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

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

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

Petauroides volans © Copyright, Tyrie Starrs (from Tallaganda NSW)

Conservation status

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

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

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

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

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

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

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

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

Species information

Taxonomy

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

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

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

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

Description

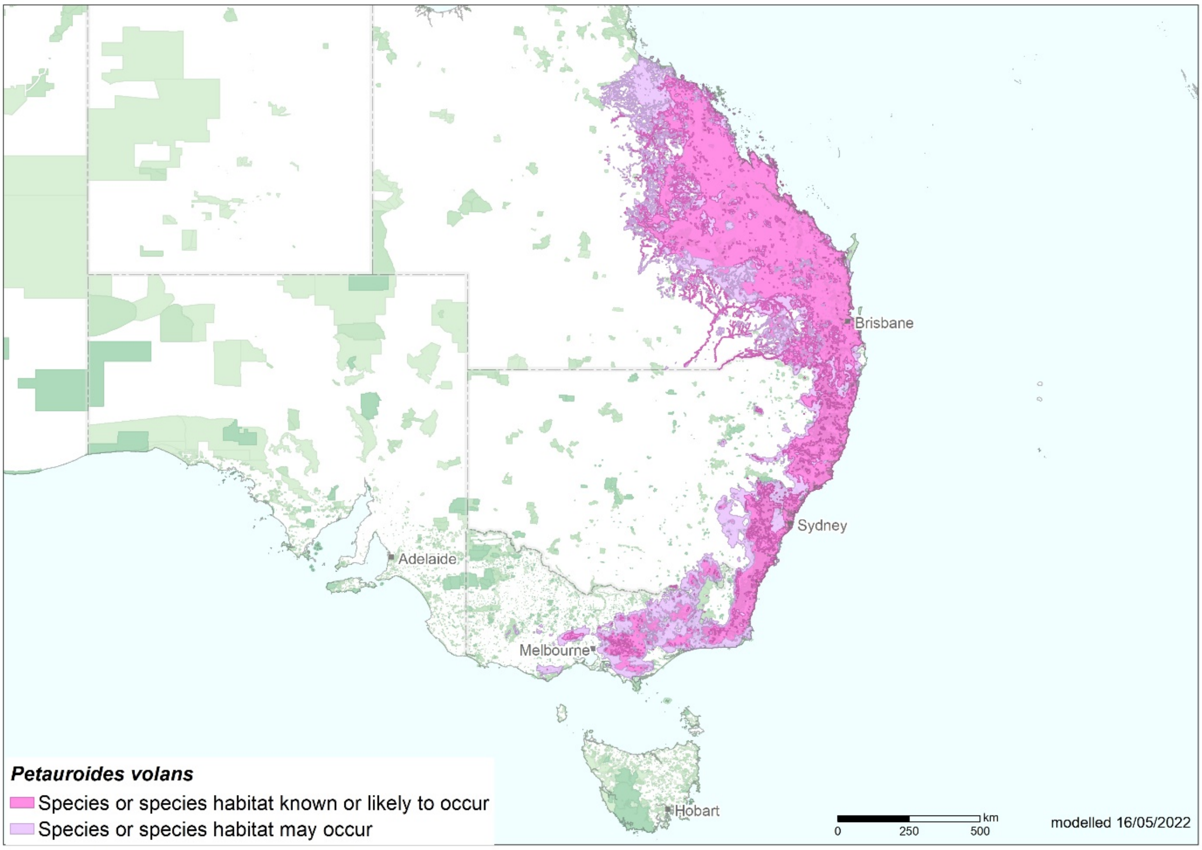
The greater glider (southern and central) is the largest gliding possum in eastern Australia. It has a head and body length of 35−46 cm, tail length of 45−60 cm, and a weight range of 900−1700 g, with females being larger than males (McKay 1989, 2008; McGregor et al. 2020). The greater glider (southern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

Distribution

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

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

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



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

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

Cultural and community significance

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

Relevant biology and ecology

General habitat

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

Den trees

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

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

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

Diet

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

Life history

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

Home ranges and densities

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

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

Disturbance ecology

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

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

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

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

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

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

Habitat critical to the survival

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

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

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

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

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

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

Important populations

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

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

Threats

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

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

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

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

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

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

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

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

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

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

Timing—identify the temporal nature of the threat;

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

Consequence—identify the severity of the threat;

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

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

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

Table 2 Greater glider (southern and central) risk matrix

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

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

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

Conservation and recovery actions

Primary conservation objective

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

Conservation and management priorities

Habitat loss, disturbance and modification (including fire)

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

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

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

Climate change

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

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

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

Ex-situ recovery actions

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

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

Stakeholder engagement/community engagement

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

Survey and monitoring priorities

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

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

Information and research priorities

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

Recovery plan

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

Links to relevant implementation documents

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

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

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

Threat abatement plan for predation by feral cats 2015

Threat abatement plan for predation by the European red fox 2008

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

Conservation Advice and Listing Assessment references

References cited in the advice

Andrew D (2001) *Post Fire Vertebrate Survey – Royal and Heathcote National Parks and Garrawarra State Recreation Area*. A report to NSW National Parks and Wildlife Service, Sydney south region.

Andrew D, Koffel D, Harvey G, Griffiths K & Fleming M (2014) Rediscovery of the greater glider *Petauroides volans* (Marsupialia: Petauroidea) in the Royal National Park, NSW. *Australian Zoologist* 37, 23–28.

Andrews SP, Gration G, Quin D & Smith AP (1994) Description and assessment of forestry impacts on fauna of the Urbenville Forestry Management Area. Report for State Forests of New South Wales. Austeco Environmental Consultants, Armidale.

