included in the analysis except one small tree <3 cm DBH. A tree of this size growing beneath a forest canopy was deemed unlikely to provide forage for a GHFF. Eucalypts <10 cm DBH in forest stands do not flower (Birtchnell & Gibson 2006).

A subset of Turpentine were observed from beneath the tree using binoculars to locate the distinctive, globular fruits which persist on the tree for several years (see **Plate C8**). Trees ≤20 cm DBH were found to consistently lack fruits. Trees up to 30 cm DBH often lacked fruits as well, or when fruits were located, they were sparse. Trees <30 cm DBH on site have relatively sparse branches and foliage owing to the shaded position beneath the canopy.

Trees ≤20 cm DBH were deemed unlikely to provide forage for GHFF and were excluded from the analysis. Trees 20-30 cm DBH are likely to provide negligible resources, given their sparse canopies and limited potential to produce flowers and nectar, however, these trees were included in the analysis as a precaution as some were found to have fruits on them, indicating that they had flowered.

Plates C1, C2 and **C5** show Turpentine growing with unconstrained canopy versus sub-canopy Turpentine similar to those observed on site. Eby and Law (2008) ranked vegetation communities containing Turpentine as a canopy element as foraging habitat, since GHFF feed on nectar in the canopy (refer **Plate C6** showing canopy Turpentine), whereas Turpentine does not occur in the canopy layer on the site (refer **Section 3.3.2**). The method used by Eby and Law (2008) would not include the site's Turpentine in the foraging habitat analysis on this basis. BES (2006) recorded the canopy layer at 20-25 m height and the Turpentine subcanopy to 14 m height. Trees growing in shaded positions with constrained canopies produce less nectar than unconstrained canopies (OEH 2016; Davis et al 2016; Birtchnell and Gibson 2006). The size of a tree is an important predictor of potential that a tree will flower, and the amount of flower produced (Law & Chidel 2007). The small subcanopy Turpentine trees which predominate on site are expected to produce comparatively little nectar. Notwithstanding, due to evidence of some flowering having occurred, all Turpentine >20 cm DBH were included in the analysis of GHFF foraging habitat area on site.

Plate C1: Turpentine with unconstrained canopy (Thirroul NSW)

Plate C2: Turpentine beneath Blackbutt canopy (on site)

Plate C3: Turpentine fruits litter the ground beneath unconstrained canopy (tree in Plate A1).

Plate C4: Ground beneath Turpentine on site; few fruits found.

Plate C5: Turpentine – typical occurrence on site.

Plate C6: Turpentine canopy tree in GEEBAM 'Very High' burnt class location (Morton National Park).

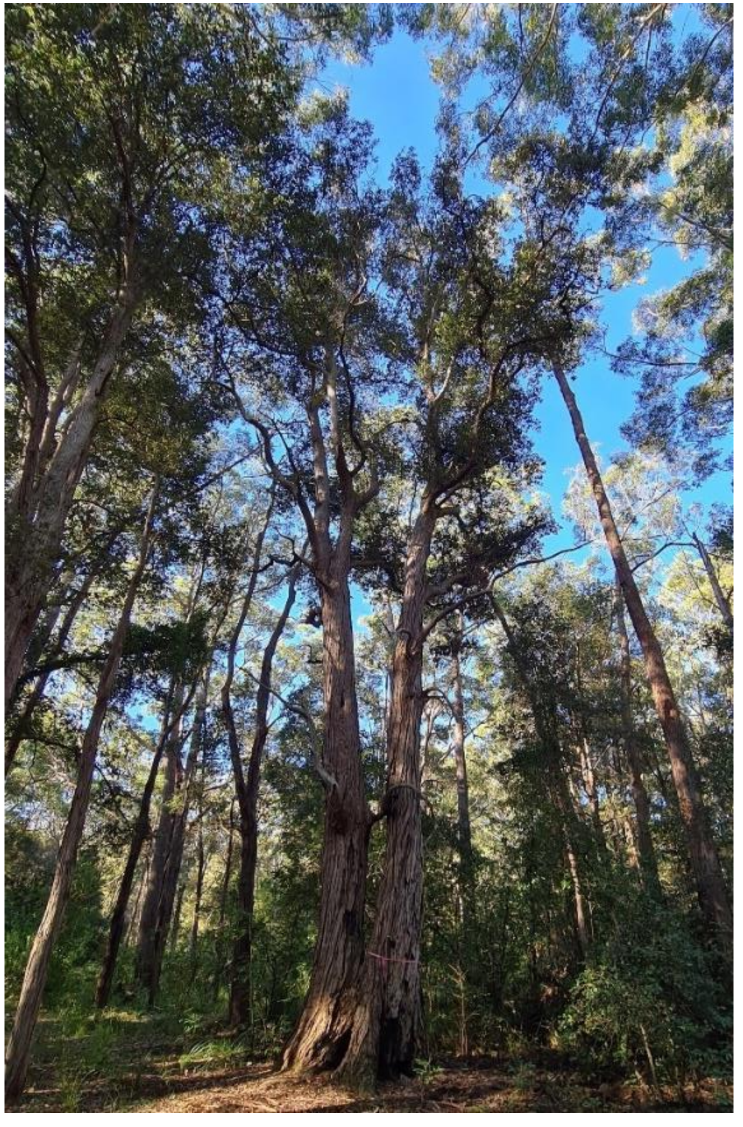


Plate C7: Turpentine – largest individual on site, retained until Stage 5; in total, 5 trees on site are of this size class (>70cm DBH)

