The Minister approved this conservation advice on 02/05/2016 and included this species in the Vulnerable category, effective from 05/05/2016

Conservation Advice

Petauroides volans

greater glider

Note: The information contained in this Conservation Advice was primarily sourced from 'The Action Plan for Australian Mammals 2012' (Woinarski et al., 2014). Any substantive additions obtained during the consultation on the draft have been cited within the advice. Readers may note that Conservation Advices resulting from the Action Plan for Australian Mammals show minor differences in formatting relative to other Conservation Advices. These reflect the desire to efficiently prepare a large number of advices by adopting the presentation approach of the Action Plan for Australian Mammals, and do not reflect any difference in the evidence used to develop the recommendation.

Taxonomy

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

This is the only species in the genus. Two subspecies are conventionally recognised: *P. v. minor* (in north-eastern Queensland) and *P. v. volans* (in south-eastern Australia).

Summary of assessment

Conservation status

Vulnerable: Criterion 1 A2(b)(c), A3(b)(c), A4(b)(c)

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

Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of new information provided to the Committee to list *Petauroides volans.*

Public Consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 40 business days between 30 September 2015 and 25 November 2015. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

Species Information

Description

The greater glider is the largest gliding possum in Australia, with a head and body length of 35−46 cm and a long furry tail measuring 45−60 cm. The greater glider 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 large furry ears and a short snout. Its tail is not prehensile (McKay 2008; NSW Office of Environment and Heritage, n.d).

Distribution

The greater glider is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria (Wombat State Forest), with an elevational range from sea level to 1200 m above sea level. An isolated inland subpopulation occurs in the Gregory Range west of Townsville (Winter et al., 2004), and another in the Einasleigh Uplands (Vanderduys et al., 2012).

The broad extent of occurrence is unlikely to have changed appreciably since European settlement (van der Ree et al., 2004). However, the area of occupancy has decreased substantially mostly due to land clearing. This area is probably continuing to decline due to further clearing, fragmentation impacts, fire and some forestry activities. Kearney et al. (2010) predicted a 'stark' and 'dire' decline ('almost complete loss') for the northern subspecies *P. v. minor* if there is a 3^{o} C temperature increase.

Relevant Biology/Ecology

The greater glider is an arboreal nocturnal marsupial, largely restricted to eucalypt forests and woodlands. It is primarily folivorous, with a diet mostly comprising eucalypt leaves, and occasionally flowers (Kehl & Borsboom 1984; Kavanagh & Lambert 1990; van der Ree et al., 2004). It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows (Andrews et al., 1994; Smith et al., 1994, 1995; Kavanagh 2000; Eyre 2004; van der Ree et al., 2004; Vanderduys et al., 2012). The distribution may be patchy even in suitable habitat (Kavanagh 2000). The greater glider favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species (Kavanagh 1984).

During the day it shelters in tree hollows, with a particular selection for large hollows in large, old trees (Henry 1984; Kehl & Borsboom 1984; Lindenmayer et al., 1991; Smith et al., 2007; Goldingay 2012). In Grafton/Casino, Urbenville and the Urunga/Coffs Harbour Forestry Management Areas (FMAs) in northern New South Wales (NSW), the abundance of greater gliders on survey sites was significantly greater on sites with a higher abundance of tree hollows (Andrews et al., 1994; Smith et al., 1994, 1995). In the Grafton/Casino FMA, the greater glider was absent from surveyed sites with fewer than six tree hollows per hectare (Smith et al., 1994). In southern Queensland, greater gliders require at least 2−4 live den trees for every 2 ha of suitable forest habitat (Eyre 2002).

Home ranges are typically relatively small (1−4 ha: Henry 1984; Kehl & Borsboom 1984; Comport et al., 1996; Gibbons & Lindenmayer 2002; Pope et al., 2005), but are larger in lower productivity forests and more open woodlands (up to 16 ha: Eyre 2004; Smith et al., 2007). They are larger for males than for females (Kavanagh & Wheeler 2004; Pope et al., 2005), with male home ranges being largely non-overlapping (Henry 1984; Kavanagh & Wheeler 2004; Pope et al., 2005).