Au J, Clark RG, Allen C, Marsh KJ, Foley WJ & Youngentob KN (2019) A nutritional mechanism underpinning folivore occurrence in disturbed forests. *Forest Ecology and Management* 453. Available on the internet at: https://doi.org/10.1016/j.foreco.2019.117585

Ball IR, Possingham HP & Lindenmayer DB (1999) A tree hollodynamics simulation model. *Forest Ecology and Management* 123, 179–194.

Beale PK, Marsh KJ, Foley WJ & Moore BD (2018) A hot lunch for herbivores: physiological effects of elevated temperatures on mammalian feeding ecology. *Biol Rev Camb Philos Soc* 93, 674–692.

Berry LE, Driscoll DA, Banks SC & Lindenmayer DB (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* 37, 39–45.

Bilney R, Cooke R & White J (2006) Change in the diet of sooty owls (*Tyto tenebricosa*) since European settlement: from terrestrial to arboreal prey and increased overlap with powerful owls. *Wildlife Research* 33, 17–24.

Bilney R, Cooke R & White J (2010) Underestimated and severe: Small mammal decline from the forests of south-eastern Australia since European settlement, as revealed by a top-order predator. *Biological Conservation* 143, 52–59.

Bluff L (2016) *Reducing the effect of planned burns on hollow-bearing trees*. Fire and adaptive management report no. 95. Victorian Government Department of Environment, Land, Water and Planning. Melbourne.

Boer MM, de Dios VR & Bradstock RA (2020) Unprecedented burn area of Australian mega forest fires. *Nature Climate Change* 10, 171–172.

Booth TH, Broadhurst LM, Pinkard E, Prober SM, Dillon SK, Bush D, Pinyopusarerk K, Doran JC, Ivkovich M & Young AG (2015) Native forests and climate change: Lessons from eucalypts. *Forest Ecology and Management* 347, 18–29.

Booth TH (2017) Impacts of climate change on eucalypt distributions in Australia: an examination of a recent study. *Australian Forestry* 80, 208–15.

Booth TH (2018) Species distribution modelling tools and databases to assist managing forests under climate change. *Forest Ecology and Management* 430, 196–203.

Bowd EJ, McBurney L, Blair DP & Lindenmayer DB (2021) Temporal patterns of forest seedling emergence across different disturbance histories. *Ecology and Evolution* 11, 9254–9292.

Braithwaite lW (1983) Studies on the arboreal marsupial fauna of eucalypt forest being harvested for woodpulp at Eden, New South Wales. I. The species and distribution of animals. *Australian Wildlife Research* 10, 219–229.

Braithwaite LW (1984) On identifying important habitat characteristics and planning a conservation strategy for arboreal marsupials within the Eden Woodpulp Concession area In *Possums and Gliders* (eds AP Smith & ID Hume), pp. 501–508. Surrey Beatty and Sons, Chipping Norton.

Brunner H, Loyd JW & Coman BJ (1975) Fox scat analysis on a forest park in south-eastern Australia. *Australian Wildlife Research* 2, 147–154.

Burns PA & Atkins ZS (2021) *Gliding from the ashes: Post-fire surveys for the greater glider and yellow-bellied glider in Far East Gippsland.* Snowline Ecology & Native Mouse Ecological Consulting.

Butt N, Pollock LJ & McAlpine CA (2013) Eucalypts face increasing climate stress. *Ecology and Evolution* 3, 5011–5022.

Chia EK, Bassett M, Nimmo DG, Leonard SWJ , Ritchie E, Clarke MF & Bennett AF (2015) Fire severity and fire-induced landscape heterogeneity affect arboreal mammals in fire-prone forests. *Ecosphere* 6. Available on the internet at: https://doi.org/10.1890/ES15-00327.1

Coman BJ (1973) The diet of red foxes, *Vulpes vulpes* L., in Victoria. *Australian Journal of Zoology* 21, 391–401.

BOM (Bureau of Metereology) & CSIRO (2020). *State of the Climate 2020.* Sixth edition. Available on the internet at: State of the Climate 2020: Bureau of Meteorology (bom.gov.au)

CSIRO & BOM (Bureau of Metereology) (2021) Climate Change in Australia: Regional Climate Change Explorer. Retrieved 17 August 2021 from: https://www.climatechangeinaustralia.gov.au/en/projections-tools/regional-climate-change-explorer/super-clusters/.

Dalton K (2018) *Use and effectiveness of glider pole linkages as a mitigation measure: Sugarloaf Pipeline project.* Australasian Network for Ecology and Transportation Conference, Creswick, Victoria.

Davey SM (1984) Habitat preferences of arboreal marsupials within a coastal forest in southern New South Wales, in AP Smith & ID Hume (eds), *Possums and Gliders.* Australian Mammal Society, Sydney. pp. 509–516.

DAWE (2021) Area of Occupancy and Extent of Occurrence for *Petauroides volans*. Unpublished report. Department of the Environment (Commonwealth), Canberra.

DECCW (Department of Environment Climate Change and Water) (2011) *The Vertebrate Fauna of Royal & Heathcote National Parks and Garrawarra State Conservation Area.* Department of Environment Climate Change and Water (NSW), Hurstville.

DeGabriel JL, Moore BD, Foley WJ & Johnson CN (2009) The effects of plant defensive chemistry on nutrient availability predict reproductive success in a mammal. *Ecology* 90, 711–719.

DELWP (Department of Environment, Land, Water and Planning) (n.d) *Forest Fire Management Victoria, Hazardous tree removal after bushfire.* Available on the internet at: https://www.ffm.vic.gov.au/__data/assets/pdf_file/0015/21282/Hazardous-tree-removal-after_KP.pdf

DELWP (Department of Environment, Land, Water and Planning) (2016) *Preliminary recommendation on a nomination for listing:* Petauroides volans volans. Flora and Fauna Guarantee – Scientific Advisory Committee. Department of Environment, Land, Water and Planning (Vic), Melbourne.