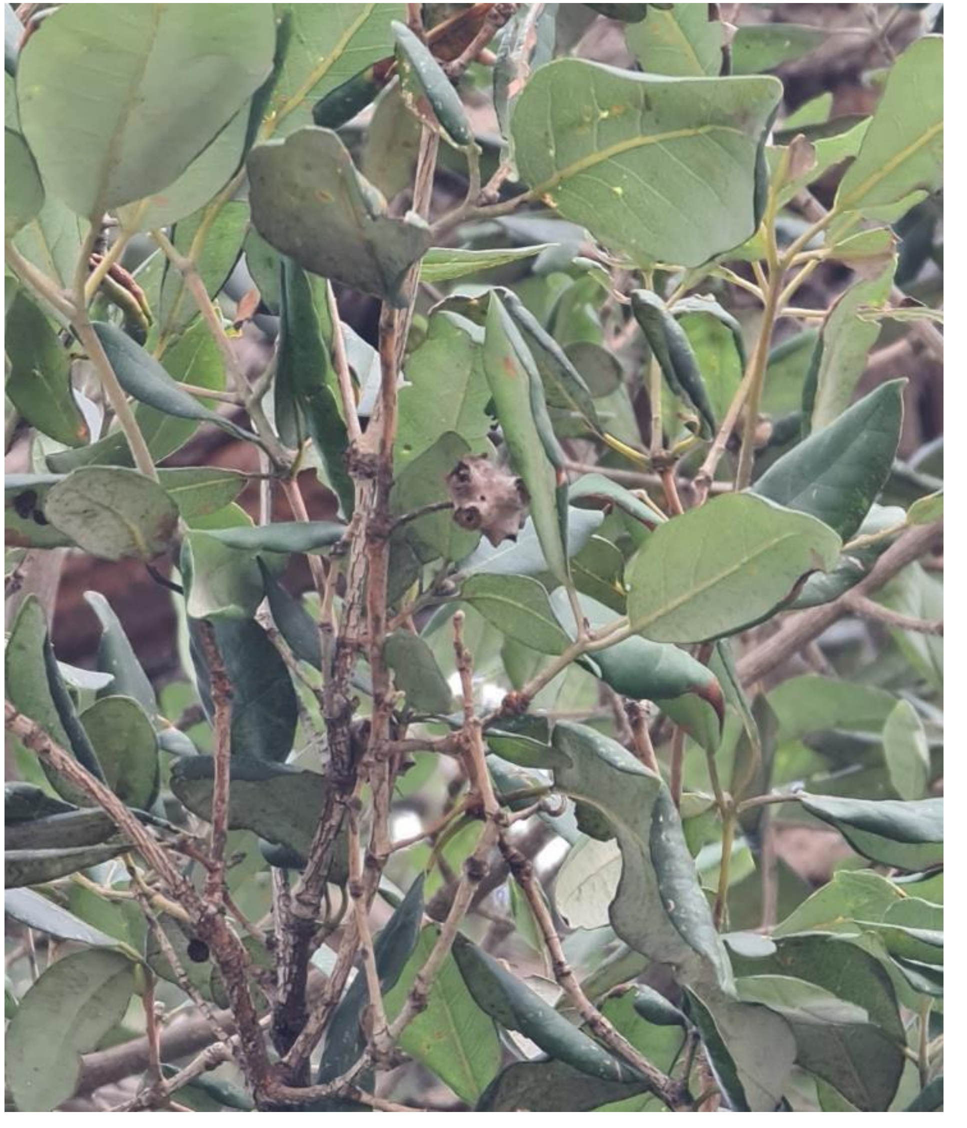


Plate C8: Turpentine fruit retained on tree.

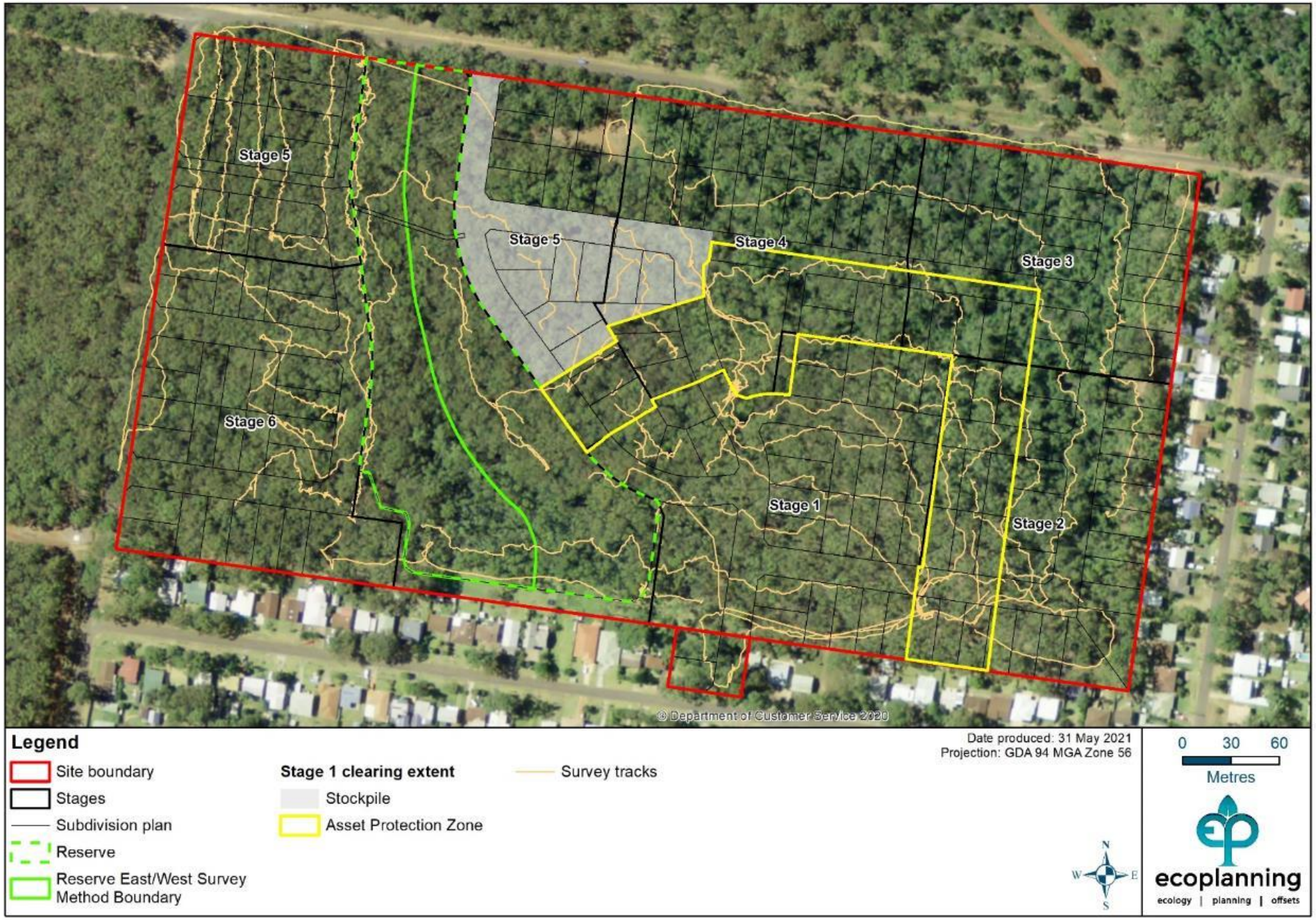


Figure C.1: GHFF habitat survey effort

C.3 Data processing

East of Reserve

The field data was processed using ArcMap ArcGIS Desktop 10.8.1. For each tree location point, the 'canopy spread' field was assigned as described above (**Section C.1**). Each tree location point was buffered by dividing the canopy spread by two, then buffering the location point by the resultant value to create a circle approximating the canopy of the tree. Overlapping circles were then dissolved to create the canopy area.

West of Reserve

Data recorded east of the Reserve was used to produce canopy area estimates correlated to the DBH data recorded west of the Reserve.

Within each recorded DBH class, the higher number in the class was cross-referenced with the canopy spread recorded for trees of that DBH in the east of the Reserve. For example, if the DBH was recorded as 30-50 cm, then 50 cm was used as the DBH to cross reference with corresponding canopy spreads recorded in the east, and if the greatest canopy spread recorded for that DBH was 15 m, then 15 m was assigned as the canopy spread for all trees tallied in the 30-50 cm DBH class in the west of the Reserve.

An area was obtained using the canopy of each tree calculated in this way, which was then reduced by a 'dissolve factor' calculated by comparing the area obtained by the summation of the canopies of trees east of the reserve versus the final area calculated by GIS software when the overlapping tree canopies were dissolved.

C.4 Data limitations

Due to the large area surveyed, canopy measurements did not adhere to more time-intensive methods typically used in arboriculture. Rather, the maximum distance from trunk of tree to the outermost branch was estimated, and this figure was doubled to produce a canopy spread diameter. This method is an overestimate because for many trees, the outermost branches extend further from the trunk than the average spread of the canopy (see **Plate 1**). Also, wherever there was uncertainty or where spread estimates were recorded to category, the larger number was used in the analysis.

