Greater Glider Protocol update

Overview

- The species inhabits the forest canopy and rarely comes to ground (Harris and Maloney 2010, p. 213).
- They shelter in tree hollows during the day, preferring larger hollows (>18 cm diameter) in large, old trees (diameter at breast height >70 cm) (Harris and Maloney 2010, p. 212; Hofman, Gracanin and Mikac 2022, p. 313;May-Stubbles, Gracanin and Mikac 2022, p. 710).
    - Mean greater glider den tree DBH in NSW studies ranging from 114cm and 128cm, and den hollows > 18 cm in diameter (Hofman, Gracanin and Mikac 2022, p. 133; May-Stubbles, Gracanin and Mikac 2022, p. 710; Goldingay 2011).
    - These hollows may take hundreds of years to form (Harris and Maloney 2010)
    - Both live and standing dead trees are used for denning (Goldingay 2012), however the species prefers to use live hollow-bearing trees when adequate numbers are available (Kehl & Borsboom 1984; Kavanagh & Wheeler 2004; Lindenmayer et al. 2004).
    - Individuals use multiple den trees with some dens, referred to as primary dens, receiving much greater use – greater gliders have about 1 primary den per hectare (Goldingay 2011).
- They frequent multiple hollows (up to 20 hollows) in their home range (1.2 – 4.1 hectares) (Harris and Maloney 2010, p. 212; DCCEEW 2022, p. 5). They seem to occupy several dens frequently and the others far less so (Lindenmayer, Pope & Cunningham 2004).
    - In south-eastern Queensland, 4–20 different den trees were used by individuals (Smith, Mathieson & Hogan 2007).
- Their distribution ranges from the east coast of Australia from north-east Queensland to central highlands of Victoria, within an elevational range 0 to 1200 m above sea level.
- Site occupancy probability in the 1990s was estimated to be 0.52 ± 0.05 in northern NSW and 0.62 ± 0.11 in southern NSW, indicating the greater glider could be expected to occur in ~52% and ~62% of surveyed sites respectively (Kavanagh et al. 2022).
- Feeds on a restricted range of eucalypt species that vary regionally. The most important food items are young leaves and flower buds of particular eucalypt species (Comport, Wards and Foley 1996).

Threats

- The species reliance on hollow-bearing trees, high site fidelity, slow reproduction and dispersal ability means they are negatively impacted by bushfire and timber harvesting (McLean et al. 2018, p. 22; May-Stubbles, Gracanin and Mikac 2022, p. 710).
- Loss of hollow-bearing trees is a key threatening process for the species under the BC Act.
    - The species is absent from areas with insufficient hollows, with a study in Grafton/Casino demonstrating a need for > 6 hollows per hectare (DCCEEW 2022, p. 5).
    - “In the Central Highlands of Victoria, a strong linear relationship was found between the total number of arboreal marsupials (including P. volans) and the abundance of potential nest trees (Lindenmayer eta/. 1990b, 1993a, 1994b). The number of trees with hollows was a significant explanatory variable in models describing the habitat requirements of this species (Lindenmayer eta/. 1990d 1993b, 1994c). Milledge et