Dickman C, Driscoll D, Garnett S, Keith D, Legge S, Lindenmayer D, Maron M, Reside A, Ritchie E, Watson J, Wintle B & Woinarski J (2020) *After the catastrophe: a blueprint for a conservation response to large-scale ecological disaster*. Threatened Species Recovery Hub, January 2020. Available on the internet at: https://www.nespthreatenedspecies.edu.au/publications-and-tools/after-the-catastrophe-a-blueprint-for-a-conservation-response-to-large-scale-ecological-disaster

DoEE (2016a) *Conservation advice for* Petauroides volans *(greater glider).* Department of the Environment and Energy (Commonwealth), Canberra.

DoEE (2016b) *Greater glider* (Petauroides volans) *recovery plan workshop: Summary of outcomes*. Unpublished report. Department of the Environment and Energy (Commonwealth), Canberra.

Downes SJ Handasyde KA & Elgar MA (1997) The use of corridors by mammals in fragmented Australian eucalypt forests. *Conservation Biology* 11, 718–726.

DPI (Department of Primary Industries) (2020) *Drought in NSW*. Viewed: 14 September 2020. Available on the internet at: https://www.dpi.nsw.gov.au/emergencies/droughthub_old/drought-in-nsw

DPIE (Department of Planning, Industry and Environment) (2020) *Understanding the effects of the 2019-20 fires.* Viewed: 15 September 2020. Available on the internet at: https://www.environment.nsw.gov.au/topics/fire/park-recovery-and-rehabilitation/recovering-from-2019-20-fires/understanding-the-impact-of-the-2019-20-fires

Driscoll DA, Lindenmayer DB, Bennett AF, Bode M, Bradstock RA, Cary GJ, Clarke MF, Dexter N, Fensham R, Friend G, Gill M, James S, Kay G, Keith DA, MacGregor C, Possingham HP, Russell-Smith J, Salt D, Watson JEM, Williams D & York A (2010) Resolving conflicts in fire management using decision theory: asset-protection versus biodiversity conservation. *Conservation Letters* 3, 215–223.

Duan H, Ontedhu J, Milham P, Lewis JD & Tissue DT (2019) Effects of elevated carbon dioxide and elevated temperature on morphological, physiological and anatomical responses of *Eucalyptus tereticornis* along a soil phosphorus gradient. *Tree Physiology* 39, 1821–1837.

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 the possums and gliders of southern Queensland, in RL Goldingay and SM Jackson (eds) *The Biology of Australian Possums and Gliders*. Surrey Beatty and Sons Chipping Norton, New South Wales. pp. 1–25.

Eyre TJ (2005) Hollow-bearing trees in a coastal forest in south-east Queensland, Australia: Abundance, spatial distribution and management. *Pacific Conservation Biology* 11, 23–37.

Eyre TJ (2006) Regional habitat selection by large gliding possums at forest stand and landscape scales in southern Queensland, Australia. I. Greater glider (*Petauroides volans*). *Forest Ecology and Management* 235, 270–282.

Eyre TJ, Butler DW, Kelly AL & Wang J (2010) Effects of forest management on structural features important for biodiversity in mixed-age hardwood forests in Australia's subtropics. *Forest Ecology and Management* 259, 534–546.

Eyre TJ, Smith GC, Venz MF, Mathieson MT, Hogan LD & Starr C (2021) *Species specific advice: Greater gliders, Queensland*. Queensland Herbarium, Department of Environment and Science, Queensland Government. Brisbane.

Ferguson DJ, Laidlaw MJ & Eyre TJ (2018) Greater Glider Habitat Resource Assessment in the Burnett Mary. Department of Environment and Science (Qld).

Fleay D (1947) *Gliders of the Gum Trees*. Bread and Cheese Club, Melbourne.

Foley WJ, Kehl JC, Nagy KA, Kaplan IR. & Boorsboom AC (1990) Energy and water metabolism in free-living greater gliders *Petauroides volans. Australian Journal of Zoology* 38, 1–10.

GHD (2017) *Report for Melbourne Water Corporation - Sugarloaf Pipeline Project Toolangi Habitat Linkage Monitoring.* GHD. 31/29843.

Gibbons P & Lindenmayer DB (2002) *Tree hollows and wildlife conservation in Australia.* CSIRO Publishing, Collingwood.

Gleadow RM, Foley WJ & Woodrow IE (1998) Enhanced CO_2 alters the relationship between photosynthesis and defense in cyanogenic *Eucalyptus cladocalyx*. *Plant, Cell and Environment* 21, 12–22.

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

Goldingay RL, Taylor BD & Parkyn JL (2018) Use of tall wooden poles by four species of gliding mammal provides further proof of concept for habitat restoration. *Australian Mammalogy* 41, 255–261.

Goldingay RL, Rohweder D & Taylor BD (2020) Nest box contentions: Are nest boxes used by the species they target? *Ecological Management & Restoration* 21, 115–122.

González-Orozco CE, Pollock, Laura J, Thornhill, Andrew H, Mishler, Brent D, Knerr, N, Laffan, Shawn W, Miller, Joseph T, Rosauer, Dan F, Faith, Daniel P, Nipperess, David A, Kujala, H, Linke, S, Butt, N, Külheim, C, Crisp, Michael D & Gruber B (2016) Phylogenetic approaches reveal biodiversity threats under climate change. *Nature Climate Change* 6, 1110–1114.