The data recorded east of the Reserve (Stage 1-4 and 5 east) is expected to be more accurate, but still an over-estimate of actual canopy area. The data recorded to the west of the Reserve (Stage 5 west and Stage 6) is less accurate but expected to be an even greater over-estimate of the actual canopy area.

Canopy spread estimates were compared to a subset of tree canopies recorded on site by an arborist – Moore Trees (2017). Canopy spread used for this assessment was confirmed to over-estimate when compared to arborist records. For example, the arborist recorded trees with 60 cm DBH having canopy spreads from 10 to 12 m, whereas this assessment assigned trees 60 cm DBH to a canopy spread of 15 m.

Appendix D Habitat critical to the survival of GHFF

D.1 Definition of habitat critical to the survival of GHFF

Winter-spring

The Minister considered that the proposed action would impact habitat critical to the survival of GHFF, as habitats containing trees which produce nectar during winter and early spring when food bottlenecks have been identified will be cleared – the Minister considered these to include Blackbutt, Grey Ironbark, and Coast Banksia. The potential significant impact considered was the risk of a mass die-off due to dietary stress caused by lack of sufficient foraging habitat during the food bottleneck period.

The food bottleneck period, as defined in Table 3.2 of Eby and Law (2008), is referred to as the winter-spring period (June-July, August-September).

Winter and spring

Following the species workshop, the Department considered that Turpentine tree should also be considered an important food tree for the purposes of this assessment. Turpentine tree on site flowers during the late gestation/ birth/ early lactation period in the reproductive cycle of the GHFF. The additional impact being considered is the risk of a decline in condition of GHFF mothers such that their offspring do not survive to weaning. Eby and Law (2008) report the following in relation to this period:

'Females spontaneously abort if exposed to physiological stress during the final trimester of pregnancy, and lactation can be interrupted during food shortages (Martin et al. 1996).'

This period, which includes spring combined with the food bottleneck period, is referred to in this report as the winter and spring period (June-July, August-September, October-November).

Food Bottleneck

This term, as it is used in Eby and Law (2008), refers to the period of time when the lowest number of diet species are in flower and the smallest land area is productive for GHFF. This period coincides with the June-July and August-September bi-months per Eby and Law (2008).

Following the species workshop, the Department considered that October-November should be added to the period when productive foraging vegetation should be considered 'habitat critical to the survival' of GHFF. However, this is not because it is part of the winter-spring bottleneck as defined in Eby and Law (2008) and referred to in the draft recovery plan (DoEE 2017) or approved recovery plan (DAWE 2021a). Rather, the Department has considered that since the period coincides with late gestation, birth, and early lactation of GHFF, plants which produce nectar during this period should also be considered habitat critical to the survival of GHFF. The risk is to the reproductive success of female GHFF, as loss in condition could lead to poor survival of young.

While the vegetation on site has been deemed by the Department as habitat critical to the survival of GHFF based on this additional criteria, the site is not an area of vegetation productive during the species food bottleneck.

From the Draft GHFF Recovery Plan (DECCW 2009):

'*On the basis of current knowledge, foraging habitat that meets at least one of the following criteria can be explicitly identified as habitat critical to survival, or essential habitat, for Grey-headed Flying-foxes. Natural foraging habitat that is:*

1. productive during winter and spring, when food bottlenecks have been identified (Parry Jones and Augee 1991, Eby et al. 1999)

2. known to support populations of > 30 000 individuals within an area of 50 km radius (the maximum foraging distance of an adult)

3. productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (September to May)

4. productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes (months vary between regions)

5. known to support a continuously occupied camp.'

The Minister made a controlled action decision based on criterion #1 above. The assessment now fits criterion #3. The time period that fits this criterion is significantly greater than for the winter-spring bottleneck (September to May). The land area which meets this criterion in SE NSW is vastly greater than during the winter-spring bottleneck (ca. 500,000 ha vs 150,000 ha), and is also more productive (area-weighted index of 0.03 vs 0.01) (refer **Table 3.3**).

From the Draft GHFF Recovery Plan (DoEE 2017):

<u>Habitat critical to the survival of the species</u>

- *'Habitat and associated seasonal resources critical to the survival of the Grey-headed Flying-fox have been mapped, but have yet to be ground-truthed (Eby and Law 2008).'*
- *'clearing key winter or spring habitats should be avoided, as should practices that reduce volumes of nectar available to Grey-headed Flying-foxes during those seasons.'*
- *'Important winter and spring habitats include vegetation communities that contain Eucalyptus tereticornis, E. albens, E. crebra, E. fibrosa, E. melliodora, E. paniculata, E. pilularis, E. robusta, E. siderophloia, Banksia integrifolia, Castanospermum australe, Corymbia citriodora, C. eximia, C. maculata (south of Nowra, New South Wales), Grevillea robusta or Melaleuca quinquenervia.'*

From the National Recovery Plan for the Grey-headed Flying-fox (DAWE 2021a):

<u>Habitat critical to the survival of the species</u>

- *'Few diet plants flower in winter, and those that flower reliably in winter occur on coastal lowlands in northern New South Wales and southern Queensland (Eby et al. 1999, Eby and Lunney 2002). There is also evidence that spring forage is currently inadequate to provide reliable resources during critical periods in the reproductive cycle of Grey-headed Flying-foxes (Eby and Law 2008).'*
- *'Important winter and spring vegetation communities are those that contain Eucalyptus tereticornis, E. albens, E. crebra, E. fibrosa, E. melliodora, E. paniculata, E. pilularis, E. robusta, E. seeana, E. sideroxylon, E. siderophloia, Banksia integrifolia,*

Castanospermum australe, Corymbia citriodora, C. eximia, C. maculata, Grevillea robusta, Melaleuca quinquenervia or Syncarpia glomulifera (Eby and Law 2008; Eby 2016; Eby et al., 2019).'

Habitat critical to the survival of the Grey-headed Flying-fox may also be vegetation communities not containing the above tree species but which:

- contain native species that are known to be productive as foraging habitat during
- the final weeks of gestation, and during the weeks of birth, lactation and conception (August to May)
- contain native species used for foraging and occur within 20 km of a nationally important camp as identified on the Department's interactive flying-fox web viewer, or
- contain native and or exotic species used for roosting at the site of a nationally important Grey-Headed Flying-Fox camp1 as identified on the Department's interactive flying-fox web viewer.

Appendix E Bi-monthly flowering schedules of Grey-headed Flying-fox diet plants

Table E.1: Southeast New South Wales (Eby and Law 2008)

Table 10.2. Bi-monthly flowering schedules of diet plants found in the SE NSW Region. The flowering schedules of some species vary within the region. X = uniform; A = north from the Illawarra; B = from the Illawarra to Bega; C = south from Bega.

Species	Dec/Jan	Feb/Mar	Apr/May	Jun/Jul	Aug/Sep	Oct/Nov
Angophora costata						X
A. floribunda	X	B,C				
Banksia integrifolia			X	X	X	
B. serrata	X	X				
Corymbia eximia						X
C. gummifera		X	C			
C. maculata		A	X	B		
Eucalyptus amplifolia	X					
E. botryoides	X	B				
E. deanei	X	X				
E. fibrosa	X	X				
E. maidenii		X				
E melliodora						X
E. moluccana		X				
E. muelleriana	X	B,C				
E. paniculata	B	B	A	A	X	B
E. parramattensis	X					
E. pilularis	X	X				
E. piperita	X	X				
E. punctata	X	X				
E. robusta			X	X	X	
E. saligna	X	X				
E. saligna x botryoides	X					
E. tereticornis					X	X
E. tereticornis (high elevation)						X
E. tricarpa			X	X		
Syncarpia glomulifera						X
Number of species	14	15	6	5	4	6

Table E.2: Upper Northeast New South Wales (Eby and Law 2008)

Table 8.2. Bi-monthly flowering schedules of diet plants found in the UNE NSW Region. The flowering schedules of three species vary within the region and these are indicated. See key below.

