



Conservation Advice for *Petauroides minor* (greater glider (northern))

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

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



Greater glider (northern) © Copyright, Carly Starr (from The Bluff State Forest, Tumoulin N Qld)

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 minor (northern) was assessed by the Threatened Species Scientific Committee to be eligible for listing as Vulnerable 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: A2c+3c+4c: Vulnerable
- Criterion 2: B2ab(i,ii,iii,iv,v): Vulnerable
- Criterion 3: Not eligible
- Criterion 4: Not eligible
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing in the Vulnerable category are population reduction, limited area of occupancy, and continuing decline in the area and quality of habitat primarily due to climate change.

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 the Queensland (Qld) *Nature Conservation Act 1992* is Vulnerable since October 2014. *Petauroides minor* (greater glider (northern)) and *Petauroides volans* (greater glider (southern)) are both included in the listing.

Species information

Taxonomy

Conventionally accepted as *Petauroides minor* Collett (1887).

Formerly, *Petauroides volans* was 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 Victoria (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* (K.N. Armstrong 2021. pers comm 24 June).

Therefore, the listed entity in this Conservation Advice is referred to as *Petauroides minor* (greater glider (northern)), while the common name greater glider refers to the genus *Petauroides*.

Description

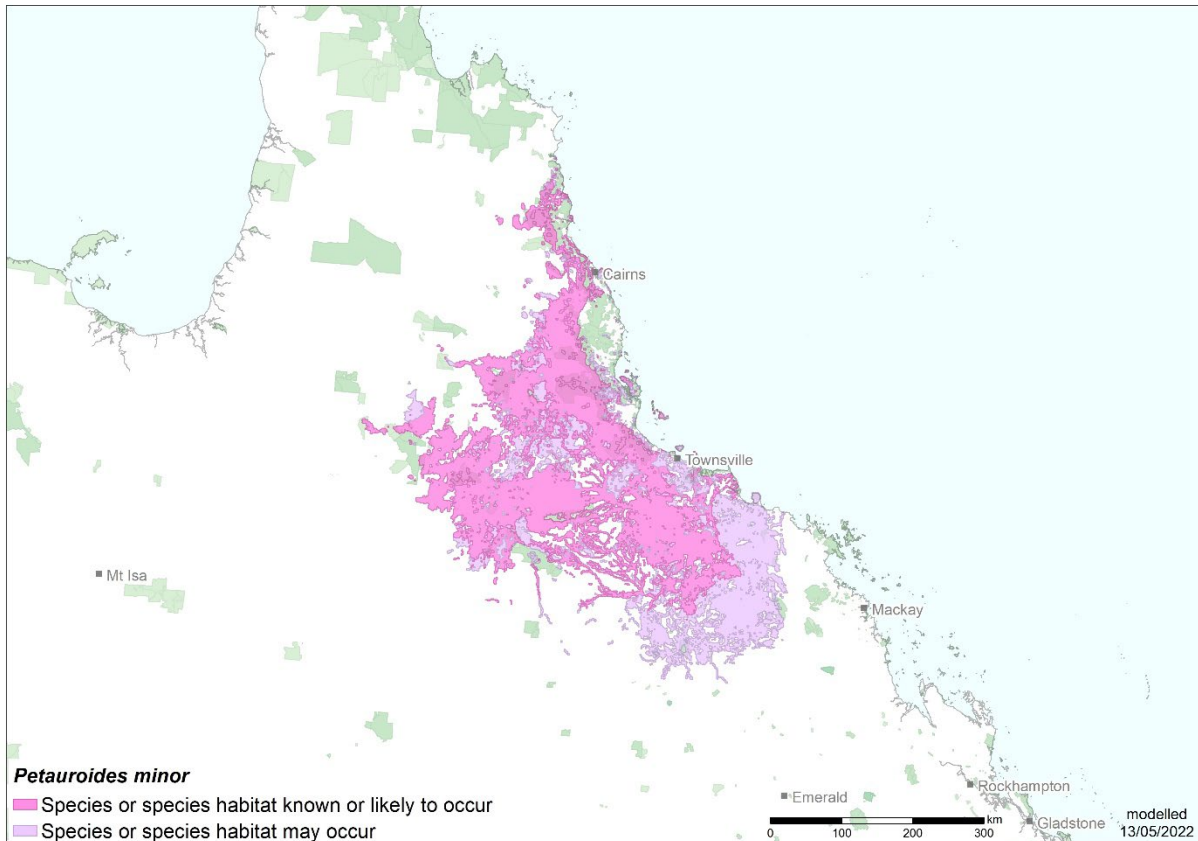
The greater glider (northern) is the largest gliding possum in north-eastern Australia. It has a head and body length of 32–40 cm, tail length of 40–48 cm, and a weight range of 650–1100 g, with females being larger than males (McKay 1989, 2008; McGregor et al. 2020). The greater glider (northern) has thick fur that increases its apparent size. Its fur colour is dusky brown above, often with a darker mid-dorsal stripe, and whitish below. It has a more slender body, with shorter ears and tail, than the greater glider (southern and central) (Comport et al. 1996). Its tail is not prehensile, and the gliding membrane extends from the forearm to the tibia (McKay 1989, 2008).