The greater glider is considered to be particularly sensitive to forest clearance (Tyndale-Biscoe & Smith 1969a) and to intensive logging (Kavanagh & Bamkin 1995; Kavanagh & Webb 1998; Kavanagh & Wheeler 2004; Kavanagh et al., 2005), although responses vary according to landscape context and the extent of tree removal and retention (Kavanagh 2000; Taylor et al., 2007). The greater glider is also sensitive to wildfire (Lunney 1987; Andrews et al., 1994; Lindenmayer et al., 2011), and is slow to recover following major disturbance (Kavanagh 2004). In the Urbenville FMA of northern NSW, the abundance of greater gliders on survey sites was significantly greater in forests that were infrequently burnt (Andrews et al., 1994).

Notwithstanding relatively small home ranges, but in part because of low dispersal ability, greater gilders may be sensitive to fragmentation (Eyre 2006; McCarthy & Lindenmayer 1999ab; Lindenmayer et al., 2000; Taylor & Goldingay 2009), have relatively low persistence in small forest fragments, and disperse poorly across vegetation that is not native forest. Modelling suggests that they require native forest patches of at least 160 km^2 to maintain viable

populations (Eyre 2002). Kavanagh & Webb (1989) found no significant movement of greater gliders into unlogged reserves from surrounding logged areas.

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 (Harris & Maloney 2010), so generation length is likely to be 7−8 years. The relatively low reproductive rate (Henry 1984) may render small isolated populations in small remnants prone to extinction (van der Ree 2004; Pope et al., 2005).

Threats

Threats to the greater glider are outlined in the table below (Woinarski et al., 2014). Cumulative effects of clearing and logging activities, current burning regimes and the impacts of climate change are a major threat to large hollow-bearing trees on which the species relies.

Threat factor	Consequence rating	Extent over which threat may operate	Evidence base
Habitat loss (through clearing, clearfell logging and the destruction of senescent trees due to prescribed burning) and fragmentation	Catastrophic	Moderate-large	The species is absent from cleared areas, and has little dispersal ability to move between fragments through cleared areas; low reproductive output and susceptibility to disturbance ensures low viability in small remnants. Roadside clearing in state forests have destroyed many hollow-bearing trees previously left on the perimeter of logging coupes (Gippsland Environment Group pers. comm., 2015).
Too intense or frequent fires	Severe	Large	Population loss or declines documented in and after high intensity fires (Lindenmayer et al., 2013).
Timber production	Severe	Moderate	Prime habitat coincides largely with areas suitable for logging; the species is highly dependent on forest connectivity and large mature trees. Glider populations could be maintained post-logging if 40% of the original tree basal area is left (Kavanagh 2000); logging in East Gippsland is significantly above this threshold (Smith 2010; Gaborov pers. comm., 2015). There is a progressive decline in numbers of hollow-bearing trees in production forests as logging rotations become shorter and as dead stags collapse (Ross 1999; Ball et al., 1999; Lindenmayer et al., 2011).

			The species occurs in many conservation reserves across its range. In NSW, 83% of the public forested lands (that lie within the Integrated Forestry Operations Approval regions) that coincide with the distribution of the greater glider are protected in formal or informal reserves (Slade & Law, in press). However, the fraction of protected areas is likely to be lowekr in Queensland and Victoria.
Climate change	Severe	Large (future threat)	Biophysical modelling indicates a severe range contraction for the northern subspecies (Kearney et al., 2010). Occupancy modelling indicates that the degree of site occupancy is associated with vegetation lushness and terrain wetness (Lumsden et al., 2013). Water stress affects growth in forest eucalypts (Matusick at al., 2013) and the availability of browse, and higher temperatures may cause heat stress and mortality (Vic SAC 2015).
Barbed wire fencing (entanglement)	Minor	Minor	There are occasional losses of individuals.
Hyper-predation by owls	Severe	Local	The greater glider forms a significant part of the powerful owl's diet (Bilney et al., 2006). Powerful owl numbers have increased greatly in the Blue Mountains since 1990 and have been recorded at many sites with greater gliders (Smith pers. comm., 2015). Reduction in the stand density of hollow-bearing trees could increase predation threat whilst the species is moving between hollows. Since the widespread decline of terrestrial species, the greater glider has become a significant part of the sooty owl's diet – increasing from 2% of its diet at pre-European settlement to 21% (Bilney et al., 2010). The greater glider has significantly declined or become locally extinct in some intact forest, possibly due to owl predation (Lindenmayer et al., 2011; Lumsden et al., 2013; Rickards pers. comm., 2015). At

