The Minister approved this conservation advice and retained this species in the Critically Endangered category, effective from 14/06/2021

Conservation Advice

Miniopterus orianae bassanii

Southern Bent-wing Bat

Taxonomy

Generally accepted as *Miniopterus orianae bassanii* Cardinal & Christidis (2000).

There is some evidence that these subspecies may warrant species-level recognition (Reinhold et al. 2000; Wood & Appleton 2010), but this has yet to be resolved (Jackson & Groves 2015; DELWP 2020). A taxonomic revision to resolve the issue is currently in progress (Armstrong et al. 2020).

Summary of assessment

Conservation status

Critically Endangered: Criterion 1 A3 (b) (c) (e), Criterion 2 B2 (a) (b) (i, iii, v)

The highest category for which *Miniopterus orianae bassanii* is eligible to be listed is Critically Endangered.

Miniopterus orianae bassanii has been found to be eligible for listing under the following categories:

Criterion 1: A2 (b) (c) for listing as Endangered.

Criterion 1: A3 (b) (c) (e) for listing as Critically Endangered.

Criterion 2: B2 (a) (b) (i, iii, v) for listing as Critically Endangered.

Species can be listed as threatened under state and territory legislation. For information on the listing status of this subspecies 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

The Southern Bent-wing Bat was previously listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), effective from 18 December 2007.

This advice follows assessment of information provided initially in the *Action Plan for Australian Mammals 2012*, and subsequently new information provided by the Southern Bent-wing Bat Recovery Team and other experts.

Public consultation

Notice of the proposed assessment and a consultation document was made available on the Department’s website for public comment for 33 business days from 17/05/2019 to 03/07/2019. Any comments received that were relevant to the survival of the subspecies were considered by the Committee as part of the assessment process.

Subspecies information

Description

The Southern Bent-wing Bat is an insectivorous, obligate cave-dwelling bat. It has dark reddish-brown to dark-brown fur on the back, grey-brown fur underneath and pale brown areas of bare skin. It has a distinctive short muzzle, a high crowned/domed head and small eyes. The ears are short, rounded and roughly triangular. The second phalanx on the third finger of the wing is about four times the length of the first phalanx, giving the typical 'bent wing' appearance (Van Dyck et al 2013). The Southern Bent-wing Bat has a mean weight of 15.7 g, head and body length of 52–58 mm, and forearm length of 45–49 mm (Churchill 2008).

While the Southern Bent-wing Bat is, on average, slightly larger than the other two subspecies of Large Bent-wing Bat, the three subspecies are morphologically very similar. The distribution of the Southern Bent-wing Bat and the Eastern Bent-wing Bat overlap in western Victoria, and individuals of each subspecies may roost together in some non-maternity caves. Currently, these two subspecies cannot be reliably distinguished using traditional field-based techniques (DELWP 2020).

Distribution

The Southern Bent-wing Bat is distributed from south-eastern South Australia (around Robe, Naracoorte and Port MacDonnell) to south-western Victoria (east to Lorne and Pomborneit) (Cardinal & Christidis 2000). Two major maternity sites with long histories of occupation are currently known: Bat Cave, which lies within the Naracoorte Caves National Park in South Australia (referred to herein as the Naracoorte maternity cave); and a sea cliff cave near Warrnambool in Victoria (referred to herein as the Warrnambool maternity cave). A third, smaller maternity site near Portland, Victoria was discovered in 2015 (referred to herein as the Portland maternity cave). The history of use by the Southern Bent-wing Bat at this third site is not known. The two major maternity caves are separated by approximately 220 km and migrations between them are thought to be rare (Dwyer 1969). The Portland maternity cave is situated between these two caves and there is likely to be greater interchange between this cave and each of the major caves. Most bats are congregated at these three caves from spring to autumn, although during this time there can also be considerable movement between the maternity caves and non-maternity (roosting) caves. The maternity caves have specific structural characteristics that allow heat and humidity to build up, creating conditions suitable for dependent young (Dwyer 1965).