Distribution

The greater glider (northern) occurs in the wet-dry tropical region of north-eastern Australia, including the Wet Tropics World Heritage Area. It is distributed from around Townsville northwards to the Windsor Tablelands (McGregor et al. 2020; B Arbogast & KN Armstrong et al. unpublished data; OZCAM records: Atlas of Living Australia 2021). This distribution is very patchy with some isolated subpopulations, for example in the Gregory Range/Gilbert Plateau west of Townsville (Winter et al. 2004) and Blackbraes National Park (Vanderduys et al. 2012).

The broad extent of occurrence (EOO) is unlikely to have changed appreciably since European settlement (Woinarski et al. 2014). 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 (Woinarski et al. 2014). Kearney et al. (2010) predicted a 'stark' and 'dire' decline of suitable habitat ('almost complete loss' ~ 90 percent) for the greater glider (northern) if there is a 3 °C temperature increase.

Map 1 Modelled distribution of greater glider (northern)



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 (northern) is poorly known. However, the habitats and area in which the greater glider (northern) are found have a long and profound history of management by Indigenous Australians.

Relevant biology and ecology

General habitat

The greater glider (northern) is an arboreal nocturnal marsupial, predominantly solitary and largely restricted to eucalypt forests and woodlands of north-eastern Australia. It is typically found in highest abundance on high elevation, wetter sites in open woodland to open forests, containing relatively old trees and abundant hollows (Eyre 2004; Vanderduys et al. 2012). 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 (northern) shelters in tree hollows, with a particular preference for large hollows (diameter >10 cm) in large, old trees (Kehl & Borsboom 1984; Smith et al. 2007; Goldingay 2012). Comport et al. (1996) reported that *Eucalyptus acmenoides* (white mahogany) and *Corymbia citriodora* (lemon-scented gum) were the favoured denning trees for the greater glider (northern), and the species utilised 4–6 dens per month. In the north of its range *E. tereticornis* (forest red gum) is favoured for denning, and two dens per hectare are utilised (Starr et al. 2021).

Diet

It is primarily folivorous, with a distinct preference for young foliage (Comport et al. 1996), supplemented by buds and flowers. It feeds from a restricted range of eucalypt species, and favours forests with a diversity of eucalypt species due to seasonal variation in its preferred tree species (Comport et al. 1996). The tree species favoured by greater gliders varies regionally. Approximately 85% 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

The greater glider's (northern) life history is assumed to be similar to the greater glider's (southern and central), where 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 (Pacifi et al. 2013; Woinarski et al. 2014). The relatively low reproductive rate (Henry 1984) may render small subpopulations in isolated remnants prone to extinction (van der Ree 2004; Pope et al. 2004).

Home ranges and densities

Home ranges are typically relatively small and are larger for males (2.5 ha) than for females (1.3 ha), with male home ranges being overlapping with other males and females (Comport et al. 1996), indicating a polygamous mating system. Starr et al. (2021) reported that the greater glider (northern) has a home range of about 1–12 ha, with home ranges also overlapping.