Species	Dec/Jan	Feb/Mar	Apr/May	Jun/Jul	Aug/Sep	Oct/Nov
Angophora costata	X					X
A. floribunda	X					
Banksia integrifolia			X	X	X	
B. serrata	X	X				
Corymbia gummifera	X	X				
C. henryi	X					X
C. intermedia	X	X				
C. maculata	X	X				
C. trachyphloia	X	X				
C. variegata	X	X				
Eucalyptus acmenoides						X
E. albens				X	X	
E. amplifolia	X					X
E. andrewsii	X	X				
E. blakelyi						
E. camaldulensis	X					
E. campanulata						X
E. crebra						
E. fibrosa	X	X				
E. grandis		X	X			
E. melanophloia	X					
E. melliodora	X					X
E. moluccana		X				
E. paniculata						
E. pilularis	B	B	A	A	A	
E. planchoniana	X					X
E. propinqua	X	X				
E. punctata	X	X				
E. pyrocarpa		X				
E. resinifera	X					
E. robusta			X	X		
E. rummeryi	X					X
E. saligna		X	X			
E. seeana					X	X
E. siderophloia	B				A	A,B
E. sideroxylon				X	X	X
E. tereticornis	D			A	A,C	C,D
Castanospermum australe	X					X
Grevillea robusta						X
Lophostemon confertus	X					
Melaleuca quinquenervia		X	X	X		
Syncarpia glomulifera					X	X
N species	25	16	6	7	8	15

A=coastal lowlands, B=foothills and ranges, C = inland low altitude, D = high altitude

Appendix F Winter and spring foraging habitat extent

Eby and Law (2008) produced mapping which provides more spatial detail and more detail regarding the relative habitat quality (in terms of nectar production and reliability) accounting for regional variations in phenology of diet plant species. This mapping is commensurate with the mapping in Figure 5d and Figure 5e of Eby, Sims, and Bracks (2019a). Eby and Law (2008) have ranked vegetation communities from 1 to 4 based on scores of food resource quality and reliability, derived from weighted productivity*reliability scores of vegetation types (represented as *Wt p*r* = $(\text{productivity})^{0.7} * (\text{reliability})^{0.3}$), and have produced separate mapping for each bi-month to account for the region-specific phenology of diet plant species occurring in those vegetation communities. Vegetation community mapping in the Manyana locality was derived from South Coast – Illawarra Vegetation Integration (**SCIVI**) (Tozer et al 2006). Ground truthing of the site has confirmed the broad-scale accuracy of this mapping in the Manyana area – which SCIVI mapped as 'Coastal Sand Forest', map unit **DSF p64**, described as:

- Dominant trees: *Eucalyptus pilularis* (freq 42 C/A 3), *Eucalyptus botryoides* (freq 65 C/A 3), *Banksia serrata* (freq 65 C/A 2), *Banksia integrifolia* (freq 54 C/A 1)

Figure 3.8 and **Figure 3.9** show the extent of winter and spring foraging habitat within 20 km of the Yatteyattah nationally important flying-fox camp and within 5 km of the site. The mapping and rankings use the most recent dataset (DPIE 2019). Vegetation ranked 1 is the highest quality foraging habitat for that bi-month, rank 4 is the lowest, and areas not ranked do not contain vegetation communities where winter or spring diet plants are a significant component of the community.

To calculate habitat scores which informed their rankings, Eby and Law (2008) devised a formula with inputs including the published scores for frequency and cover/abundance of each GHFF food tree found in the mapped vegetation community as well as the species-specific weighted productivity*reliability score for nectar production. The final habitat wt p*r derived from this formula then informed the rankings of that mapped vegetation community.

Tree species with frequencies <0.3 or cover/abundance scores <2 were excluded from calculations due to their sparse occurrence in the vegetation community. On this basis, for example, the winter and spring food tree species found on site would not have been included in the calculations of habitat quality in winter or spring bi-months due to their sparse occurrence.

Dr Bradley Law (pers. comm.) confirms that the habitat ranking data of Eby and Law (2008) is suitable for use when analysing the relative importance of habitat in the post-bushfire context. Areas ranked as habitat were ranked due to the presence of significant food resources for GHFF in the mapped vegetation community (e.g. SCIVI map, Tozer et al 2006) and areas unranked generally lack significant food resources.

Appendix G GHFF regional habitat mapping limitations and accuracy

Grey Ironbark and Coast Banksia

Regarding the site itself, the key element of Eby and Law (2008) mapping is the dominant 'Diet Species' assigned to the mapped vegetation community over the site, as these are the species whose nectar productivity scores are entered into the formula from which the habitat rankings are ultimately derived. The data package for these habitat rankings includes a lookup table (Microsoft Excel) of habitat attributes used to score the nectar productivity of each mapped (ranked) area. For ranking, DSF p64 is assigned the following dominant species – Blackbutt, Bangalay (*Eucalyptus botryoides*), and Old Man Banksia (*Banksia serrata*).

BES (2006) mapped three vegetation communities on site – Northern Coastal Sands Shrub/ Fern Forest (**NCSSFF**), Bangalay Moist Woodland/ Open Forest (**BMWOF**), and Bangalay Paperbark Woodland (**BPW**) – which are described below as compared to Eby and Law (2008) mapping of the site. Old Man Banksia is not a dominant component of the site's vegetation, so this aspect of the mapping used by Eby and Law (2008) is inaccurate in this regard – Old Man Banksia flowers December-March, as do Bangalay and Blackbutt. While systematic surveys did not record all of the GHFF diet species which might flower on the site across various seasons, it is the opinion of Ecoplanning based on visual estimates (not systematic survey) that BES (2006) may have overestimated the prevalence of Sydney Peppermint (*Eucalyptus piperita*) on site, and while Red Bloodwood (*Corymbia gummifera*) occurs with greater frequency than Sydney Peppermint it is still much less common than Blackbutt. Blackbutt is by far the dominant canopy tree on the site, both in terms of frequency of mature individuals and canopy cover. Sydney Peppermint flowers December-March and Red Bloodwood flowers in February-March, as do Blackbutt and Bangalay. Notwithstanding, the species of relevance to this assessment are the Blackbutt and Bangalay which have been assigned by Eby and Law (2008) as dominant on site, which is accurate, as summarised in **Table G.1**.