In addition to the Naracoorte maternity cave, there are 52 caves in South Australia known to be used as roosting sites (Mott & Aslin 2000; Lear 2012a; Bourne 2019). In Victoria, there are 18 caves used as roosting sites, spread throughout the south-west of the state (DELWP 2020). During the colder months, the population is dispersed across the subspecies' distribution, using the non-maternity caves and the maternity caves to varying extents. Some caves are occupied by several thousand bats, while others have very few. Not all caves are used every year, and not all are used each month. Most of the significant Southern Bent-wing Bat caves are probably known, but there is a possibility that some undiscovered sea caves on rugged coastlines are used as roosts. Searches for new roosting caves continue throughout the range, and there is ongoing monitoring of population size in the main non-maternity caves, especially in Victoria (A. Bush pers. comm. 2020). The eastern extent of the subspecies is not yet fully understood. As it is difficult to distinguish Southern and Eastern Bent-wing Bats morphologically, genetic analysis is required to conclusively determine the limits of their distribution and the extent of overlap between the subspecies. Genetic analysis undertaken in the Castlemaine to Blackwood region of central Victoria revealed that only Eastern Bent-wing Bats were present (Lumsden et al. 2012).

The Victorian and South Australian Southern Bent-wing Bat populations appear to differ somewhat in terms of historic population sizes (Dwyer & Hamilton-Smith 1965), timing of breeding (Dwyer 1969), genetic variation (Wood and Appleton 2010), morphology (Holz et al. 2020b), and disease susceptibility (Holz 2018). Recent PIT-tagging data at the Naracoorte maternity cave demonstrate that a very high proportion of individuals return each year to their natal cave for the maternity season (E. van Harten, pers. comm. 2020). This suggests discrete populations may be operating at some level. However, although we refer to the Victorian population and South Australian populations herein, it is unlikely that a discrete geographic boundary exists between the two populations. Recent studies (discussed in subsequent sections of this document) show that Southern Bent-wing Bats readily commute long distances. There are many caves located between the three maternity caves. There does not appear to be any barrier limiting the movement of individuals between the two populations. It is possible, if not probable, that individuals from both populations share some non-maternity caves located between the maternity caves.

Relevant biology/ecology

Life cycle and breeding

Sexual maturity in females is thought to be reached in the second year of age. This is based on the known biology of the conspecific Eastern Bent-wing Bat (Dwyer 1963) and some corroborative evidence on Southern Bent-wing Bats (E. van Harten pers. comm. 2020). Males are also thought to reach sexual maturity in their second year (Dwyer 1963). Full testis size in male Southern Bent-wing Bats may be reached in the first year (Dwyer & Hamilton-Smith 1965), although in the Eastern Bent-wing Bat, full testis size is not reached until the third year (Dwyer 1963). In this assessment, we have defined reproductively mature adults as those in their second year, although it is not known what proportion successfully reproduce at this age.

Mating occurs in late autumn to early winter, with a subsequent gestation period of 6−7 months (Dwyer 1963). It is not fully known where mating occurs. Mating has been observed in the Naracoorte maternity cave (E. van Harten pers. comm. 2020), but it may also occur in non-maternity caves. An extensive PIT-tag study in South Australia has shown there is mass dispersal from the Naracoorte maternity cave to a non-maternity cave 70 km south in early autumn (van Harten et al. 2019). Most bats return to the maternity cave in mid-autumn for some weeks, possibly to mate, before dispersing again for the winter (van Harten et al. 2019). Few individuals use the Naracoorte maternity cave over winter, with bats commencing the annual return in August and peak occupation occurring in November (E. van Harten pers. comm. 2020). A similar autumn dispersal pattern is apparent in Victoria, however, there is still significant movement between the maternity and nearby non-maternity caves in this period (A. Bush and L. Lumsden pers. comm. 2020).

Extensive monitoring of the Victorian maternity and nearby non-maternity caves has been undertaken in recent years (A. Bush and L. Lumsden pers. comm. 2020). Between December and March (during the breeding period), there are often large fluctuations in numbers as bats move regularly (even nightly) between these caves. Regular movement between caves also occurs outside the breeding season. With the exception of the Warrnambool maternity cave, there are no known roosts within the Warrnambool area that house large numbers of Southern Bent-wing Bats in the middle of winter. Some bats may disperse to roost in smaller unidentified caves or rock crevices over winter. Likewise, little is known of the inter-cave movement patterns of the bats that use the Portland cave for breeding. However, a similar pattern of regular movements throughout the year is apparent at nearby non-maternity caves, with large nightly and monthly fluctuations in numbers recorded.