The density of the greater glider (northern) has been reported as 3.3–3.8 ha⁻¹ for Taravale Station north-west of Townsville (Comport et al. 1996), 2.6–5.8 ha⁻¹ for Blackbraes National Park (Vanderduys et al. 2012), and recently in the north of its range (the Bluff State Forest) as 0.24 to 0.38 individuals per hectare in wet and dry sclerophyll forest respectively (Starr et al. 2021). Vanderduys et al. (2012) reported the greater glider (northern) at high densities from two land

zones in the Einasleigh Uplands, which were described as 1) *E. crebra* (narrow-leaved ironbark) and/or *Eucalyptus* spp. and/or *Corymbia* spp. open woodland to open forest on gently undulating sandplain plateaus; and 2) *Eucalyptus* spp., lemon-scented gum and white mahogany open forest on high plateaus on earths and sands.

Disturbance ecology

While there is very little available information regarding the effect of disturbance on the greater glider (northern), its similar ecology and biology means its responses to disturbance can be expected to be very similar to the greater glider (southern and central). The greater glider (southern and central) is particularly sensitive to forest clearance (Tyndale-Biscoe & Smith 1969a) and to intensive logging (Kavanagh & Bamkin 1995; Kavanagh & Webb 1998; Kavanagh & Wheeler 2004; Mclean et al. 2018; Starr et al. 2021). Responses vary according to landscape context and the intensity of disturbance (Kavanagh 2000; Taylor et al. 2007). Greater glider populations are slow to recover following major fires (Kavanagh 2004) due to the low reproductive rate of the species and its limited dispersal capabilities. Substantial losses or declines of greater glider populations have been documented after fires, through direct mortality and indirect impacts on habitat (McLean et al. 2018).

The greater glider (northern) is likely sensitive to fragmentation, similarly to the greater glider (southern and central) (McCarthy & Lindenmayer 1999a,b; Lindenmayer et al. 2000; Eyre 2006; Taylor & Goldingay 2009) which has relatively low persistence in small forest fragments, and disperses poorly across vegetation that is not native forest (Pope et al. 2004).

Habitat critical to the survival

Habitat critical to survival for the greater glider (northern) 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 trees¹ 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 diameter at breast height > 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 (northern), 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 (northern) may still represent habitat critical to survival, if the recruitment of hollow-bearing

trees in the future 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.

The number and locations of populations and metapopulations of the greater glider (northern) across its distribution have not been determined. However, an important population may be defined as a population that occurs:

- in a defined geographical area containing habitat critical to survival; or
- in areas where the species persists in relatively higher density or abundance at a regional level; or
- where its habitat provides refugia in times of stress or from threatening processes (particularly where other nearby populations have substantially declined or may be expected to do so in the future); or
- populations that are isolated or occur at the margins of the species' range, that may be important for maintaining genetic diversity and evolutionary adaptation.

There are two known isolated populations, one in the Gregory Range/Gilbert Plateau west of Townsville, and one in the Einasleigh uplands (Winter et al. 2004; Vanderduys et al. 2012). These isolated populations should be considered to be important populations.

Threats

Key threats to the greater glider (northern) are 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 (Woinarski et al. 2014), and the impacts of climate change will place increased pressure on its remaining habitat.

Table 1 Threats impacting the greater glider (northern)

Threat	Status and severity ^a	Evidence
Climate Change		
Increased temperatures and changes to rainfall patterns	<ul style="list-style-type: none"> • Timing: current and future • Confidence: inferred • Consequence: catastrophic • Trend: increasing • Extent: across the entire range 	<p>The greater glider’s unique physiology and a strict eucalypt diet make it 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.</p> <p>Climate change projections show that the Wet Tropics and monsoonal north-east of Australia will experience increases in average and maximum temperatures, frequency of hot days, the duration of warm spells, and intensity of extreme rainfall events (McInnes et al. 2015; Moise et al. 2015). Biophysical modelling predicts a severe and dire range contraction (~90%) for the greater glider (northern), under a 3 °C temperature increase (Kearney et al. 2010).</p> <p>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). While changes in the amount of rainfall in the distribution of the greater glider (northern) are uncertain under future climate change projections (McInnes et al. 2015; Moise et al. 2015), a warmer climate is likely to impact food availability for greater gliders and could be expected to reduce reproduction rate and population size (DeGabriel et al. 2009; Kearney et al. 2010). At high temperatures greater gliders 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). Above temperatures of 35°C, greater gliders need to dissipate >100% of metabolic heat production by evaporative means (Rübasamen 1984). 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).</p> <p>There are limited documented responses of the greater glider (northern) to increased temperatures and changes to rainfall patterns. However, responses are likely to be similar to that of the greater glider (southern and central), for which the following has been documented: higher night-time temperatures were attributed to be the cause of population declines at lower altitude (<500 m) surveyed sites in the Blue Mountains (Smith & Smith 2018, 2020); increased night-time temperatures have been implicated in the declines of some Victorian subpopulations (Wagner et al. 2020).</p>