Griffiths SR, Lentini PE, Semmens K, Watson SJ, Lumsden LF & Robert KA (2018) Chainsaw-Carved Cavities Better Mimic the Thermal Properties of Natural Tree Hollows than Nest Boxes and Log Hollows *Forests* 9, 235. Available on the internet at: https://doi.org/10.3390/f9050235

Hancock N, Harris R, Broadhurst L & Hughes L (2018) Climate-ready revegetation. A guide for natural resource managers. Version 2. Sydney, Macquarie University. Available on the internet at: https://www.mq.edu.au/__data/assets/pdf_file/0006/807666/Climate-Reveg-Guide-v2-2018.pdf

Henry SR (1984) Social organisation of the greater glider (*Petauroides volans*) in Victoria, in AP Smith & ID Hume (eds), *Possums and Gliders.* Surrey Beatty and Sons, Chipping Norton. pp. 221–228.

Henry SR (1995) Greater glider *Petauroides volans*, in PW Menkhorst (ed), *Mammals of Victoria: distribution, ecology and conservation.* Oxford University Press, Melbourne. pp. 118–120.

Hovenden MJ & Williams AL (2010) The impacts of rising CO2 concentrations on Australian terrestrial species and ecosystems. *Austral Ecology* 35, 665–684.

Incoll RD, Loyn RH, Ward SJ, Cunningham RB & Donnelly CF (2001) The occurrence of gliding possums in old-growth forest patches of mountain ash (*Eucalyptus regnans*) in the Central Highlands of Victoria. *Biological Conservation* 98, 77–88.

IUCN Standards and Petitions Committee (2019) *Guidelines for Using the IUCN Red List Categories and Criteria. Version 14.* Prepared by the Standards and Petitions Committee. Available on the internet at: http://www.iucnredlist.org/documents/RedListGuidelines.pdf

Jackson S & Groves C (2015) *Taxonomy of Australian mammals*. CSIRO Publishing, Clayton South.

Jones E & Coman BJ (1981) Ecology of the Feral Cat, Felis *catus* (L.), in South-Eastern Australia I. Diet. *Wildlife Research* 8, 537–547.

Kavanagh RP (1984) Seasonal changes in habitat use by gliders and possums in southeastern New South Wales. In AP Smith ID Hume (eds) *Possums and Gliders*. Surrey Beatty and Sons, Chipping Norton. pp. 527–543.

Kavanagh RP (1987) *Floristic and phenological characteristics of a eucalypt forest in relation to its use by arboreal marsupials*. MSc thesis. Australian National University, Canberra.

Kavanagh RP (1988) The impact of predation by the powerful owl, *Ninox strenua*, on a population of the greater glider, *Petauroides volans*. *Austral Ecology* 13, 445–450.

Kavanagh RP (1995) *Nocturnal Forest Birds and Arboreal Marsupials of Coolah Tops, Warung Management Area, Western Region*. Forest Resources Series No. 28. State Forests of New South Wales, Sydney. 24 pp.

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* 6, 18–30.

Kavanagh RP (2004) Distribution and conservation status of possums and gliders in New South Wales. In RL Goldingay & SM Jackson (eds) *The Biology of Australian Possums and Gliders*. Surrey Beatty and Sons, Chipping Norton. pp. 130–148.

Kavanagh RP & Bamkin KL (1995) Distribution of nocturnal forest birds and mammals in relation to the logging mosaic in south-eastern New South Wales, Australia. *Biological Conservation* 71, 41–53.

Kavanagh RP, Debus S, Tweedie T & Webster R (1995) Distribution of nocturnal forest birds and mammals in north-eastern New South Wales: relationships with environmental variables and management history. *Wildlife Research* 22, 359–377.

Kavanagh RP & Lambert M (1990) Food selection by the greater glider: is foliar nitrogen a determinant of habitat quality? *Australian Wildlife Research* 17, 285–299.

Kavanagh RP & Webb GA (1998) Effects of variable-intensity logging on mammals, reptiles and amphibians at Waratah Creek, south-eastern New South Wales. *Pacific Conservation Biology* 4, 326–347.

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 Australian Possums and Gliders*. Surrey Beatty and Sons, Sydney. pp. 413–425.

Kavanagh R, McLean C & Stanton M (2021) *Greater glider and yellow-bellied glider population responses to the 2019-2020 wildfires in north-eastern NSW and south-eastern NS*W. A report to the Department of Agriculture, Water and Environment. Canberra.

Kearney MR, Wintle BA & Porter WP (2010) Correlative and mechanistic models of species distribution provide congruent forecasts under climate change. *Conservation Letters* 3, 203–213.

Kehl J & Borsboom A (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 and Sons, Chipping Norton. pp. 229–236.

Kerr R (1792) *The animal kingdom, or zoological system, of the celebrated Sir Charles Linnaeus: Class 1. Mammalia: containing a complete sydtematic description, arrangement, and nomenclature, of all known species and varieties of the Mammalia, or animals which give suck to their young: being a translation of that part of the Systema Naturae, as lately published, with great improvements, by Proffessor Gmelin of Goettingrn. Together with numerous additions from more recent zoological writers, and illustrated with copperplates.* J Murray & R Faulder: London.

Land Conservation Council (1984) *North-eastern area (Benalla-Upper Murray) Review*. Melbourne.

Lawler IR, Foley WJ, Woodrow IE & Cork SJ (1997) The effects of elevated CO_2 atmospheres on the nutritional quality of *Eucalyptus* foliage and its interaction with soil nutrient and light availability. *Oecologia* 109, 59–68.

Legge S, Woinarski JCZ, Garnett ST, Nimmo D, Scheele BC, Lintermans M, Whiterod N & Ferris J (2020) *Rapid analysis of impacts of the 2019–2020 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 (Commonwealth), Canberra.