The population structure in November through early January consists of pups (birth until just before first flight), juveniles, and adults. The terminology used in this assessment for the different life stages is as follows:

- Pups – dependent young from birth to the stage of commencing to fly (typically 6–8 weeks).
- Juveniles – from when they start to fly (typically in January) until they become sexually mature in their second year.
- Mature adults – commencing when males and females become sexually mature and start mating at approximately 17 months of age.

These three stages are used to calculate female reproductive rates and to determine adult population sizes from flyout counts (which only include adults and juveniles) or total population estimates (including all three life stages).

Juvenile survival rates from Naracoorte have been used to estimate the number of pups in each population that are likely to have survived from the previous year. This survival rate is used to estimate the proportion of adults vs. non-breeding juveniles among the individuals observed during flyout counts. The sex ratio of adults is assumed to be equal. The number of mature females is estimated using this information, and the proportion of females giving birth in one breeding season can be inferred by the number of pups born.

Females give birth to single young from mid-November to January, with bats at the Warrnambool maternity roost tending to give birth later than those at Naracoorte (Kerr & Bonifacio 2009; DELWP 2020). Not all reproductively mature females give birth each year. It is difficult to accurately determine the proportion of breeding females, and previous estimates have been highly variable. For example, in 2020, it was estimated that 97% of females at the Portland maternity cave gave birth to young, compared with only 39% at the Warrnambool maternity cave. There are no recent estimates for the Naracoorte maternity cave, but in 2003, it was estimated that 54% of mature females gave birth (S. Bourne pers. comm. 2020). It is unknown why such a low proportion of reproductively mature females at the Warrnambool and Naracoorte maternity caves appear to be breeding each year, or why the proportion of breeding females is so variable between maternity sites.

It is also difficult to obtain accurate estimates of the number of pups born each year. This is due to the inaccessibility of the breeding sites within the caves, the need to reduce disturbance during the breeding period, and the imprecision of current monitoring techniques.

In the Warrnambool maternity cave, an infrared camera and infrared illuminators are used to take photographs of the roosting cluster of pups from 25 m away. Estimates of abundance are made by manually counting individuals from the mass of bodies. In 2020, approximately 3 000 pups were counted. A flyout count undertaken on the same day yielded 17 000−18 000 mature adults and juveniles (A. Bush and L. Lumsden pers. comm. 2020). At the Portland maternity cave, 700 pups were born in 2020 from a total adult and juvenile count of 1900 individuals. In 2003, approximately 8000 pups were born in the Naracoorte maternity cave, and a flyout count estimated 35 000 adults and juveniles (S. Bourne pers. comm. 2020).

Longevity and annual survival

Southern Bent-wing Bats have been recorded living up to 22 years of age (Lumsden & Gray 2001). This longevity figure has been used to calculate a generation length of 10−12 years (Woinarski et al. 2014). Adults are reported to still be reproductively active at 22 years of age (Lumsden & Gray 2001). It is possible that since adults can breed over such a long time period, they do not need to breed every year.

Understanding annual survival rates and how this differs between the sexes and age cohorts is critical to ascertaining the current status of the population and likely future trends. The extensive PIT-tagging study undertaken in South Australia is revealing essential but previously unknown information on survival rates (E. van Harten pers. comm. 2020). Almost 3000 individuals were PIT-tagged at the Naracoorte maternity cave over a three-year period and their survival history tracked by recording their tag number each time they flew through a large loop antenna set within the cave (van Harten et al. 2019; Figure 1). Using a 'capture-mark-recapture/resight' approach, annual and seasonal survival rates were estimated for each cohort. The study identified seasonal variation in survival rates, as well as differences between adult and juvenile survival rates. There was also a markedly lower survival rate in 2016 than for the following two years, corresponding with a severe drought in the region (E. van Harten pers. comm. 2020). This information can be used to help predict future population trends. In particular, the lower survival rate recorded in the drought year provides valuable information that can be used to model the impacts of increasing drought frequency under future climate change scenarios.

For the survival analysis, the term 'juvenile' is applied to young of the year from the time of tagging to the end of their first year (van Harten et al. 2019). This does not include the period between first flight and tagging, which ranged from several days to several weeks. There are no data on survival rates for this highly vulnerable period of life (as they learn to fly), nor from birth to first flight.