Threat	Status and severity ^a	Evidence
Habitat disturbance and modification		
Habitat clearing and fragmentation	<ul style="list-style-type: none"> • Timing: current and future • Confidence: observed • Consequence: catastrophic • Trend: unknown • Extent: across parts of the range 	<p>Much of the woodland and open forest habitat in the greater glider's (northern) range has been cleared, primarily due to development, agriculture and timber production (Woinarski et al. 2014). Extensive clearing and habitat degradation is continuing (Woinarski et al. 2014). The greater glider (northern) is absent from cleared areas and has little dispersal ability to move through cleared areas between fragments (Comport et al. 1996).</p> <p>Fragmentation effects are likely exacerbated by inappropriate fire regimes.</p>
Timber harvesting	<ul style="list-style-type: none"> • Timing: current and future • Confidence: observed • Consequence: major • Trend: unknown • Extent: across parts of the range 	<p>Timber harvesting occurs in some habitat in the species' range (Woinarski et al. 2014). The greater glider (northern) is highly dependent on forest connectivity and large mature trees, and impacts are similar to the greater glider (southern and central). Fire-logging interactions likely increase risks to greater glider populations.</p>
Inappropriate fire regimes	<ul style="list-style-type: none"> • Timing: current and future • Confidence: inferred • Consequence: moderate • Trend: unknown • Extent: across parts of the range 	<p>Responses to fire have not been documented for this species. However, its responses to fire are likely to be similar to the greater glider (southern and central).</p> <p>No known bushfire events have substantially impacted the greater glider (northern). The species was only minimally impacted by the unprecedented 2019-20 bushfires in south-eastern Australia, which overlapped an estimated 0.1% of the species' distribution (Legge et al. 2021).</p> <p>However, it is possible that bushfires could become a greater threat to the species in the future due to climate change. Altered weather conditions are leading to higher frequency and intensity of bushfires (CSIRO 2020). Although there are limited documented responses of the greater glider (northern) to increased frequency and intensity of bushfires, its response is likely to be similar to that of the greater glider (southern), for which substantial population losses or declines have been documented in and after high intensity fires (Lindenmayer et al. 2013; Berry et al. 2015; McLean et al. 2018).</p> <p>Conversely, vegetation change is occurring in some parts of its range due to reduced fire frequency and intensity, which has resulted in rainforest encroachment on wet sclerophyll forest (Harrington & Sanderson 1994; Winter et al. 2004). Sclerophyll trees are unable to regenerate in shade and usually require fire to provide the appropriate conditions (Harrington & Sanderson 1994). This altered vegetation structure and floristics may reduce habitat suitability for the greater glider (northern), including the availability of hollows and food trees (Winter et al. 2004).</p>
Barbed wire fencing (entanglement)	<ul style="list-style-type: none"> • Timing: current and future • Confidence: observed • Consequence: minor • Trend: unknown • Extent: across the entire range 	<p>There are occasional losses of individuals due to entanglement in barbed wire fences across the greater glider's range (van der Ree 1999).</p>

Threat	Status and severity ^a	Evidence
Introduced species		
Predation by feral cats (<i>Felis catus</i>)	<ul style="list-style-type: none"> • Status: current and future • Confidence: observed • Consequence: minor • Trend: unknown • Extent: across parts of the 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.

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 (northern) risk matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain	Low risk	Moderate risk	Very high risk	Very high risk Timber harvesting	Very high risk Increased temperatures and changes to rainfall patterns Habitat clearing and fragmentation
Likely	Low risk	Moderate risk	High risk	Very high risk	Very high risk
Possible	Low risk	Moderate risk	High risk Inappropriate fire regimes	Very high risk	Very high risk
Unlikely	Low risk	Low risk Barbed wire fencing (entanglement) Predation by feral cats	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 outcome

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

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 existing habitat in order to facilitate movement.