al. (1991) also suggested that the distribution of P. volans was closely related to hollow availability in these forests." (Gibbons and Lindemayer 1997, p. 30).
    - "The number of hollow-bearing trees actually required per glider is not known though it has been observed that gliders will have a small number of primary (i.e. most frequently used) dens (Kehl and Borsboom 1984; Comport et al. 1996; Kavanagh and Wheeler 2004; Lindenmayer et al. 2004)." (Goldingay 2021, Report to Natural Resources Commission p. 3).
- The Southern Greater Glider (Petauroides volan) was listed as endangered in NSW in November 2022, after the IFOA was made in 2022 and the 2019-20 bushfires impacted approximately 40% of its distribution (NSW Threatened Species Scientific Committee (TSSC) 2022)
- It's population size reduced 47% over 21 years to 2022, not considering severe fire and drought (NSW TSSC 2022).
- The species was listed on the provisional list of mammals requiring urgent management intervention after the 2019-20 bushfires (the bushfires) (DCCEEW 2020, p. 5).
    - The bushfires impacted approximately 40% of its distribution, with over 80% of the Eurobodalla population habitat impacted (Legge et al. 2021, p. 9, 41, 103; NSW TSSC 2022, 10; NRC report 2021, p. 87).
    - In sites exposed to fire, there was an estimated 85% population loss within one week, and 10-year population estimates post fire indicate poor recovery or continuing decline (Legge et al. 2021, p. 41).
    - Fire can cause direct mortality through lethal heating or suffocation from smoke, or indirect mortality by reducing habitat and food resources (McLean et al. 2018, p. 22).
- Unburned areas are important places for the long-term recovery of Southern Greater Gliders (DEECC 2022, p. 18; Berry et al. 2015, p. 43).
    - Most of Tallaganda State Forest was unburnt in the 2019-20 bushfires, making the area an important location for the ongoing survival and long-term recovery of Greater Gliders.
    - The neighbouring Tallaganda State Conservation Area and Tallaganda National Park comprise of large patches of extreme burnt areas, with smaller areas of medium-high and low burnt areas.
- Southern Greater Gliders are adversely affected by timber harvesting and recover slowly (NSW TSSC 2022, 12).
    - Logging has "a consistent, negative influence on key habitat elements (e.g. hollow abundance) and species populations" (McLean et al. 2018, p. 23).
    - Research shows the species is absent from cleared areas and struggles to move through cleared areas between fragments (NSW TSSC 2022).
    - Kavanagh and Webb (1998) found that southern NSW populations failed to recover within eight years of logging (at sites retaining 62%, 52% and 21% of the original tree basal area), which the most heavily logged compartment suffering the largest decline in Southern Greater Glider numbers (Kavanagh and Webb 1998, p 334).
    - Lightly and intensively logged areas have significantly lower densities of Southern Greater Gliders in wet sclerophyll forests in north-eastern NSW (McLean et al. 2018, p. 22).
    - The species were absent in Victorian Mountain Ash forests post-timber harvesting for >38 years (Macfarlane 1988 in NSW TSSC 2022, 12).

- Loss of hollow-bearing trees is a key threatening process for the species under the BC Act. The species shelter in tree hollows during the day, preferring larger hollows (>10cm diameter) in large, old trees.
- Greater Gliders are also important prey for the Powerful Owl, which is vulnerable under the BC Act.
- The Coastal IFOA was not designed to mitigate the impacts of logging in landscapes disturbed by the serve and large scale 2019-20 bushfires.
- The IFOA was designed based on the assumption that biodiversity protection is primarily provided by large-scale undisturbed protected areas (such as national parks, flora reserves, old growth, rainforest, wetlands, riparian areas and threatened ecological communities) and then supplemented by protections at the harvesting site (such as increased protection for trees with hollows).
- With catastrophic, large-scale impacts occurring across protected areas because of the fires, the validity of this protection model remains compromised.

Effective protections for the Southern Greater Glider

- Protecting hollowing bearing trees is the most effective protection for Southern Greater Gliders. (NSW TSSC 2022; Harris and Maloney 2010, p. 212; McLean et al. 2018, p. 19).
  - Retaining young and relatively small (DBH 50–100 cm) trees is important to ensure suitable hollows are formed into the future as large hollow-bearing trees die (Hofman, Gracanin and Mikac 2022,p. 135).
  - " … studies by Lindenmayer eta/. (1990b, 1991 a, 1992), and confirmed in validation surveys (Lindenmayer et a/. 1994b), detected no asymptote in the relationship between the density of potential nest trees and populations of arboreal marsupials. Sites including as many as ten hollow-bearing trees per ha were included in these analyses (Lindenmayer eta/. 1990b, 1993b)." (Gibbons and Lindenmayer 1997, p. 36)
  - "Populations of the Greater Glider and, to a lesser extent, the Powerful Owl, were positively associated with the number of trees with hollows in north-eastern NSW (Kavanagh et al. 1995) and the south-western slopes of NSW (Kavanagh and Stanton 1998)" Gibbons and Lindenmayer 2002, p.117).
  - Greater gliders can be found in regrowth forest provided sufficient hollows are present (Macfarlane 1988; Lindenmayer et al. 1990a), and conversely are absent when there are insufficient hollows.
- Several studies have examined how many den trees/hollow bearing trees are required
  - "In recognition of studies demonstrating greater glider (*Petauroides volans*) den tree requirements (Kehl and Borsboom, 1984, Lindenmayer et al., 1990) the Code specifies six live hollow-bearing trees per hectare to be retained in coastal wet to moist hardwood forests and coastal/inland dry sclerophyll forests where the greater glider is expected to occur. Four live hollow-bearing trees per hectare must be retained in coastal/inland dry sclerophyll forests where the greater glider is not expected to occur" (Eyre 2006, p. 270).
  - Gibbons and Lindemayer (1997) have estimated the number of den trees per ha likely to be utilised by seven species of arboreal marsupial, with greater gliders using 0.5 to 23 nest trees per ha of continuous suitable habitat. This large range is due to the range of habitat in which the studies were conducted (Gibbons and Lindenmayer 1997, p. 38).