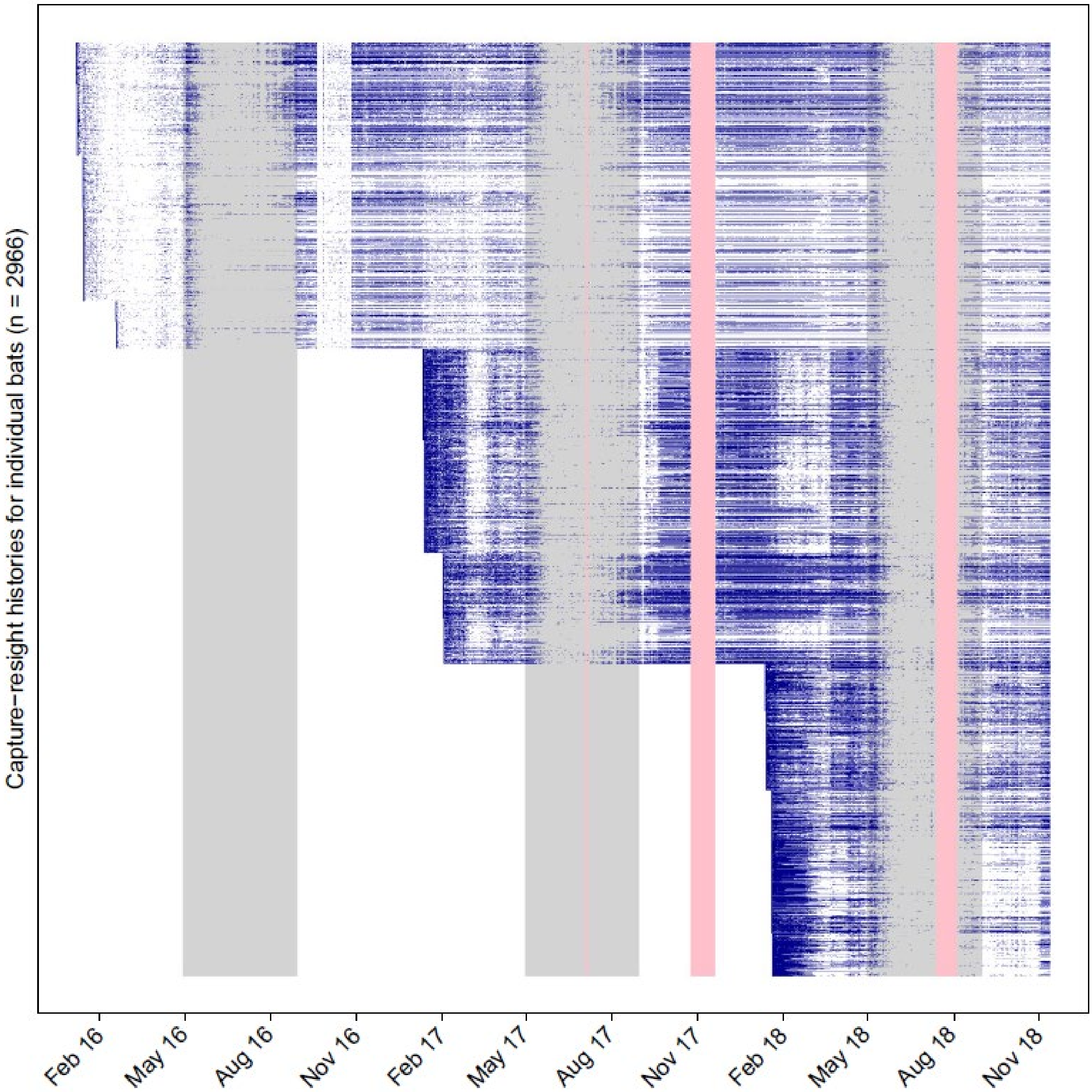

Figure 1: Capture-resight histories of PIT-tagged Southern Bent-wing Bats at Naracoorte Bat Cave from February 2016 to November 2018. Each of the 2966 tagged individuals is represented as a row on the *y*-axis, with initial capture and subsequent daily detections/presence at Bat Cave marked in blue. Absence (white) could be due to death, tag loss, migration to other cave locations, or lack of detection. The data occur in blocks because individuals were tagged over 3 years and seven trapping events. Pink shading indicates missing data due to power outages. Grey shading indicates May to August, when bats typically disperse away from Bat Cave. Source: van Harten et al. (2019).