Legge S, Woinarski JCZ, Garnett ST, Geyle H, Lintermans M, Nimmo DG, Rumpff L, Scheele BC, Southwell DG, Ward M, Whiterod NS, Ahyong ST, Blackmore CJ, Bower DS, Brizuela-

Torres D, Burbidge AH, Burns PA, Butler G, Catullo R, Dickman CR, Doyle K, Ensbey M, Ehmke G, Ferris J, Fisher D, Gallagher R, Gillespie GR, Greenlees MJ, Hayward-Brown B, Hohnen R, Hoskin CJ, Hunter D, Jolly C, Kennard M, King A, Kuchinke D, Law B, Lawler I, Lawler S, Loyn R, Lunney D, Lyon J, MacHunter J, Mahony M, Mahony S, McCormack RB, Melville J, Menkhorst P, Michael D, Mitchell N, Mulder E, Newell D, Pearce L, Raadik TA, Rowley J, Sitters H, Spencer R, Valavi R, Ward M, West M, Wilkinson DP & Zukowski S (2021) *Estimates of the impacts of the 2019-2020 fires on populations of native animal species*. NESP Threatened Species Recovery Hub project 8.3.2 report. Brisbane, Australia.

Lindenmayer DB (2002) *Gliders of Australia: A Natural History.* UNSW Press, Kensington.

Lindenmayer DB (2009) *Forest pattern and ecological process: a synthesis of 25 years of research*. CSIRO Publishing, Melbourne.

Lindenmayer DB & Sato C (2018) Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. *Procedures of the National Academy of Sciences* 115, 5181–5186.

Lindenmayer DB, Cunningham RB, Tanton MT, Smith AP & Nix HA (1990a). Habitat requirements of the mountain brushtail possum and the greater glider in the montane ash-type eucalypt forests of the central highlands of Victoria. *Australian Wildlife Research* 17, 467–478.

Lindenmayer DB, Cunningham RB, Tanton MT & Smith AP (1990b) The conservation of arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, southeast Australia. I. Factors affecting the occupancy of trees with hollows. *Biological Conservation* 54, 111–131.

Lindenmayer DB, Cunningham RB, Tanton MT, Smith AP & Nix HA (1991) Characteristics of hollow-bearing trees occupied by arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, south-east Australia. *Forest Ecology and Management* 40, 289–308.

Lindenmayer DB, Cunningham RB & Donnelly CF (1993) The conservation of arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, southeast Australia. IV. The distribution and abundance of arboreal marsupials in retained linear strips (wildlife corridors) in timber production forests. *Biological Conservation* 66, 207-221.

Lindenmayer DB, Cunningham RB, Pope M & Donnelly CF (1999) The response of arboreal marsupials to landscape context: a largescale fragmentation study. *Ecological Applications* 9, 594–611.

Lindenmayer DB, Lacy RC & Pope ML (2000) Testing a simulation model for population viability analysis. *Ecological Applications* 10, 580–597.

Lindenmayer DB, Ball I, Possingham HP, McCarthy M & Pope ML (2001) A landscape test of the predictive ability of a spatially explicit model for population viability analysis. *Journal of Applied Ecology* 38, 36–48.

Lindenmayer DB, MacGregor CI, Cunningham RB, Incoll RD, Crane M, Rawlins D & Michael DR (2003) The use of nest boxes by arboreal marsupials in the forests of the central highlands of Victoria *Wildlife Research* 30, 259–264.

Lindenmayer DB, Pope ML & Cunningham RB (2004). Patch use by the greater glider (*Petauroides volans*) in a fragmented forest ecosystem. II. Characteristics of den trees and preliminary data on den-use patterns. *Wildlife Research* 31, 569–577.

Lindenmayer DB, Wood JT, McBurney L, MacGregor C, Youngentob K & Banks SC (2011) How to make a common species rare: a case against conservation complacency. *Biological Conservation* 144, 1663–1672.

Lindenmayer DB, Blanchard W, McBurney L, Blair D, Banks S, Liken GE, Franklin JF, Laurance WF, Stein J & Gibbons P (2012) Interacting factors driving a major loss of large trees with cavities in a forest ecosystem. *PLOS One* 7, e41864.

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

Lindenmayer DB, Blanchard W, Blair D, McBurney L & Banks SC (2017a) Relationships between tree size and occupancy by cavity-dependent arboreal marsupials. *Forest Ecology and Management* 391, 221–229.

Lindenmayer DB, Cunningham RB & Donnelly CF (2017b) Decay and Collapse of Trees with Hollows in Eastern Australian Forests: Impacts on Arboreal Marsupials. *Ecological Applications* 7, 625–641.

Lindenmayer DB, Blanchard W, Blair D, McBurney L, Stein J & Banks SC (2018a) Empirical relationships between tree fall and landscape-level amounts of logging and fire. *PLoS One* 13, e0193132.

Lindenmayer DB, Wood J, MacGregor C, Foster C, Scheele B, Tulloch A & O'Loughlin LS (2018b) Conservation conundrums and the challenges of managing unexplained declines of multiple species. *Biological Conservation* 221, 279–292.

Lindenmayer DB, Blanchard W, Blair D, McBurney L, Taylor C, Scheele BC, Westgate MJ, Robinson N & Foster C (2020) The response of arboreal marsupials to long-term changes in forest disturbance. *Animal Conservation.* Available on the internet at: https://doi.org/10.1111/acv.12634

Lindenmayer D, Blair D, McBurney L, Banks S & Bowd E. (2021) Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday wildfires in Victoria's Mountain Ash forest. *Australian Zoologist* 41, 220–230.

Lumsden LF, Nelson JL, Todd CR, Scroggie MP, McNabb EG, Raadik TA, Smith SJ, Acevedo S, Cheers G, Jemison ML & Nico MD (2013) *A New Strategic Approach to Biodiversity Management – Research Component. Arthur Rylah Institute for Environmental Research.* Unpublished Client Report for the Department of Environment and Primary Industries, Heidelberg, Victoria.

Lunney D (1987) Effects of logging, fire and drought on possums and gliders in the coastal forests near Bega, N.S.W. *Australian Wildlife Research* 13, 67–92.