Table G.1: GHFF foraging habitat – accuracy of regional vegetation mapping of the site

Dominant canopy (BES 2006)			Dominant canopy regional mapping (SCIVI)	Accuracy: Flowering period Actual/ mapped
NCSSFF 13.09 ha	BMWOF 5.39 ha	BPW 0.92 ha		
Blackbutt	-	-	Blackbutt	summer/ summer
-	Bangalay	Bangalay	Bangalay	summer/ summer
-	-	-	Old Man Banksia	- / summer
Sydney Peppermint*	-	-	-	summer/ -
Red Bloodwood*	-	-	-	summer/ -

*much less abundant than Blackbutt

Eby and Law (2008) give the site the highest ranking, which is '1', for December-January and February-March bi-months, which is accurate because Blackbutt, Bangalay, Sydney Peppermint, and Red Bloodwood flower during those months on the site. Old Man Banksia also flowers during those months, but is not dominant on site, so the vegetation community mapping inaccuracy is not expected to affect the accuracy of seasonal rankings (for example, if Old Man Banksia had flowered in autumn, then this would result in an overstated autumn ranking). The total area of 20.4 ha on site is expected to be productive in summer months in the years when trees on site are flowering, and depending on localised synchrony – Blackbutt moderate synchrony (40%-70% of patches over a 25 km range), low frequency (<40% of years); and Bangalay moderate synchrony, low frequency. At other months of the year, the site would provide negligible resources for GHFF on a regional scale, using the methodology of Eby and Law (2008).

Briefly, regarding accuracy – some summer flowering trees have been mapped as dominant on the site which are not dominant, while some other summer flowering trees which do occur on the site have not been mapped. The rank assigned to the site in summer is '1' which is the highest possible ranking. So altogether, the inaccuracies likely balance out, and in any event, summer is already assigned the highest rank.

In summary, the site may produce significant food resources for GHFF in summer in less than 40% of years. In winter and spring, the site would produce negligible foraging resources and would be ranked '0' (unranked) using the methodology of Eby and Law (2008). The GHFF foraging habitat mapping of the site is accurate.

Turpentine

By the metrics used in Eby and Law (2008), an occurrence of Turpentine such as that found on site would be excluded from their mapping (ranked '0'). Using SCIVI mapping, only frequently occurring canopy trees were considered. In DSF p64, Turpentine occurs with frequency 0.1, while Eby and Law (2008) excluded trees with frequency <0.3. Using SCIVI metrics, the Turpentine on site would, however, meet the threshold for cover/ abundance (C/A), being >2, which equates to '5% cover and common', if it were to occur on site as a canopy element, however, on site it occurs only in the subcanopy beneath Blackbutt (refer example **Plate C5**).

Regional mapping

It has been suggested by some that Eby and Law (2008) rankings are now obsolete, as the rankings are based on the *relative* importance of flowering vegetation – that is, the importance of flowering vegetation in one area versus other areas, and if other areas have burnt, then any flowering vegetation that is not burnt would be assigned a higher ranking if the assessment were undertaken post-bushfire. Dr Bradley Law considers that the rankings in Eby and Law (2008) are relevant post-bushfire (Brad Law pers. comm.). Even if one were to consider that the winter-spring habitat rankings could be obsolete, the basis for those rankings was a system of correlating the amount of nectar produced for GHFF to the mapped vegetation community. These rankings are still informative.

Eby et al (2019a) confirmed that Eby and Law (2008) rankings reflect the real-world feeding preferences of GHFF, especially regarding habitats ranked '1' or '2'.

Appendix H Fire impacts

Fire impacts compared logging impacts

References to Eucalypts requiring decades to recover flowering productivity may derive from studies of flowering recovery at logged sites, where regrowth forests do not produce similar amounts of nectar and flower compared to mature trees for many decades after felling, e.g. Law and Chidel (2007b). Except in the areas of very highest fire intensity where whole trees have been killed, logging impacts are not similar to fire impacts.

The impacts to a tree's physiology, stored carbon, stored energy reserves, etc. are very different for a previously felled, regenerating tree when compared to a burnt regenerating tree. In fact, one of the key advantages to epicormic sprouting is that it allows a tree to attain an 'escape height' above the surrounding vegetation and efficiently photosynthesize (and therefore produce food) much more quickly. A tree in a burnt landscape has an intact root system, does not need to regrow dense, carbon-intensive woody tissue, and has lost many of its competitors for water and soil nutrients. One of the greatest risks to a tree post-fire is continued drought, as exposed soils in a burnt landscape are more susceptible to drying out. La Niña has brought above average rainfall from February 2020 to the present date, so the conditions for recovery of canopy trees are optimal with regard to soil moisture. See physiology studies – Bär et al (2019), Pausas and Keeley (2014), or Clarke et al (2013), Bradstock et al (2002).

In terms of nectar production, it is more likely that persistent drought would reduce production to a greater degree than fire followed by abundant rainfall. Apiarists have reported that rainfall is one of the greatest predictors of nectar production (Birtchnell and Gibson 2008). The chief physiological impact of fire on a tree's flowering (except when canopy is completely destroyed) is the destruction of flower buds. Replacing buds lost to fire is not as energy intensive as regrowing woody tissue and achieving mature canopy height. 75-80% of the carbon within a tree is in structures below the crown. The physiological impact of persistent drought, by contrast, is the lack of water available for photosynthetic processes, the closing of stomates to stop water loss and therefore the reduction of photosynthetic activity. This results in less surplus energy available for reproductive processes. See – Leys (2021), Kapoor et al (2020), Bradstock et al (2002), Unwin and Kriedeman (2000).

The physiological impacts of fire are complex, but generally fire destroys existing, unprotected vegetative tissues, reduces competitors for those plants which survive or otherwise can take advantage of the post-fire landscape, and increases availability of light and soil nutrients while altering soil biota (the rhizosphere). While Eucalypts with scorched or consumed canopies have lost apical and axillary growth points, leaves, and terminal branches; the main trunk, scaffold and lateral branches remain, and in all but the hottest fires, eucalypts retain surviving 'epicormic strands' which extend far deeper into the tree trunk than the epicormic buds of other taxa (Burrows 2013). Eucalypts are some of the most successful post-fire resprouters, particularly epicormic resprouting after higher intensity fires (Burrows 2013). The impacts of fire on the rhizosphere are more difficult to quantify, but may significantly affect the long-term survival and recovery of eucalypts within the fire grounds. For a surviving eucalypt, there is less energy to be invested in regrowth of large, dense, carbon-intensive vegetative tissues before surplus energy becomes available for reproductive processes, but there is also a less-intact rhizosphere able to provide uptake of water and soil nutrients for growth of canopy tissues. A tree which has been logged and resprouted (e.g. coppiced) is set back much farther than a burnt (but still living) tree. See – Bradstock et al (2002), Whelan (2005).

Therefore, studies of post-logging recovery should not be used to project estimates of post-fire flowering recovery.

Fauna species vulnerability to fire impacts

Other references to species' habitat requiring decades to recover may refer to species which are specialists of dense undergrowth, such as the Eastern Bristlebird (*Dasyornis brachypterus*), a skulker which shuns open habitats and is known to require unburnt refugia in order to persist after fire (Lindenmayer 2020). There is no doubt that some habitat types (e.g. lower forest strata) and some habitat-specialist threatened species may require significantly more time to recover than the projections in **Figure 3.14** would indicate, however, the subject species of this assessment are all either wide-ranging generalist canopy nectarivores (GHFF and SP), or canopy-dwelling folivores (GG). The relevant question is the recovery rate of canopy habitat values, not groundcover. The relevant impact is the burn condition of the canopy, and not whether the ground layer has burned.

The post-fire recovery that is relevant to this assessment is the recovery of canopy tree flowering, and not attributes of the forest habitat that are not utilised by GHFF, or that might relate to predation risk in the post-fire environment, or competition, etc. The impact which is relevant to this assessment is the foraging resource available in the post-fire landscape. While certain species face prolonged recoveries, as has often been cited, this is most often true for species known to be specialists of landscapes of long unburnt successional age – where undergrowth is dense, where hollow ground logs, leaf litter, and other attributes of the lower stratum are required for habitat – see DAWE (2021d).