Population health

A comprehensive baseline health assessment was undertaken for the Southern Bent-wing Bat and Eastern Bent-wing Bat from 2015–2017 (Holz 2018). This has involved studies on viruses (Holz et al. 2018a), fungi (Holz et al. 2018b), ectoparasites (Holz et al. 2018c), blood parasites (Holz et al. 2019a), pathology (Holz et al. 2019b), haematology (Holz et al. 2020a), and morphology (Holz et al. 2020b). No association was found between any of the infectious and parasitic agents surveyed and measures of the health of the individuals. However, Victorian Southern Bent-wing Bats had more herpesviruses, ectoparasites and parasitic blood infections, which may be indicative of some type of chronic stress impacting the immune systems of individuals in this population (Holz 2018).

An important component of this work was assessing the risk of introduction to Australia of the fungus that causes White-nose Syndrome (WNS), *Pseudogymnoascus destructans*. This fungal disease has resulted in the deaths of millions of cave-roosting bats on other continents since 2006 (Puechmaille et al. 2010). Holz et al. (2018b) tested 325 Southern Bent-wing Bats and Eastern Bent-wing Bats for *P. destructans*. All samples were negative, indicating that the fungus is not yet in Australia. However, further testing from a wider area of south-eastern Australia and a range of bat species is required to confirm this.

A risk assessment has been undertaken to assess the probability of *P. destructans* being introduced to Australia, the potential mechanism for introduction, and the likely consequences for bat species (Holz et al. 2016, 2019c). The risk assessment concluded that the introduction of the fungus into Australia was 'highly likely/almost certain' over the next 10 years, and that the Southern Bent-wing Bat would probably be the most impacted taxon (Holz et al. 2016, 2019c). This view has been confirmed by a separate study (Turbill & Welbergen 2020), which found that 100% of the range of the Southern Bent-wing Bat was within the optimal temperature range for growth of *P. destructans*.

In addition to other health issues, genetic studies have revealed a significant reduction in genetic variation within the Southern Bent-wing Bat over the 2000s, which may have a detrimental impact on the long-term viability of this subspecies (Wood & Appleton 2010).

Habitat and diet

The Southern Bent-wing Bat predominantly roosts in limestone caves, but also in lava tunnels, coastal cliff rock crevices, and, occasionally, in man-made tunnels. Aspects of cave climate and structure that are important for Southern Bent-wing Bats are not well understood. Non-maternity caves vary enormously in shape, structure, climate, and size. Some are consistently used each season and may at times support up to 7000 individuals, while others are used infrequently or by only a few bats. Non-maternity caves occur in a range of land-use types, both public and private, including in national parks, remnant native forests, pine plantations, open irrigated and non-irrigated paddocks, and sea cliffs. The three known maternity caves also differ greatly from one another in structure, and it is not clear why these particular caves are chosen over others that appear equally suitable.

While caves that are consistently used by large numbers of Southern Bent-wing Bats may be considered critical sites, the availability of a large number of sites, even those used infrequently, may be equally important for the subspecies' survival.

Recent research has provided new insights on movement patterns, seasonal migration, and torpor/hibernation (A. Bush and E. van Harten pers. comm. 2020). The traditional view, based on the work of Dwyer (1963), had assumed there were two seasonal migrations, with all bats leaving overwintering caves in spring and taking several weeks to return to the maternity caves via stopovers at transition caves. In autumn, bats were thought to disperse from the maternity sites to overwintering caves, where they would enter extensive periods of torpor. Individuals were assumed to remain at these overwintering caves for the duration of winter. However, the new research, which tracks PIT-tagged Southern Bent-wing Bats in South Australia, has revealed far more complex movement patterns. Tracking data has shown that so-called "overwintering caves" can be used at any time of year, leading to discontinuation of the term "overwintering cave" in favour of "non-maternity cave".