Lunney D, Triggs B, Eby P & Ashby E (1990) Analysis of scats of dogs *Canis familiar* and foxes *Vulpes vulpes* (Canidae: Carnivora) in coastal forests near Bega New South Wales. *Australian Wildlife Research* 17, 61–68.

Lunney D, Menkhorst P, Winter J, Ellis M, Strahan R, Oakwood M, Burnett S, Denny M & Martin R (2008) *Petauroides volans*. In 'IUCN red list of threatened species.' Version 2012.2. Viewed: 11 December 2012. Available on the internet at: http://www.iucnredlist.org/species/40579/166500472

Macfarlane MA (1988) Mammal populations in Mountain Ash forests (*Eucalyptus regnans*) forests of various ages in the Central Highlands of Victoria. *Australian Forestry* 51, 14–27.

Mackowski DM (1984) The otengeny 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*. Surrey Beatty and Sons, Chipping Norton. pp. 553–662.

Maloney KS (2007) The status of the greater glider *Petauroides volans* in the Illawarra region. M.Sc.-Res. Thesis, School of Biological Sciences, University of Wollongong, Wollongong.

Matusick G, Ruthrof KK, Brouwers NC, Dell B & Hardy GE (2013) Sudden forest canopy collapse corresponding with extreme drought and heat in a mediterranean-type eucalypt forest in southwestern Australia. *European Journal of Forest Research* 132, 497–510.

McCarthy MA & Lindenmayer DB (1999a) Conservation of the greater glider (*Petauroides volans*) in remnant native vegetation within exotic plantation forest. *Animal Conservation* 2, 203–209.

McCarthy MA, & Lindenmayer DB (1999b) Incorporating metapopulations dynamics of greater gliders into reserve design in disturbed landscapes. *Ecology* 80, 651–667.

McGregor DC, Padovan A, Georges A, Krockenberger A Yoon H & Youngentob KN (2020) Genetic evidence supports three previously described species of greater glider, *Petauroides volans, P. minor, and P. armillatus. Scientific Reports* 10, 19284. Available on the internet at: https://doi.org/10.1038/s41598-020-76364-z

McKiernan AB, Hovenden MJ, Brodribb TJ, Potts BM, Davies NW & O'Reilly-Wapstra JM (2014) Effect of limited water availability on foliar plant secondary metabolites of two Eucalyptus species. *Environmental and Experimental Botany* 105, 55–64.

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. *Forest Ecology and Management* 415-16, 19–25.

McKay GM (1989) Petauridae. In DW Walton & BJ Richardson (eds) *Fauna of Australia. Vol. 1B. Mammalia.* Australian Government Printing Service. Canberra. pp. 665–679.

McKay GM (2008) Greater glider *Petauroides volans*, in S Van Dyck & R Strahan (eds) *The Mammals of Australia*. Third edition. Reed New Holland, Sydney. pp. 240–242.

Menkhorst PW (1984) Use of nest boxes by forest vertebrates in Gippsland: acceptance, preference and demand. *Australian Wildlife Research* 11, 255–26.

Moore BD, Wallis IR, Marsh KJ & Foley WJ (2004) The role of nutrition in the conservation of the marsupial folivores of eucalypt forests, in D Lunney (ed) *Conservation of Australia's Forest Fauna*. Second edition. pp 549–575.

NSW National Parks and Wildlife Service South Coast Branch (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 and Corramy Regional Park*. Report prepared by Phillip Craven and Gary Daly.

Nelson JL, Scroggie MP, Durkin LK, Cripps JK, Ramsey DSL & Lumsden LF (2018) *Estimating the density of the greater glider in the Strathbogie Ranges, North East Victoria, with an assessment of coupes scheduled for timber harvesting in 2018.* Arthur Rylah Institute for Environmental Research Technical Report Series No. 293. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Parliament of Victoria (2020) Research note No. 1. 2019-2020 Bushfires, Quick Guide. Parliamentary Library Services, Parliament of Victoria. Available on the internet at:

https://www.parliament.vic.gov.au/publications/research-papers/download/36-research-papers/13904-bushfires-2019-20

Parnaby H, Lunney D, Shannon I & Fleming M (2010) Collapse rates of hollow-bearing trees following low intensity prescription burns in the Pilliga forests, New South Wales. *Pacific Conservation Biology* 16, 209–220.

Pope ML, Lindenmayer DB & Cunningham RB (2004) Patch use by the greater glider (*Petauroides volans*) in a fragmented forest ecosystem. I. Home range size and movements. *Wildlife Research* 31, 559–568.

Possingham HP, Lindenmayer DB, Norton TW & Davies I (1994) Metapopulation viability analysis of the greater glider *Petauroides volans* in a wood production area: *Biological Conservation*, 70, 227–236.

Queensland Herbarium (2018) *Threatened species and ecosystems at SWBTA: A summary of threatened fauna, flora and ecosystems surveys conducted November 2017 – April 2018*. Department of Energy and Science, Brisbane Botanic Gardens.

Ross Y (1999) Hollow-bearing trees in native forest permanent inventory plots in southeast Queensland. *Forest Ecosystem Research and Assessment Technical Papers*, pp. 99–123. Queensland Department of Natural Resources.

Rübsamen K, Hume ID, Foley WJ & Rübsamen U (1984) Implications of the large surface area to body mass ratio on the heat balance of the greater glider *Petauroides volans*. *Journal of Comparative Physiology, B-Biochemical, Systemic, and Environmental Physiology* 154, 105−111.

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

Smith AP, Andrews SP, Gration G, Quinn D & Sullivan B (1994b) Description and assessment of forestry impacts on fauna of the Urunga - Coffs Harbour Forestry Management Area. Report for 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* 34, 472‒483.

Smith GC, Lewis T & Hogan L (2015) Fauna community trends during early restoration of alluvial open forest/woodland ecosystems on former agricultural land. *Restoration Ecology* 23, 787−799.