- Where feasible, undertake habitat restoration/enhancement to improve micro-climate conditions in areas at high risk of extreme temperatures and drought.
- Ensure that eucalypt forests and the impacts of disturbance 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 (northern) continue to be the dominant canopy trees.

Habitat loss, disturbance and modification (including fire)

- Protect and maintain sufficient areas of suitable habitat, including denning and foraging resources and habitat connectivity, to sustain viable populations throughout the species' range.
- 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.
- 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. Incorporate avoidance and protection measures for the species into 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 subpopulations of the greater glider (northern). 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. Timber harvesting in climate or post-fire refuges should be avoided.

- 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, 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.

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

- Where threats from introduced predators (including the 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 feral cat, as detailed in the relevant Threat Abatement Plan.

Stakeholder engagement/community engagement

- Seek stakeholder input into assessment and planning processes that include protections for the greater glider (northern) 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 create guidelines for on-ground management of the greater glider (northern).
- 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.

- Encourage landholders to enter land management agreements, particularly in-perpetuity covenants, that promote the protection and maintenance of 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 (individual and compounding) threats, and
 - evaluate the relative benefits and effectiveness of management actions.
- Following disturbance events such as bushfires, heatwaves or drought, conduct on-ground surveys to establish habitat and population impacts as a result of the event and to provide a baseline for future population monitoring. Leverage post-disturbance monitoring at sites where surveys were undertaken prior to the event, to assess population trends.
- Monitor the incidence and impacts of fire and timber harvesting in the species' range.
- 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.
- Undertake surveys on high priority timber harvesting coupes, 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.
- Improve understanding of actions that can be undertaken to improve rates of survival and recovery in climate-affected populations.
- Identify areas likely to be climate refuges for greater glider under robust scenarios of climate change.
- 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 population size 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).
- Improve understanding of the species' diet and life history, especially in areas where populations have declined. Determine the likely effects of increased temperatures and drought on food supply, behaviour and survival.
- Identify priority isolated subpopulations for conservation (for example Gregory Range/Gilbert Plateau).

Recovery plan

The Committee recommends that there should be a recovery plan for *Petauroides minor* (greater glider (northern)). Stopping decline and supporting recovery is complex, due to the requirement for a high level of planning to abate the threats, knowledge gaps relating to addressing climate change as a key threat, a highly adaptive management process and a high level of support by key stakeholders. Existing mechanisms are not adequate to address these needs.

Links to relevant implementation documents

[Threat abatement plan for predation by feral cats 2015](#)

Conservation Advice and Listing Assessment references

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THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the *Environment Protection and Biodiversity Conservation Act 1999*

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

Attachment A: Listing Assessment for *Petauroides minor* (greater glider (northern))

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	unknown	>10 000	> 30 000	The maximum plausible value of >30 000 individuals was estimated by Woinarski et al. (2014) for the northern subspecies <i>P. v. minor</i> as part of the Action Plan for Australian Mammals. Although this estimate has low reliability, it is unlikely that there are fewer than 10 000 mature individuals.
Trend	contracting			
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 (Pacifci et al. 2013; Woinarski et al. 2014).
Extent of occurrence	48 946 km ²	43 655 km ²	48 946 km ²	Woinarski et al. (2014) estimated the extent of occurrence (EOO) as 43 655 km ² , calculated using records from 1993 to 2012. The 48 946 km ² figure was based on the mapping of point records from 1997 to 2017, 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.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	contracting			Woinarski et al. (2014) considered that the broad extent of occurrence (EOO) is unlikely to have changed appreciably since European settlement. However, the species is predicted to undergo a severe range contraction due to increased temperatures as a result of climate change (Kearney et al. 2010).
Area of Occupancy	524 km ²	500 km ²	<2000 km ²	The 524 km ² figure is based on the mapping of point records over 1997–2017, 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 underestimated due to limited sampling across the species range (Woinarski et al. 2014). It is not possible to determine an upper plausible estimate to adjust for the under sampling, but given the expected range contraction due to climate change (Kearney et al. 2010), the maximum plausible value is likely to be <2000 km ² .
Trend	contracting			The AOO has declined since European settlement, with loss of habitat from land clearing, fragmentation, timber harvesting, inappropriate fire regimes and climate change (Woinarski et al. (2014)). The species is predicted to undergo a severe range contraction due to increased temperatures as a result of climate change (Kearney et al. 2010).
Number of subpopulations	Unknown	Unknown	>10	There is no reliable estimate for the number of subpopulations due to limited sampling across the species' range. However, Woinarski et al. (2014) estimated it as >10.
Trend	contracting			As the number of greater gliders (northern) and its AOO are continuing to decline, the number of subpopulations is also likely to be declining.
Basis of assessment of subpopulation number	The number of subpopulations is unknown as there is a limited sampling and survey effort across its range.			