			Boodoree National Park, the increase in large forest owls coincided with a reduction in foxes, which may have reduced competition for prey with the powerful owl and sooty owl (Lindenmayer et al., 2011).
Competition from sulphur-crested cockatoos	Minor-moderate	Local	Numbers of cockatoos in the Blue Mountains have increased significantly since 1990. They are likely to be competing with greater gliders for hollows and have been observed taking over nesting hollows of powerful owls (Smith pers. comm., 2015).
Phytophthora root fungus	Minor	Large	The fungus is known to impact on the health of eucalypts.

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

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

	Critically Endangered 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

Evidence:

Eligible under Criterion 1 A2(b)(c), A3(b)(c), A4(b)(c) for listing as Vulnerable

There are no robust estimates of population size or population trends of the greater glider across its total distribution. However, declines in numbers, occupancy rates and extent of habitat have been recorded at many sites, from which a total rate of decline can be inferred.

Victoria

The most comprehensive monitoring program for greater gliders is in the central highlands of Victoria, where 160 permanent 1 ha sites across a 1800 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 declined by an average of 8.8 percent per year (a rate that if extrapolated over the 22 year period relevant to this assessment is 87 percent) (Lindenmayer et al., 2011). Higher rates of decline were recorded in forests subject to logging than in conservation reserves, and declines were also associated with major bushfires and lower-than-average rainfall. More recent surveys undertaken by Lumsden et al. (2013, p. 3) stated: *'*A striking result from these surveys was the scarcity of the Greater Glider which was, until recently, common across the Central Highlands'.

Major bushfires in 2003, 2006−2007 and 2009 burnt much of the greater glider's range in the state, and further fragmented its distribution as evidenced by surveys and species records (Lumsden et al., 2013; Vic SAC 2015). Reoccupation of burnt sites in subsequent years is likely to be a slow process due to the small home ranges (1−2 ha) of the species and its limited dispersal capabilities (L. Lumsden pers. comm., cited in Vic SAC 2015). It also depends on there not being 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 in these areas have significantly declined (Cobern pers. comm., 2015). The occupancy model in Lumsden et al. (2013) predicts that areas most likely to be occupied following the 2009 fires are now patchily distributed.

Preliminary results of an occupancy survey in 2015 suggest low occupancy rates in three of four survey areas. Approximately 50 percent of the individual transects in this study incorporated sites of known previous occupancy by greater gliders based on systematic surveys in the 1990s (Gaborov pers. comm., 2015). Other evidence supports a decline in East Gippsland; 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 has been sighted in the 18 months leading up to November 2015 (Gippsland Environment Group pers. comm., 2015).

However, there is evidence of some declines in occupancy in unburnt sites in the same parts of Victoria (Lumsden et al., 2013), and also at Booderee National Park in NSW (Lindenmayer et al., 2011), suggesting that factors other than fire are involved in the species' decline (Vic SAC 2015). A decline in suitable browse due to water stress is likely to have been a contributing factor, as central Victoria was significantly hotter and drier than normal during 2001−2009 (Vic SAC 2015). Occupancy modelling by Lumsden et al. (2013) found that the degree of site occupancy is associated with site ruggedness, vegetation lushness and terrain wetness.