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

Smith P & Smith J (2020) Future of the greater glider (*Petauroides volans*) in the Blue Mountains, New South Wales. *Proceedings of the Linnean Society of New South Wales* 142, 55−66.

Smith P & Smith J (2021) *Arboreal mammal survey of the Bigga-Tuena area*. Final report. New South Wales.

Standards Reference Group SERA (2021) *National Standards for the Practice of Ecological Restoration in Australia*. Edition 2.2. Society for Ecological Restoration Australasia. Available on the internet at: http://www.seraustralasia.com/standards/home.html

Taylor AC, Tyndale-Biscoe CH & Lindenmayer DB (2007) Unexpected persistence on habitat islands: genetic signatures reveal dispersal of a eucalypt-dependent marsupial through a hostile pine matrix. *Molecular Ecology* 16, 2655–2666.

Taylor BD & Goldingay RL (2009) Can road-crossing structures improve population viability of an urban gliding mammal? *Ecology and Society* 14, 13. Available on the internet at: https://www.ecologyandsociety.org/vol14/iss2/art13/

Taylor C, McCarthy MA & Lindenmayer DB (2014) Nonlinear effects of stand age on fire severity. *Conservation Letters* 7, 355–370.

Tyndale-Biscoe CH & Smith RFC (1969a) Studies on the marsupial glider *Schoinobates volans* (Kerr). III. Response to habitat destruction. *Journal of Animal Ecology* 38, 651–659.

Tyndale-Biscoe CH & Smith RFC (1969b) Studies on the marsupial glider, *Schoinobates volans* (Kerr). II. Population structure and regulatory mechanisms. *Journal of Animal Ecology* 38, 637–650.

Van Dyck S & Strahan R (2008) *The Mammals of Australia*. Reed New Holland, Sydney.

van der Ree R (1999) Barbed wire fencing as a hazard for wildlife. *The Victorian Naturalist* 116, 210–217.

van der Ree R, Ward SJ & Handasyde KA (2004) Distribution and conservation status of possums and gliders in Victoria, in RL Goldingay & SM Jackson (eds) *The Biology of Australian Possums and Gliders*. Surrey Beatty and Sons, Sydney. pp. 91–110.

Vinson SG, Johnson AP & Mikac KM (2020) Current estimates and vegetation preferences of an endangered population of the vulnerable greater glider at Seven Mile Beach National Park. *Austral Ecology*. Available on the internet at: https://doi.org/10.1111/aec.12979

Wagner B, Baker PJ, Stewart SB, Lumsden LF, Nelson JL, Cripps JK, Durkin LK, Scrogge M & Nitschke CR (2020) Climate change drives habitat contraction of a nocturnal arboreal marsupial at it's physiological limits. *Ecosphere* 11, e03262. Available on the internet at: https://doi.org/10.1002/ecs2.3262

Wallis RL & Brunner H (1986) Changes in mammalian prey of foxes, *Vulpes vulpes* (Carnivora: Vanidae) over 12 years in a forest park near Melbourne, Victoria. *Australian Mammology* 10, 43–44.

Woinarski JCZ, Burbidge AA & Harrison PL (2014) *The Action Plan for Australian Mammals 2012*. CSIRO Publishing, Collingwood.

Woinarski JCZ, McCosker JC, Gordon G, Lawrie B, James C, Augusteyn J, Slater L & Danvers T (2006) Monitoring change in the vertebrate fauna of central Queensland, Australia, over a period of broad-scale vegetation clearance, 1975-2002. *Wildlife Research* 33, 263–274.

Wormington K & Lamb D (1999) Tree hollow development in wet and dry sclerophyll eucalypt forest in south-east Queensland, Australia. *Australian Forestry* 62, 336–345. Available on the internet at: https://doi.org/10.1080/00049158.1999.10674801

Youngentob KN, Wallis IR, Lindenmayer DB, Wood JT, Pope ML & Foley WJ (2011) Foliage influences tree choice and landscape use of a gliding marsupial folivore. *Journal of Chemical Ecology* 37, 71–84. Available on the internet at: https://doi.org/10.1007/s10886-010-9889-9

Youngentob KN, Yoon H-J, Coggan N & Lindenmayer DB (2012) Edge effects influence competition dynamics: A case study of four sympatric arboreal marsupials. *Biological Conservation* 155, 68–76.

Youngentob KN, Wood JT & Lindenmayer DB (2013) The response of arboreal marsupials to landscape context over time: a large-scale fragmentation study revisited. *Journal of Biogeography* 40, 2082–2093. Available on the internet at: https://doi.org/10.1111/jbi.12158

Youngentob KN, Yoon H-J, Stein J, Lindenmayer DB & Held AA (2015) Where the wild things are: using remotely sensed forest productivity to assess arboreal marsupial species richness and abundance. *Diversity and Distributions* 21, 977–990.

Youngentob KN, Lindenmayer DB, Marsh KJ, Krockenberger AK & Foley WJ (2021) Food intake: an overlooked driver of climate change casualties? *Trends Ecol Evol* 36, 676–678.

Other sources cited in the advice

Armstrong KN (2021) Personal communication via email, 24 June 2021. University of Adelaide.

Atlas of Living Australia (2021). OZCAM records of *Petauroides*. Available at URL: http://ozcam.org.au/. Accessed 17 August 2021. https://doi.org/10.26197/ala.5d4b8ad1-7607-4f17-8193-861b8f5d05a3

Blake B (2020) Personal communication by email, 29 September 2020. Proconpest – Contractor for World Wide Fund for Nature (WWF).

Bluff L (2020) Personal communication by email, 15 September 2020. Acting Regional Manager; Natural Environment Programs, Gippsland; Forest, Fire and Regions. Department of Environment, Land, Water and Planning (Vic), Melbourne.