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	1	1	>10	There is no robust estimate for the number of locations. However, Woinarski et al. (2014) estimated it as >10. The biophysical modelling of Kearney et al. (2010) predicted a severe range contraction for the greater glider in the Wet Tropics (approximately the range of greater glider (northern)) if there is a 3°C temperature increase. As this potentially impacts the entire population, a single location is given as the minimum value.
Trend	stable			Climate change is likely to result in a decline in the occupied range of the greater glider (northern) (Kearney et al. 2010). However, as the number of locations used in the assessment is 1, this cannot have a declining trend.
Basis of assessment of location number	Kearney et al. (2010) utilising biophysical modelling, predicted a severe and dire range contraction (~90%) for the greater glider (northern) with a 3 °C temperature increase.			
Fragmentation	No data to suggest distribution is severely fragmented.			
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%
<p>A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.</p> <p>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.</p> <p>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]</p> <p>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.</p>	Based on any of the following		<p>(a) direct observation [except A3]</p> <p>(b) an index of abundance appropriate to the taxon</p> <p>(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat</p> <p>(d) actual or potential levels of exploitation</p> <p>(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites</p>

Criterion 1 evidence

Eligible under Criterion 1 A2c+3c+4c for listing as Vulnerable

The greater glider (northern) 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.

In 2016, *Petauroides volans* (understood at the time to be a single species consisting of both the greater glider (northern) and greater glider (southern and central)) was assessed by the Threatened Species Scientific Committee to be eligible for listing as Vulnerable under Criterion 1 (TSSC 2016). However, the current assessment addresses the greater glider (northern) specifically, which is at the northern end of the range of the formerly assessed species. The 2016 assessment used a preponderance of data from the southern part of the range and thus fewer direct data are available for this assessment. The 2016 assessment of *P. volans* provides only a broad indication of the likely status of the greater glider (northern) in isolation. There are no robust estimates of population size or population trends of the greater glider (northern) across its distribution. In fact, there are few published studies on the species abundance at all, save for Comport et al. (1994), Vanderduys et al. (2012) and a recent study (Starr et al. 2021).

Legge et al. (2021) gave estimates of population decline separate to those caused by the 2019-20 bushfires (as well as caused by the fires). This gave an estimated overall decline for the greater glider (northern) of 18 percent (range 7-33%) over the next three generations, assuming current management conditions. This estimate does not include the impacts of future fire and droughts.

The biophysical modelling of Kearney et al. (2010) predicted a severe range contraction for the greater glider in the Wet Tropics (approximately the range of greater glider (northern)), with a 3°C temperature increase. Two correlative models (Maxent and Bioclim) predicted 98.4 percent and 94 percent range contractions respectively, while a mechanistic model (Niche Mapper) predicted a 76.3 percent decline. The CSIRO (2020) State of the Climate Report shows that the Australian average temperature has increased by up to 0.5°C since the date of the distributional data used in Kearney et al. (2010) was collected, and is projected to increase by a similar amount by 2025 (i.e. by approximately 1°C over ~ three generations). A similar temperature rise is expected over the period from the present (2021) to 2040 (approximately three generations into the future).

Approximately one third of the temperature increase modelled by Kearney et al. (2010) will occur, or has occurred, over any three generation time period relevant to this assessment. The predictions of Kearney et al. (2010) provide an endpoint, but do not describe the pattern of likely decline and thus it is not possible to precisely predict levels of range contraction. Nevertheless, they are sufficient to infer that the distribution of the greater glider (northern) both has contracted, and is projected to contract, by at least 30 percent within time periods relevant to this assessment.