<u>New South Wales and the ACT</u>

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, from greater glider presence in 22 of the sites in 2002 to absence from all sites since 2007. In the Blue Mountains, declines have been recorded at Murphy's Glen; spotlighting undertaken between 1986 and 2014 shows that the species used to be consistently and regularly detected, but by 2010 were difficult to detect and no longer present (Smith pers. comm., 2015). However, spotlighting undertaken in 2015 recorded greater gliders on each of the three occasions (1, 2 and 5 individuals), so numbers may be recovering at Murphy's Glen (Smith pers. comm., 2015). Anecdotal reports, including from local ecologists, indicated similar declines elsewhere in the lower Blue Mountains, and the NSW Bionet Atlas confirms a marked drop in records in the region (Blue Mountains National Park: 357 records 1990−2004, 8 records 2004−2014. Blue Mountains LGA: 142 records 1990−2004, 1 record 2004−2014) (Smith pers. comm., 2015).

An isolated population at Royal National Park has been lost due to fire and regional-scale decline in the Illawarra area (Maloney 2007). Following the 1994 wildfire, which burnt more than 90 percent of the park, the first confirmed sighting of a greater glider in Royal National Park was

in 2012 (Andrew et al., 2014) despite a number of surveys and searches conducted since the fire. Kavanagh and Webb (1998) monitored greater gliders in 500 ha of wood production forest near Bombala in southern NSW, and found that the population declined in all logging compartments and had not recovered eight years after harvesting.

Queensland

In central Queensland, the abundance of greater gliders 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 (Qld DEHP 2015) and evidence of a decline in large, hollow-bearing trees due to past logging activities and repeated prescribed burning (Eyre 2005; Eyre et al., 2010). 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).

Conclusions

There is little other published information on population trends over the period relevant to this assessment (around 22 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 22 year (three generation) period (Woinarski et al., 2014), and indeed may far exceed 30 percent. The population of the greater glider is 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).

The Committee considers that the species has undergone a substantial reduction in numbers over three generation lengths (22 years for this assessment), equivalent to at least 30 percent and the reduction has not ceased, the cause has not ceased and is not understood. Therefore, the species has been demonstrated to have met the relevant elements of Criterion 1 to make it eligible for listing as Vulnerable.

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

Evidence:

Not eligible

The extent of occurrence is estimated at 1 586 870 km^2, and the area of occupancy estimated at 16 164 km^2. These figures are based on the mapping of point records from 1995 to 2015,

obtained from state governments, museums and CSIRO. The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014 (DotE 2015). Woinarski et al. (2014) noted that the AOO, which they estimated to be 15 960 km^2, is likely to be a significant under-estimate due to limited sampling across the occupied range.

Following assessment of the data the Committee has determined that the geographic distribution is not very restricted, restricted or limited. Therefore, the species has not met this required element of this criterion.

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

Evidence:

Not eligible

There is no reliable estimate of population size. Lunney et al. (2008) considered that the greater glider had a 'presumed large population' and was 'locally common'. Winter et al. (2004) noted that it was 'common' in the north Queensland portion of its range. In NSW, Kavanagh (2004) considered it 'widespread and common … particularly in north-eastern New South Wales'. Density estimates in Victoria range from 0.6 to 2.8 individuals per hectare (Henry 1984; van der Ree et al., 2004), and across its broader distribution density ranges from 0.01 to 5 individuals per hectare (Kavanagh 1984; Kehl & Borsboom 1984; Maloney 2007). In southern Queensland, trees with hollows are extremely limited in some extensive forest types that have been historically used for timber production, and this in turn limits greater glider distribution and abundance (Eyre 2006). Woinarski et al. (2014) estimate the number of mature individuals to be greater than 100 000.

The Committee considers that the total number of mature individuals is not limited, low or very low. Therefore, the species has not met this required element of this criterion.

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

Evidence:

Not eligible

Woinarski et al. (2014) estimate the population size to be greater than 100 000 mature individuals (see Criterion 3).

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

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

Evidence:

Not eligible

Several local-level population viability analyses have been undertaken (Taylor & Goldingay 2009), but none for the full species (Woinarski et al., 2014). Therefore, the species has not met this required element of this criterion.

Conservation Actions

Recovery Plan

The Committee recommends that there should be a recovery plan for *Petauroides volans* (greater glider). Stopping decline and supporting recovery is complex, due to the requirement for a high level of planning to abate the theats, 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.