Canberra Nature Map (2019) Viewed: 21 October 2019. Available on the internet at: https://canberra.naturemapr.org/

Cobern C (2015) Personal communication by email, 9 November 2015. Landcare Coordinator, Upper Goulburn Landcare Network, Victoria.

DEHP (Department of Environment and Heritage Protection) (2015) *Submission on the eligibility of Petauroides volans (greater glider) to be categorised as Vulnerable on the EPBC Act threatened species list.* Received 25 November 2015. Department of Environment and Heritage Protection (Qld), Brisbane.

DELWP (Department of Environment, Land, Water and Planning) (2019) Personal communication by email, 15 October 2019. Department of Environment, Land, Water and Planning (Vic), Melbourne.

DELWP (Department of Environment, Land, Water and Planning) (2021) Personal communication by email, 22 April 2021. Department of Environment, Land, Water and Planning (Vic), Melbourne.

Eyre T (2021) Personal communication by email, 11 January 2021. Queensland Herbarium.

Gippsland Environment Group (2015) Personal communication by email, 24 November 2015.

Jones KE, Bielby J, Cardillo M, Fritz SA, O'Dell J, Orme CDL, Safi K, Sechrest W, Boakes EH, Carbone C, Connolly C, Cutts MJ, Foster JK, Grenyer R, Habib M, Plaster CA, Price SA, Rigby EA, Rist J, Teacher A, Bininda-Emonds ORP, Gittleman JL, Mace GM & Purvis A (2009) PanTHERIA: a species-level database of life history, ecology, and geography of extant and recently extinct mammals. *Ecology* 90, 2648.

Liepa D (2020) Personal communication via phone conversation, 10 September 2020. Greening Australia.

Moorrees A (2020) Personal communication via phone conversation, 14 September 2020. Department of Environment, Land, Water and Planning (Vic), Melbourne.

Nelson J (2021) Personal communication by email, 16 and 19 April 2021. Department of Environment, Land, Water and Planning (Vic), Melbourne.

Pacifici M, Santini L, Di Marco M, Baisero D, Francucci L, Grottolo Marasini G, Visconti P, Rondinini C (2013) Database on generation length of mammals. 5427 data records. Online at http://doi.org/10.5061/dryad.gd0m3, version 1.0 (last updated on 2013-08-27), Resource ID: 10.5061/dryad.gd0m3, Data Paper ID: doi: 10.3897/natureconservation.5.5734

Rickards P (2015) Personal communication by email, 24 November 2015. Owner of forested property in East Gippsland, Victoria.

Ridgeway P (2021) Personal communication by email, 6 January 2021. Senior land Services Officer (Biodiversity), Greater Sydney Local Land Services.

Smith J (2015) Personal communication by email, 22 November 2015. P&J Smith Ecological Consultants, New South Wales.

Smith J (2020) Personal communication by email, 10 December 2020. P&J Smith Ecological Consultants, New South Wales.

Smith P & J (2021) Personal communication by email, 24 June 2021. P&J Smith Ecological Consultants, New South Wales.

Stimson N (2021) Personal communication by email, 26 June 2021. Enviro Images, New South Wales.

Vic SAC (2015) *Submission on the EPBC Act assessment of the greater glider. Received 25 November 2015.* Victorian Scientific Advisory Committee. Department of Environment, Land, Water and Planning. State Government of Victoria, Melbourne.

VicForests (2021) *Submission on the consultation on species listing eligibility and conservation actions* – Petauroides volans *(greater glider (southern)).* Received 24 June 2021. Melbourne.

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

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

Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC.

Assessment of eligibility for listing

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

Key assessment parameters

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

Table 3 Key assessment parameters

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

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

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

Criterion 1 Population size reduction

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

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

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

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

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

Based on any of the following

(a) direct observation [except A3]

(b) an index of abundance appropriate to the taxon

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

(d) actual or potential levels of exploitation

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

Criterion 1 evidence

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

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

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

Prior to 2019-20 bushfires

Victoria

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

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

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

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

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

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

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

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

New South Wales and the Australian Capital Territory

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

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

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

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

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

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

Queensland

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

After the 2019-20 bushfires

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

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

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

Victoria

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

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

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

New South Wales

South Coast

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

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

Blue Mountains Region

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

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

Crookwell

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

Far North Coast

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

Queensland

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

Overall population decline

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

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

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

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

Conclusion

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

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

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

Criterion 2 evidence

Not eligible

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

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

Criterion 3 Population size and decline

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

Criterion 3 evidence

Not eligible

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

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

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

Criterion 4 Number of mature individuals

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

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

Criterion 4 evidence

Not eligible

Woinarski et al. (2014) estimate the population size to be greater than 100 000 mature individuals (see Criterion 3) and it is highly unlikely that the number of mature individuals is less than 1000. Additionally, the greater glider (southern and central) does not meet the quantitative threshold for Vulnerable under sub-criterion D2. The area of occupancy (AOO) is estimated to be 15 532 km^2 and the species occurs at more than five locations.

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

Criterion 5 Quantitative analysis

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

Criterion 5 evidence

Insufficient data to determine eligibility

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

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

Adequacy of survey

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

Public consultation

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

Listing and Recovery Plan Recommendations

The Threatened Species Scientific Committee recommends:

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

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

Cataloguing data

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

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

Department of Climate Change, Energy, the Environment and Water
GPO Box 858, Canberra ACT 2601
Telephone 1800 900 090
Web dcceew.gov.au

Version history table

Document type	Title	Date
Conservation Advice (including listing assessment	Conservation Advice for *Petauroides volans* (greater glider (southern and central))	Approved 05/07/2022
Conservation Advice (including listing assessment)	Conservation Advice for *Petauroides volans* (greater glider)	Approved 25/05/2016