Prediction of fire impacts on foraging habitat for GHFF in 'Very High' burnt class

The terms fire intensity and fire severity are often used somewhat interchangeably. Keeley (2009) describes fire intensity as 'the physical combustion process of energy release from organic matter' – the total energy released over the various stages of vegetation combustion. In contrast, the term fire severity is used to describe the effects of fire on vegetation, with most practitioners quantifying severity as the volume of organic matter consumed above and below ground (Fairman et al. 2017; Keeley 2009). Fire severity is thus influenced by a range of factors, including fire intensity, heat residence duration, fuel load characteristics, plant attributes and fire weather (Bradstock, Williams & Malcolm 2002; Keeley 2009). Many studies concerning fire severity within temperate eucalypt forests have used definitions similar to those in **Table H.1**, which are based on a visual classification of organic matter loss (Keeley 2009; Nolan et al. 2020; Prior, Williamson & Bowman 2016; Vivian et al. 2008).

Table H.1: The matrix used by the Rural Fire Service of NSW and the Department of Planning, Industry & Environment to define fire severity in terms of organic matter loss (2020)

Fire severity	Description
Unburned	Vegetation green with no evidence of scorching present
Low	Burnt understory with an unaffected canopy
Moderate	Burnt understory with partially scorched canopy
High	Complete canopy scorch with partial canopy consumption
Extreme	Full canopy consumption

Southern eucalypt forests tend to experience high intensity, low frequency wildfire (Murphy et al. 2013). Fire activity is predominately governed by biomass production, fuel moisture, fire weather and ignition (Bradstock et al. 2010). In the tall eucalypt forests of south eastern Australia, the accumulated fuel load is high, however frequent fire is limited by fuel moisture. The relationship between fuel characteristics, fire weather, topography and rate of ignition define the risk of wildfire, the inter-fire interval, severity and fire behaviour (Benson, Roads & Weise 2008; Bradstock et al. 2010; Williams & Baker 2012). Ultimately, fuel characteristics, fire spread, and ignitions are influenced by long-term regional climatic trends and humanity.

While GEEBAM mapping captures attributes relevant to the assessment of nectar foraging habitat within mapped ‘Unburned’, ‘Low’, ‘Moderate’, and ‘High’ fire severity areas such that within areas mapped in these categories, the recovery of nectar production can be projected based on prior empirical observations; GEEBAM mapping does not capture the most relevant attributes of the GEEBAM mapped ‘Very High’ (or ‘Extreme’) fire severity areas. These attributes are the survival of apical buds in the canopy of trees. If apical buds have survived, trees can be confidently predicted to survive and flower in the post fire environment with time frames likely to be similar to mapped ‘High’ burnt class areas (Scott McKenzie pers. comm.). In areas where only epicormic growth is observed on surviving trees, the recovery of flowering is uncertain. Trees subject to such fire intensities ultimately may not survive, or these trees may face prolonged recoveries. Some trees in these ‘Very High’ fire severity areas have flowered already in 2020, as observed during Ecoplanning surveys of Conjola National Park and Morton National Park (refer **Plate H1**). However, trees which have flowered in response to fire stress may not survive.

The trajectory of the recovery of GEEBAM ‘Very High’ areas is likely to track against the degree to which the vegetation in a particular area has been subject to the above processes. For areas where ‘Very High’ burnt class has not translated to death of vital tissues in canopy trees, such as apical buds and/or epicormic strands, the recovery is likely to track closer to that observed for GEEBAM ‘High’ burnt class areas. For locations where death of most or all above ground tissues has occurred, where fire has not only consumed the canopy but also destroyed apical buds, the recovery rate of flowering may track more closely to what would be observed in a logged forest.

For the purposes of this assessment, areas mapped by the GEEBAM as 'Unburnt', 'Low', 'Medium' and 'High' can be predicted to recover to flowering condition after no more than 5 years, with the actual date of next flowering subject to species-specific patterns of flowering frequency and synchrony (many tree species flower in irregular cycles with a periodicity of several years regardless of fire impacts). Within areas mapped by the GEEBAM as 'Very High', the recovery is less certain but expected to correlate to survival of apical growth buds in the canopy (Scott McKenzie, Risk Manager at TreeServe Pty Ltd, pers. comm.).

Plate H1: Large eucalypt in Very High burnt class area which has flowered in 2020 due to fire-induced stress (Morton National Park)

Appendix I BioNet records – EPBC Act listed species records March-April 2017

EPBC Act listed species records within and adjacent to the site were submitted to NSW OEH for upload to the BioNet dataset in 2017. Records currently in the NSW BioNet dataset, which is also a dataset displayed in the Atlas of Living Australia, show two of the subject species of this assessment, and one of the subject species of the Referral, located on the site in the period between 24th March 2017 and 15th April 2017:

- Swift Parrot (BioNet record User Key SJJSI0292382 recorded on 25/3/2017)
- Greater Glider (BioNet record User Key SJJSI0292383 recorded on 15/4/2017)
- Southern Brown Bandicoot (BioNet record User Key SJJSI0292385 on the approximate date 24/3/2017)

All of these records are anomalous either spatially or temporally in the context of the cumulative records for these species in the area.

<u>Southern Brown Bandicoot</u>

NSW Office of Environment and Heritage (OEH) was contacted regarding the Southern Brown Bandicoot record, which is the most anomalous of the above concurrent records, and the local expert officer at OEH made the following comment:

'*I am not familiar with that particular record but would be highly dubious of it given the location. Outside of Booderee there are no known populations of the species between there and Ku-ring-gai Chase National Park to the north, and Eden to the south.*

The fact that it is a "O for Observation" makes me question it, given how common Long-nosed Bandicoots are in the local area. ***Given this is tied in with development the record needs to be properly scrutinised****. Put in a request to licensing for further information. Ideally, you would have further corroborating evidence before being accepting of the record itself.* [emphasis added]*'*

The Southern Brown Bandicoot record was later identified in the BioNet as:

'*source code changed from sighting to possible ID after review by experts and accountable officer'*

<u>Greater Glider</u>

Except for the abovementioned record, the BioNet contains no additional Greater Glider records in the area south of Bendalong Road after 2008. The last record of a Greater Glider within 5 km of the site was in 2013 in the area west of Bendalong.

For the current assessment, 114 person-hours of targeted survey was conducted for Greater Gliders in the area within and adjacent to the site, as well as one night as far north as the North Bendalong Triangle track, which is north of Bendalong and south of Nerrindillah Creek. These surveys took place in May-June 2020, and included surveying the exact location of the above record, which was noted as 'crossing Curvers Drive'. Over a period of approximately 107 hours of survey across 10 nights, between two and six observers surveyed transects including along Curvers Drive for Greater Gliders, including the exact location of the above database record. No Greater Gliders were found.