Primary Conservation Actions

1. Reduce the frequency and intensity of prescribed burns.
2. Identify appropriate levels of patch retention, habitat tree retention, and logging rotation in hardwood production.
3. Protect and retain hollow-bearing trees, suitable habitat and habitat connectivity.

Conservation and Management Actions

The greater glider is currently not listed as threatened under any state legislation, except for two populations in NSW (the Mount Gibraltar Reserve Area, and Eurobodalla Local Government Area) that are listed as Endangered. The species occurs in many conservation reserves across its extensive range. In production forests some logging prescriptions have been imposed to reduce impacts upon this species, however these are not adequate to ensure its recovery.

In Victoria, logging of areas where greater gliders occur in densities of greater than two per hectare, or greater than 15 per hour of spotlighting, require a 100 ha special protection zone (Vic DNRE1995). However, this threshold is quite high given that density estimates in Victoria range from 0.6 to 2.8 individuals per hectare (Henry 1984; van der Ree et al., 2004), and mature tree densities are declining meaning a lower probability that gliders will occur at higher densities (Gaborov pers. comm., 2015). This management requirement may therefore not adequately protect existing habitat and greater glider populations.

In New South Wales, conservation projects are being developed for the two greater glider populations listed as Endangered under state legislation. In addition, logging of areas where greater gliders occur in densities of greater than one per hectare require eight hollow-bearing trees to be retained per hectare (Terms of Licence). However, such tree-retention measures are typically not species-specific, and do not consider factors which influence the occupancy of hollows and their suitability for different fauna species (Gibbons & Lindenmayer 2002), including intra-specific or inter-specific competition for hollows and changes in predation by owls related to changes in forest structure.

In Queensland, there are no species-specific management actions currently in place for the greater glider. Under previous Native Forest Codes of Practice there were some specific recommendations to retain habitat trees particularly for the greater glider, however these are no longer implemented (Qld DEHP 2015).

Recommended management actions are outlined in the table below (Woinarski et al., 2014).

Theme	Specific actions	Priority
Active mitigation of threats	Reduce the frequency and intensity of prescribed burns.	High
	Constrain impacts of hardwood production through appropriate levels of patch and hollow-bearing tree retention, appropriate rotation cycles, and retention of wildlife corridors between patches.	High
	Constrain clearing in forests with significant subpopulations, to retain hollow-bearing trees and suitable habitat.	High
	Avoid fragmentation and habitat loss due to development and upgrades of transport corridors.	High
	Restore connectivity to fragmented populations.	Medium
Captive breeding	N/a	
Quarantining isolated populations	N/a	
Translocation	Reintroduce individuals to re-establish populations at suitable sites.	Low
Community engagement	Develop conservation covenants on lands with high value for this species.	Low

Survey and monitoring priorities

Theme	Specific actions	Priority
Survey to better define distribution and abundance	Assess population size (or relative abundance) and viability of populations across the species' range, using standardised and repeatable methodology.	Low
	Determine the distribution and abundance in relation to forest vegetation class, age class, and amount of old growth forest in the landscape to understand the pattern of occurrence.	Medium
Establish or enhance	From existing monitoring projects, design an	High

monitoring program	integrated monitoring program across major subpopulations, linked to the assessment of management effectiveness.	
	Monitor the abundance and size structure of critical habitat tree species, and their responses to management including before and after prescribed burns, and before and after logging.	High
	Continue to model impacts of wildfire and logging on population viability.	Medium
	Monitor the incidence of wildfire within the species' range.	Medium

Information and research priorities

Theme	Specific actions	Priority
Assess relative impacts of threats	Assess the impacts of a range of possible fire regimes on the species.	Medium-high
	Assess the impacts of ongoing habitat fragmentation (e.g. through peri-urban expansion, coal seam gas mining activities, road networks).	Medium
	Investigate the potential causes of recent declines, including cumulative impacts and impacts of owl predation.	Medium
Assess relative effectiveness of threat mitigation options	Assess the impacts of fire management (prescribed burning programs) on habitat, hollow availability, preferred tree species, and glider population size.	High
	Assess responses to habitat re-connections (e.g. rope ladder crossings over transport corridors).	Medium
	Continue to assess and monitor the species' responses to logging regulations and conditions.	Medium
	Investigate the practicality of supplementing hollow availability with artificial hollows.	Low-medium
Resolve taxonomic uncertainties	Assess the extent of genetic variation and exchange between subpopulations.	Low
	Review taxonomic status.	Low
Assess habitat requirements	Investigate the numbers, densities and types of hollow-bearing trees that must be retained to ensure viable populations.	High
Assess diet, life history	N/a	