    - In North East NSW, estimates for the number of hollows and hollow-bearing trees occupied by vertebrate fauna in eucalypt forests and woodlands were 18-40 and 6 – 13 respectively Gibbons and Lindenmayer 2002, table 7.1).
    - "Two studies have found that the Greater Glider was generally absent from sites supporting less than six hollow-bearing trees per hectare (Smith et al. 1994a, Lamb et al. 1998)." (Gibbons and Lindenmayer 2002, p.121).
        - In the Grafton/Casino region of NSW, SGG was not recorded from surveyed sites containing fewer than six tree hollows per hectare (Smith et al. 1994).
    - McLean et al. (2018) suggest that 8 HBT per Ha observed through their study sites likely maintained SGG presence.
    - In south-eastern Queensland, 4−20 different den trees were used by individuals (Smith. Mathieson and Hogan, 2007). With home ranges of 1-3Ha on average, 8 HBT trees per Ha could be adequate to address this range.
    - In southern Qld, the species appears to require at least 2–4 live den trees for every 2 ha of suitable forest habitat (Eyre 2002).
    - Lamb et al. (1998) advocated a zoning system for hollow-tree retention in south-east Queensland. In Zone A — Maximum habitat-tree densities (to sustain populations of hollow-using fauna at optimum densities), they recommended that 12 hollow bearing trees per hectare in wet and moist forests be retained. In Zone B - Standard habitat-tree densities (to sustain the full complement of hollow-using fauna, but at reduced population densities than would otherwise occur in natural (unmanaged) forests), they recommended 6 hollow-bearing trees per hectare in wet and moist forests and dry sclerophyll forests within the predicted range of the Greater Glider (Gibbons and Lindenmayer 2002).
- Protection of unburned habitat is critical to support population recovery post bushfire, including protection of post fire refuges and hollow-bearing trees and avoiding hazard reduction burns (DEECC 2022, p. 18).
- Protecting actively used dens is effective at preventing immediate harm to Southern Greater Gliders occupying a tree.
    - However, the protection is likely to be short term as the species frequently moves between dens.
    - The protection also relies on current den records, which are intensive to identify (requires night-time spotlight surveys and/or stag watching to observe the species entering *and* leaving hollows).
    - The entirety of dens is unlikely to be fully identified due to the species frequent movement. Consequently, a recorded den may not be in use by the time harvest operations commence, and/or animals may be inhabiting a different, unidentified (and unprotected) den and at risk of immediate harm if the tree is felled.
- Protection of eucalypt feed trees is unlikely to be necessary, as they are widely available and likely to be protected through tree retention requirements (Harris and Maloney 2010).

Other hollow dependent species benefit from greater glider protections

- "Approximately 15% of terrestrial vertebrate species, including around 100 species listed as threatened, use hollows in eucalypt forests (Gibbons and Lindenmayer, 2002) and populations of hollow-dependent fauna are limited by the numbers of trees with hollows (Pausas et al., 1995)" (Gibbons, McElhinny and Lindenmayer 2010, p. 976).
- Gibbons and Lindenmayer (2002) found that 46 mammals, 85 birds, 32 reptiles and 16 frogs are hollow-dependent in NSW.

- Of the 22 species of bats that have been recorded to utilise tree hollows in NSW, 10 of these are listed as threatened in the *Threatened Species Conservation Act 1995* (Gibbons and Lindenmayer 1997).
- Additionally, like greater gliders, most non-flying, Australian arboreal and scansorial mammal species use multiple hollows.[1] Goldingay (2011) concludes that there is likely commonality across tree use by Australian arboreal mammals because of their shared ecological elements.