The Department commissioned further surveys in March-April 2021. These surveys also encompassed the area surrounding the Curvers Drive record, as well as publicly accessible land parcels in the area surrounding this record, and the area further north to Bendalong and extending ultimately as far north as the north-western edge of Conjola National Park and as far west as Morton National Park near the Pacific Highway (DAWE assessment officer pers. comm.). The area surveyed included unburnt vegetation where Greater Gliders, if present, might have survived. These surveys located Greater Gliders at only one survey location, near Mondayong, which is approximately 10 kilometres to the north of the site, and which is within a very extensive area of GEEBAM mapped 'Very High' burnt class vegetation, with small patches of GEEBAM burnt class 'High' and negligible (ca. 1 to 5 ha) patches of GEEBAM burnt class 'Low' or 'Medium' vegetation found in the vicinity (within about 1 km radius). Ecoplanning was able to re-find a Greater Glider at this known location after 0.0028 person-hours of survey. By contrast, the Greater Glider recorded as having been seen on Curvers Drive in 2017 has not been re-located despite the 107 person-hours of survey undertaken by Ecoplanning, the additional regional survey undertaken by Gaia Research, and a great deal of unpublished survey undertaken by members of the public and by the World Wildlife Fund (WWF), who used infrared-equipped drones to search the site and adjacent lands for Greater Gliders in May of 2020 (Ecoplanning, pers. obs.).

Based on what is known of the Greater Glider's ecology, particularly with respect to its dispersal capability and detectability, this record is particularly anomalous. Greater Gliders can live for 15 years and occupy small home ranges, so it is unusual that the same individual, or at least other members of a local population, has not been found. The only reasonable conclusion, assuming this record is genuine, is that the Greater Glider was seen at this location immediately prior to becoming locally extinct.

Swift Parrot

The timing of this record in late March is unusual, as well as the accompanying sighting note of '*One bird with flock of Rainbow Lorikeets*'.

Swift Parrots are more typically associated with flocks of Fuscous Honeyeaters, White-naped Honeyeaters, Scarlet Honeyeaters, Little Lorikeets, or Musk Lorikeets when they are found on the mainland. There is a significant, negative effect on the likelihood of Swift Parrot occurrence at a foraging site when Rainbow Lorikeets are present at that foraging site (Saunders and Heinsohn 2008).

Swift Parrots have been detected in mainland Australia in every month of the year, however, the numbers detected between the months of April and September in NSW are many times greater than during other months of the year (refer **Section 4.2**). Like the records for GHFF and the Greater Glider, this record is anomalous.

Notwithstanding, Swift Parrots may plausibly be found virtually anywhere within southeast Australia at any month of the year, due to their wide-ranging migrations and ability to forage across any productive habitat anywhere within this range. Although this record is more plausible than the records for GHFF and the Greater Glider, like those two records, it is anomalous.

Appendix J Greater Glider denning habitat

Plate J1: **HBT 5 – Unlikely, hollow >7cm but branch too narrow, unlikely to have sufficient interior dimensions**

Plate J2: HBT 23 – unlikely, vertical opening, recent break

Plate J3: HBT 24 – likely

Plate J4: HBT 50 – likely

Plate J5: **HBT 2 – unlikely - hollow >7cm, possibly shallow hollow in recently broken branch**

Plate J6: HBT 3 – likely

Plate J7: HBT 13 – unlikely, hollow 3m high, spout extending to secondary opening at bottom of tree

Plate J8: HBT 16 – likely, hollow 5m high

Plate J9: HBT 18 – likely, hollow >7cm, possibly larger interior dimensions (in main trunk)

Plate J10: HBT 19 – possible, recently broken crown, hollow with vertical opening

Plate J11: HBT 20 – unlikely, narrow diameter branch, hollow unlikely to have large interior dimensions

Plate J12: HBT 33 – possible, hollow 6m high, opening vertically, recent break

Plate J13: HBT 34 – possible

Plate J14: **HBT 40 – likely**

Plate J15: HBT 41 – likely

Plate J16: HBT 49 – likely

Plate J17: HBT 1 – likely, hollow 6m high

Plate J18: HBT 9 – unlikely, branch too small to contain a large diameter cavity despite >7cm entrance

Plate J19: HBT 12 – possible, tree >100cm DBH but hollow only 3m high

Plate J20: HBT 15 – possible, at base of broken dead branch, 6m high

Plate J21: HBT 17 – likely

Plate J22: HBT 22 – likely, hollow 5-6m high

Plate J23: HBT 25 - likely

Plate J24: HBT 29 – likely, at crown of tree

Plate J25: HBT 31 – likely

Plate J26: HBT 32 – possible, at base of broken branch, small (50cm dbh) tree

Plate J27: HBT 37 – likely, hollow 4m high

Plate J28: HBT 38 – likely

Plate J29: HBT 39 – likely, hollow in swollen part of 40cm diameter branch

Plate J30: HBT 42 – likely, hollow 5m high

Plate J31: HBT 43 – likely, hollow 4m high

Plate J32: HBT 46 – possible, ringbarked stag tree <6m high, several hollows from 3 – 5m high

Plate J33: HBT 47 – possible, stag tree

Plate J34: HBT 48 – possible, at base of broken branch

Plate J35: **Unlikely - hollow >7cm, recent break and unlikely sufficient depth or interior dimensions**

Plate J36: Unlikely – potential hollow >7cm, shallow hollow in recently broken branch, unlikely to have sufficient interior dimensions

Plate J37: **Unlikely - Multiple hollows <7cm, in small branches very unlikely to have interior space for Greater Glider**

Plate J38: **Unlikely – Multiple hollows <7cm, small branches very unlikely to have interior space for Greater Glider**

Appendix K Definition of key terms

Certain terms have been loosely applied in submissions to the Department regarding the impacts of the proposed action relative to the 2019-2020 bushfires. This contributes to confusion between the broader usage of these terms when describing the effects of the bushfires, and the application of these terms to the assessment of the subject species and the proposed action.

Refuge

Much has been written about the significance of refugia in the post-fire environment. A 'refugium' is defined as an area in which a population of organisms can survive through a period of unfavourable conditions. The site is demonstrably not a refugium for the subject species of this assessment. None of the subject species are resident within the site. For highly mobile species, the site contains insufficient resources to provide a post-fire foraging refuge which could sustain individuals during periods which overlap with critical life history events and seasonal movements of these species. While it is important to conserve unburnt refugia, the site is unburnt, but it is not a refugium for these species.

The site is a 'fire refugium' more broadly, as it is an area which remained unburnt and retains ecosystem functions largely unaffected by the fire. It is clearly providing a refuge for common species in the locality, such as Eastern Grey Kangaroos and Long-nosed Bandicoots. Fire refugia provide habitat for individuals or populations in which they can survive fire, in which they can persist in the postfire environment, and from which they can disperse into the higher-severity burned landscape (Robinson et al. 2013). None of the subject species are resident within the site, none have persisted in the post-fire environment within the site, and none are likely to establish a source population within the site from which the surrounding landscape may be recolonised.

When references are made to the importance of conserving refugia for threatened species after the 2019-2020 bushfires, the refugia referred to are places where the subject species are present post-fire.

Metapopulation

Classical metapopulations are defined by specific prerequisites, of which a simplified description with reference to the current assessment is provided as follows:

- Patches – a fragmented landscape (pre-fire) wherein more or less independent sub-populations of Greater Gliders are found in discrete patches of suitable habitat – surrounded by a landscape which is clearly and distinctly different from the habitat patches and thus unsuitable – with limited dispersal between patches due to fragmentation. The 'patches' are a fixed feature of the landscape – that is, lower-severity burnt areas cannot be termed 'patches' within a higher-severity burnt landscape – rather, in the context of metapopulation dynamics, the fire would be considered a 'stochastic event' which would (in a metapopulation system) affect each true habitat patch, and therefore each sub-population, differently (asynchronously).
- Asynchrony – environmental factors affect populations in certain patches in different ways at different times, leading to extinction in some patches while others survive. Due

to asynchrony (and turnover), both occupied and unoccupied patches require conservation in order to maintain the dynamic equilibrium of the whole population. This phenomenon is where the imperative to conserve ‘unoccupied patches’ originates from.