Recommendations

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

Petauroides volans

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

Threatened Species Scientific Committee

2/3/2016

References cited in the advice

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, S. P., Gration, G., Quin, D., & Smith, A. P. (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.

Ball, I.R., Possingham, H.P., & Lindenmayer, D.B. (1999). A tree hollodynamics simulation model. *Forest Ecology and Management 123*, 179-194.

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.

Comport, S. S., Ward, S. J., & Foley, W. J. (1996). Home ranges, time budgets and food tree use in a high density tropical population of greater gliders, *Petauroides volans minor* (Pseudocheiridae: Marsupialia). *Wildlife Research 23*, 401-419.

Department of the Environment (DotE) (2015). Area of Occupancy and Extent of Occurrence for *Petauroides volans*. Unpublished report, Australian Government Department of the Environment, Canberra.

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

Eyre, T. J. (2004). Distribution and conservation status of the possums and gliders of southern Queensland. In *The Biology of Australian Possums and Gliders* (eds R. L. Goldingay & S. M. Jackson), pp. 1-25. Surrey Beatty & Sons, Chipping Norton.

Eyre, T. J. (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, T. J. (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, T.J., Butler, D.W., Kelly, A.L., & 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(3)*, 534-546.

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

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

Harris, J. M., & Maloney, S. (2010). *Petauroides volans* (Diprodontia: Pseudocheiridae). *Mammalian Species 42*, 207-219.

Henry, S. R. (1984). Social organisation of the greater glider (*Petauroides volans*) in Victoria. In *Possums and Gliders* (eds A. P. Smith & I. D. Hume), pp. 221-228. Surrey Beatty and Sons, Chipping Norton.

Jackson, S. M., & Thorington, R. W. Jr. (2012). *Gliding mammals: taxonomy of living and extinct species*. Smithsonian Institution Scholarly Press, Washington.

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

Kavanagh, R. P. (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, R. P. (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, R. P. (2004). Distribution and conservation status of possums and gliders in New South Wales. In *The Biology of Australian Possums and Gliders* (eds R. L. Goldingay & S. M. Jackson), pp. 130-148. Surrey Beatty and Sons, Chipping Norton.

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

Kavanagh, R.P. & Webb, G.A. (1989). Silvicultural Options for the Management of Wildlife Habitats in Southeast New South Wales. Unpublished report.

Kavanagh, R.P., & Webb, G.A. (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, R. P., & Wheeler, R. J. (2004). Home range of the greater glider *Petauroides volans* in tall montane forest of southeastern New South Wales, and changes following logging. In *The Biology of Australian Possums and Gliders* (eds R. L. Goldingay & S. M. Jackson), pp. 413-425. Surrey Beatty and Sons, Sydney.

Kavanagh, R.P., 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.

Kearney, M. R., Wintle, B. A., & Porter, W. P. (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 *Possums and Gliders* (eds. A. P. Smith & I. D. Hume), pp. 229-236. Surrey Beatty and Sons, Chipping Norton.

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

Lindenmayer, D. B., Cunningham, R. B., Tanton, M. T., Smith, A. P., & Nix, H. A. (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, D. B., Lacy, R. C. & Pope, M. L. (2000). Testing a simulation model for population viability analysis. *Ecological Applications 10*, 580–597.

Lindenmayer, D. B., Wood, J. T., McBurney, L., MacGregor, C., Youngentob, K. & Banks, S. C. (2011). How to make a common species rare: a case against conservation complacency. *Biological Conservation 144*, 1663-1672.