Surveying for greater gliders

- Spotlighting, which uses a handheld, powerful light bean to detect an animal's reflected eyeshine or body shape, is a widely employed, general survey technique for nocturnal arboreal mammals (Goldingay, McHugh and Parkyn 2022, p. 3; Lindenmayer et al. 2001, p. 105).
- While spotlighting is a widely accepted method for surveying greater gliders, its effectiveness is limited. Lindenmayer et al (2001) have found that spotlighting may substantially underestimate the actual abundance of animals in a given area (Lindenmayer et al. 2001, p. 108). They compared the location of animals detected by spotlighting to the known locations of radio-tracked animals and found experienced spotlight observers had a low success rate.[2]
  - In their study estimating the detectability in occupancy surveys for arboreal marsupials, Wintle et at (2005) found that the probability of detecting greater gliders with single-visit spotlighting was low and suggested repeated surveys. See *Figure 1* and *Figure 2*.
- Stag watching, which involves direct observation of nocturnal animals emerging or leaving hollows, can be used to identify dens and count actual numbers of animals. However, it is labour intensive, requiring observers to be stationed beneath all large hollow-bearing trees (dead or living), or within a grid and look upwards continuously for a period before and after sunset (Smith et al. 1989, p. 575-576).
- Thermal imaging cameras may be used to survey Southern Greater Gliders and is best used on nights below 24°C (Vinson, Johnson and Mikac 2020, p. 372). Research by Vinson, Johnson and Mikak (2020) found real time thermography detected as many or more Southern Greater Gliders than spotlighting (although the detection of more Southern Greater Gliders was not statistically significant).
- Because gliders move between multiple dens, it impossible for spotlight surveys to identify all actively used dens because the species will absent from some hollows at the time of the survey.
- Additionally, the protections prescribed for greater glider dens are both short term, as gliders move on to new and unprotected dens.
- Surveying for dens (mainly) addresses direct risks to individuals via felling of trees, whereas landscape approach addresses risks to population and its persistence in the landscape, aligns with required outcome of the CIFOA

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[1] Goldingay, Ross "Characteristics of tree hollows used by Austrlaian arboreal and scansorial mammals", *Australian Journal of Zoology,* 59, 277-294 (2011).

[2] "*Combining the information across patches, there was a total of nine successful detections of animals by spotlighting from 35 opportunities (26%).*"

Table 1. Summary of detection and occupancy data for 6 species (common ringtail possum, greater glider, yellow-bellied glider, sugar glider, powerful owl, sooty owl) in the Eden region of SE Australia in 2001. The occupancy estimate (*p*) describes the proportion of sites in the study thought to contain the species. The single-visit detection probability (*d*), calculated using the zero-inflated binomial model, is the probability that the species will be detected during a single visit to an occupied site.

	No. of sites species was detected	No. of times detected	Single-visit detection probability (*d*) with 95% CI	Occupancy estimate (*p*) with 95% CI
Common ringtail possum	27	54	0.21	0.63
			0.15, 0.28	0.47, 0.82
Greater glider	25	84	0.41	0.51
			0.34, 0.49	0.37, 0.65
Yellow-bellied glider	47	194	0.51	0.94
			0.46, 0.57	0.84, 0.98
Sugar glider	50	221	0.55	1
			0.47, 0.63	1, 1
Powerful owl	33	50	0.13	0.91
			0.09, 0.18	0.72, 1
Sooty owl	29	67	0.26	0.63
			0.20, 0.33	0.48, 0.79

Figure 2: Wintle et al (2005).

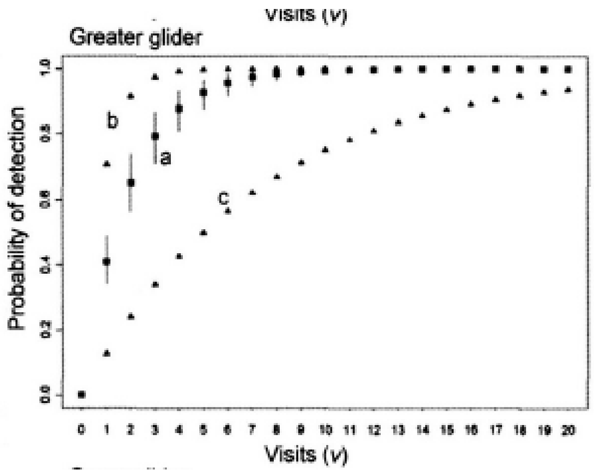

Figure 1: Detectability curve for greater glider in the Eden region of SE Australia. Curves are based on single-visit detection probabilities estimates from 2001 survey data. Points represent the probability that each species will be detected after *v* visits to a given survey location. Vertical lines represent 95% credible intervals on the mean estimates (curve [a], described by the square symbols). The detectability curves described by solid triangles are based on estimates of the single-visit detection probability (d) for best (b) and worst (c) detected conditions encountered (Wintle et al. 2005, p. 913)

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