The Committee considers that the species has undergone a substantial reduction in numbers over three generations (21 years for this assessment) and projected to reduce further in the future (2021–2040), equivalent to at least 30 percent, and 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 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 (E00)	< 100 km ²	< 5,000 km ²	< 20,000 km ²
B2. Area of occupancy (A00)	< 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			

Criterion 2 evidence

Eligible under Criterion 2 B2ab(i,ii,iii,iv,v) for listing as Vulnerable

The extent of occurrence (E00) is estimated at 48 946 km², and the area of occupancy (A00) estimated at 524 km². These figures are based on the mapping of point records over 1997–2017, obtained from state governments, museums and CSIRO (DAWE 2021). The E00 was calculated using a minimum convex hull, and the A00 calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2019. Woinarski et al. (2014) noted that the A00, which they estimated to be 716 km², is likely to be a significant underestimate due to limited sampling across the occupied range. For the purposes of this assessment, the A00 is considered to be >500 km². It is not possible to determine an upper plausible estimate to adjust for the under sampling, but given the expected range contraction due to climate change (Kearney et al. 2010) it is judged here to be <2000 km².

Woinarski et al. (2014) estimated the number of locations to be >10. However, with a severe range contraction of up to 98 percent predicted due to temperature increase across the greater glider’s (northern) range (Kearney et al. 2010), there can be considered to be a single location in the context of this criterion, which meets subcriterion (a). The are insufficient data to determine whether the distribution of the greater glider (northern) is severely fragmented.

The area of suitable habitat, and therefore A00 and E00, of the greater glider (northern) are projected to continue to decline under future climate change scenarios (Kearney et al. 2010). As a consequence, the number of subpopulations and mature individuals (see also Criterion 1) are also inferred to be declining. This meets subcriterion (b)(i,ii,iii,iv,v).

After assessment of the data, the Committee considers that the A00 is limited, there is only one location, and there is a continuing decline in E00, A00, habitat, number of subpopulations and

number of mature individuals. Therefore, the species has met the relevant elements of Criterion 2 to make it eligible for listing as Vulnerable.

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. Winter et al. (2004) considered that the greater glider (northern) had a 'presumed large population' and was 'locally common'. Density estimates in north-eastern Qld range from 2.6 to 5.8 individuals per hectare (Comport et al. 1996; Vanderduys et al. 2012). A recent density estimates for the greater glider (northern) from The Bluff State forest range from 0.24 to 0.38 individuals per hectare in wet and dry sclerophyll forest respectively (Starr et al. 2021). These estimates suggest >10 000 individuals if applied across the species' area of occupancy (e.g. using an AOO of 500 km² and density estimate of 3/ha gives 16 667 individuals).

Woinarski et al. (2014) estimated the number of mature individuals to be greater than 30 000, but noted that this estimate has low reliability. With none of the greater glider (northern) habitat affected by the 2019–2020 bushfires, it is unlikely that the population of greater glider (northern) has been reduced to substantially below 30 000 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 number of mature individuals is unlikely to be 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

The number of mature individuals is likely to be greater than 10 000 (see Criterion 3) and highly unlikely to be less than 1000. Additionally, the greater glider (northern) does not meet the quantitative threshold for Vulnerable under sub-criterion D2. Although the species is considered to occur at a single location, the plausible future threat (climate change) is unlikely to drive the species to critically endangered within a very short time (one generation) (see Criterion 1).

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

Population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the subspecies 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 **including** *Petaurus minor* in the list in the Vulnerable category.
- (ii) that there should be a recovery plan for this species.

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Version history table

Document type	Title	Date
Conservation Advice (including listing assessment)	Conservation Advice for <i>Petauroides volans</i> (greater glider (northern))	Amended to replace “basal diameter” with “diameter at breast height” in the “Habitat critical to the survival” section. Amendment approved by the Minister’s delegate 04/09/2023
Conservation Advice (including listing assessment)	Conservation Advice for <i>Petauroides volans</i> (greater glider (northern))	Approved 05/07/2022
Conservation Advice (including listing assessment)	Conservation Advice for <i>Petauroides volans</i> (greater glider)	Approved 25/05/2016