- Turnover – extinction and recolonisation of patches happens in relatively rapid succession with respect to the species’ generation time. Over a time-scale relevant to the subject species (e.g. months or years for an insect; decades or centuries for a mammal), individual subpopulations occupying separate and distinct patches go extinct, only for that same patch to become recolonised again from a nearby (but not connected by regular dispersal) patch.
- Dispersal – declining probability of successful interpatch dispersal as distance increases.

The Greater Glider population in the Manyana area could only satisfy the last of these prerequisites, and so cannot be called a metapopulation system.

Likely

Environment Protection and Biodiversity Conservation Act 1999:

‘Section 18 Actions with significant impact on listed threatened species or endangered community prohibited without approval

(4) A person must not take an action that:

(a) has or will have a significant impact on a listed threatened species included in the vulnerable category; or

(b) is likely to have a significant impact on a listed threatened species included in the vulnerable category.’

Consistent with the objects of the EPBC Act, the expression ‘likely’ is understood in the sense of ‘prone’, ‘with a propensity’ or ‘liable’; in other words a ‘real or not remote chance or possibility’ regardless of whether it is less or more than fifty per cent.

<u>GHFF</u>

The impacts assessed to GHFF in this document are not likely. In winter and spring, GHFF have occurred in the Yatteyattah camp in 22% of recent years, and have only been documented to occur in this camp in large numbers during years of mass flowering on the South Coast – key species local to this camp being Spotted Gum and Forest Red Gum (refer **Section 3.6**). The tree species which are the subject of the current assessment of GHFF foraging habitat are recorded as flowering in <40% of years by Eby and Law (2008). The possibility that a GHFF could be affected by clearing winter and spring foraging habitat on the site such that starvation would occur as a result, or such that unweaned young may not survive due to a loss of the parent’s condition, is not likely; it is only a remote possibility.

The possibility that clearing 1.25 ha of winter and spring habitat could impact a number of GHFF such that starvation or loss of unweaned young might occur in proportions so great that the species as a whole could be affected, either through a decrease in the size of the population or such that the species’ ability to recover from the 2019-2020 bushfires is impeded, is an extremely remote possibility.

Greater Glider

Greater Gliders have only been found approximately 10 km north of the site, despite extensive recent survey (Craven and Daly 2020; Gaia Research 2021). No Greater Gliders occur within the site, and none have been found in the locality despite recent survey (refer **Section 5.2.3**). Given the species' low dispersal ability, it is extremely unlikely that one could be found on the site (refer **Section 5.2.2**) in any time period relevant to recovery after the Currowan fire. The possibility that any individual Greater Glider could be impacted in any way by the loss of habitat within the site within the next several decades is extremely remote.

Swift Parrot

Regular surveys of this species' non-breeding range have led to the identification of key non-breeding foraging areas, which are defined by regular visitation of multiple birds, often over extended time periods (refer **Section 4.2**). Only one record of a single Swift Parrot exists within 5 km of the site, and the wider locality surrounding the site has not been identified as an important area in the species' non-breeding range (refer **Section 4.3**). None of the known key food tree species for Swift Parrots on the South Coast are found on the site (refer **Section 4.1**). The possibility that the canopy trees found on site could be productive during the time period when Swift Parrots occur in mainland Australia, that the canopy trees could be utilised as a foraging resource, and that the foraging resources would be necessary to ensure the survival of individuals, is not likely.

Significant

GHFF

In the time since the 2019-2020 bushfires, the Department has considered the following impacts not to be significant:

- Clearing 0.78 ha of GHFF foraging habitat within 20 km of Yarramundi GHFF camp, which is regularly occupied, and within 11 km of Windsor nationally important flying-fox camp which supported >50,000 GHFF in November 2019. The 0.78 ha of GHFF foraging habitat which is to be cleared contained a dominant canopy of *Corymbia eximia*, with *Eucalyptus tereticornis* and *Eucalyptus crebra* also present. *C. eximia* is a GHFF diet species which flowers in the October-November bi-month in that area. *E. tereticornis* is a diet species flowering from August-November. *E. crebra* is not identified as a GHFF diet species. The Referral considered that this foraging habitat would only support a small number of individuals. The time period over which the impacts would occur was not considered.
- Clearing 0.42 ha of GHFF foraging habitat within 8 km of Broulee nationally important flying-fox camp. The 0.42 ha of GHFF foraging habitat which is to be cleared contains *Angophora floribunda*, *Eucalypts globoidea*, and *E. tereticornis*. *E. tereticornis* is a diet plant flowering in August to November in that area. *A. floribunda* is a summer flowering GHFF diet plant. *E. globoidea* is not listed as a diet plant. The time period over which the 0.42 ha of clearing would occur was not considered.
- Clearing 40.2 ha of GHFF foraging habitat within 17 km of the Brinawarr St, Nowra nationally important flying-fox camp, which is permanently occupied. In total, there are three GHFF camps within 20 km of the impact site – Bomaderry Creek, Nowra, and Wandandian – and a fourth camp having been identified *within* the referral area.

Winter flowering Spotted Gum, which is critically important to GHFF foraging on the South Coast in winter months, is mapped as a dominant canopy component of the vegetation community within the area cleared. The referral did not survey for, or consider, the presence of Spotted Gum within the referral area, stating only that '*C. maculata and E. robusta were not recorded in the floristic plots'*. This assessment considered that 11,029.90 ha of habitat is available within a 10 km radius of the impact site. This assessment considered all burnt habitat, including GEEBAM burnt classes 'Low', 'Medium', 'High', and 'Very High' as suitable foraging habitat for GHFF. The time period over which the 40.2 ha of clearing would occur was not considered. The controlled action decision was called for the following species: *Caladenia tessellata* (Thick-lipped Spider-orchid) – vulnerable, *Cryptostylis hunteriana* (Leafless Tongue-orchid) – vulnerable, *Dasyurus maculatus* (Spot-tailed Quoll) – endangered, *Genoplesium baueri* (Yellow Gnat-orchid) – endangered, *Petauroides volans* (Greater Glider) – vulnerable, and *Syzygium paniculatum* (Magenta Lilly Pilly) – vulnerable; but not for GHFF.

The scale of impacts in the proposed action area is less than, or similar to, the impacts of these approved actions, in particular considering that the majority of impact (1.02 ha) in the proposed action area is composed of small subcanopy Turpentine tree, which cannot possibly provide significant amounts of flower or nectar and, therefore, could not possibly sustain large numbers of GHFF.

<u>Greater Glider</u>

The Department has made no determinations in the period since the 2019-2020 bushfires where actions within localities that are unoccupied by Greater Gliders were determined to significantly impact Greater Gliders.

<u>Swift Parrot</u>

The Department has made no determinations in the period since the 2019-2020 bushfires where actions within locations that do not contain key food trees, or which have not been previously identified as important areas for Swift Parrots, were determined to significantly impact Swift Parrots.