Lindenmayer, D.B., Blanchard, W., McBurney, L., Blair, D., Driscoll, D., Smith, A.L. & Gill, A.M. (2013) Fire severity and landscape context effects on arboreal marsupials. *Biological Conservation 167*, 137-148.

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

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., 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.

Maloney, K. S. (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, K.K., Brouwers, N.C., Dell, B. & Hardy, G.E.StJ. (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(3)*, 497-510.

Maxwell, S., Burbidge, A. A., & Morris, K. (1996). *The 1996 Action Plan for Australian Marsupials and Monotremes*. Wildlife Australia, Canberra.

McCarthy, M. A., & Lindenmayer, D. B. (1999a). Conservation of the greater glider (*Petauroides volans*) in remnant native vegetation within exotic plantation forest. *Animal Conservation 2*, 203-209.

McCarthy, M. A., & Lindenmayer, D. B. (1999b). Incorporating metapopulations dynamics of greater gliders into reserve design in disturbed landscapes. *Ecology 80*, 651-667.

McKay, G. M. (2008). Greater Glider *Petauroides volans*. In *The Mammals of Australia*. Third edition. (Eds S. Van Dyck & R. Strahan), pp. 240-242. Reed New Holland, Sydney.

NSW Office of Environment and Heritage. Greater Glider population in the Eurobodalla local government area - profile. Viewed: 23 February 2015. Available on the Internet at: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20056

Pope, M. L., Lindenmayer, D. B., & Cunningham, R. B. (2005). Patch use by the greater glider (*Petauroides volans*) in a fragmented forest ecosystem. I. Home range size and movements. *Wildlife Research 31*, 559-568.

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.

Slade, C. & Law, B. (2016). The other half of the coastal State Forest estate in New South Wales; the value of informal forest reserves for conservation*. Australian Zoologist (in press).*

Smith, A. P., Moore, D. M., & Andrews, S. P. (1994). 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, A. P., Andrews, S. P, Gration, G., Quin, D, & Sullivan, B. (1994). 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, G. C., 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, A, (2010). *Effects of proposed logging on populations of the Greater Glider* (Petauroides volans) *and Yellow-bellied Glider* (Petaurus australis) *in Four Coupes at Brown Mountain, East Gippsland, Victoria.* Report to the Supreme Court of Victoria Proceedings No. 8547 of 2009.

Smith G.C., 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.

Taylor, A. C., Tyndale-Biscoe, C. H. & Lindenmayer. D. B. (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, B. D., & Goldingay, R. L. (2009). Can road-crossing structures improve population viability of an urban gliding mammal? *Ecology and Society 14(2),* 13. [online].

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

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

Vanderduys, E. P., Kutt, A. S., & Kemp, J. E. (2012). Upland savannas: the vertebrate fauna of largely unknown but significant habitat in north-eastern Queensland. *Australian Zoologist 36*, 59-74.

van der Ree, R., Ward, S. J., & Handasyde, K. A. (2004). Distribution and conservation status of possums and gliders in Victoria. In *The Biology of Australian Possums and Gliders* (eds R. L. Goldingay & S. M. Jackson), pp. 91-110. Surrey Beatty and Sons, Sydney.

Vic Department of Natural Resources and Environment (Vic DNRE) (1995). *East Gippsland – Forest Management Plan.* Melbourne.

Winter, J. W., Dillewaard, H. A., Williams, S. E., & Bolitho, E. E. (2004). Possums and gliders of north Queensland: distribution and conservation status. In *The Biology of Australian Possums and Gliders* (eds R. L. Goldingay & S. M. Jackson.), pp. 26-50. Surrey Beatty and Sons, Sydney.

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

Woinarski, J. C. Z., McCosker, J. C., 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.

Other sources cited in the advice

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

Gaborov, R. (2015). Personal communication by email, 25 November 2015. Ecologist, Victoria.

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

Queensland Department of Environment and Heritage Protection (Qld DEHP) (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. Brisbane.

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

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

Terms of licence under the Threatened Species Conservation Act 1995 – Lower North East region. Available on the internet at: https://www.epa.nsw.gov.au/resources/forestagreements/terms-lower-north-east.pdf

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