The use of non-maternity caves is now understood to be highly dynamic. For example, bats leaving the Naracoorte maternity cave in early autumn may visit many non-maternity caves over the course of a few weeks before returning to the maternity cave (E. van Harten pers. comm. 2020). Large distances can be flown in short periods of time. There are numerous examples of individuals flying between the Naracoorte maternity cave and a non-maternity cave 70 km away (this cave also has a PIT-tag reader) over the period of just a few hours, and sometimes returning to the maternity cave on the same night – a total distance of 140 km in 24 hours. Periods of torpor also appear to be shorter than previously thought, with some activity during winter, including movement between caves.

Comparatively little is known about preferred foraging habitats and locations. The subspecies is known to forage in a range of habitat types, including wetlands, native forested areas, native remnant vegetation and non-native shelterbelts in farmland, and as well as over cleared agricultural and grazing land (Grant 2004; A. Bush pers. comm. 2020).

There has only been one detailed study of the diet of the Southern Bent-wing Bat (Kuhne 2020). This study used DNA metabarcoding to determine diet from guano (bat droppings). Fresh guano samples were collected from the Naracoorte and Warrnambool maternity caves, a key non-maternity cave in South Australia, and four Victorian non-maternity caves. The study found that at the time of sampling, Southern Bent-wing Bats across the range were feeding predominantly on moths (Order Lepidoptera). Some 67 moth species were identified, many of which are known to be agricultural pests. A few other insect orders were also identified. That moths form a major component of the diet is consistent with analysis of stomach contents from both the Eastern Bent-wing Bat and Northern Bent-wing Bat (Vestjens & Hall 1977). Further studies should investigate the diet across all seasons, as well as prey availability. This information will help to determine the type of habitat required to support foraging. As the natural landscape has been altered considerably over the last 50 years, it is unclear if the current diet is natural or a result of adaptation to prey availability.

Southern Bent-wing Bats require free water for drinking. The subspecies visits external water bodies, including farm dams and wetlands, to drink. In addition, water is accessed by licking droplets from drip sites in caves (Bourne & Hamilton-Smith 2007).

Habitat critical to survival

Habitat critical to the survival of the Southern Bent-wing Bat includes the three maternity caves, non-maternity caves that are used by a significant proportion of the population or at key times during the yearly cycle, and key foraging areas (yet to be defined) (DELWP 2020). Due to the severe decline in numbers in recent decades, all populations are considered important.

Threats

A range of threats have been identified as potentially impacting on the Southern Bent-wing Bat (Table 1). Of these threats, the most important are likely to be destruction and disturbance of roost sites (particularly maternity sites) and declining extent and quality of foraging habitat. An emerging threat is the likely introduction of White-nose Syndrome to Australia, which is predicted to severely impact the Southern Bent-wing Bat across its entire distribution (Holz et al. 2016, 2019c; Turbill and Welbergen 2020).

Although several potential threats to the subspecies have been identified, the main cause(s) of the severe decline in numbers and the mechanisms of that decline remain unclear (DELWP 2020).

Table 1 Threats impacting the Southern Bent-wing Bat in approximate order of severity of risk, based on available evidence.

Threat factor	Threat type and status	Evidence base
Habitat loss and degradation		
Damage or destruction of roost sites	Known past and potential	There have been historic losses of major roost sites due to the extraction (mining) of bat guano, which entailed enlarging holes in cave roofs (Lewis 1977). In some cases, these modifications significantly altered the microclimate of caves, rendering them unsuitable to bats (Simpson & Smith 1964; Baudinette et al. 1994; Hamilton-Smith 1998). One significant maternity cave, Thunder Point Blowhole in Victoria, has collapsed due to natural weathering. Some roost sites have been abandoned by bats due to their use as rubbish dumps, or intentionally closed as part of risk mitigation or for the protection of Aboriginal rock art (Kerr & Bonifacio 2009). Bent-wing bats generally do not tolerate gates installed over cave entrances – even those designed to allow the movement of bats (Slade & Law 2008). Both major maternity caves are now managed for bat conservation. The Warrnambool cave is situated in a dynamic section of the coast, putting it at risk of collapse. Small parts of the cave have collapsed in recent years due to natural weathering, and previous land management practices may have weakened the structural integrity of the roof of the cave. Increased storm frequency due to climate change may exacerbate the rate of collapse (DELWP 2020). Vegetation growth around the entrance to some caves has obstructed the flight space, and, in some cases, prevented bat access to the roost site (DELWP 2020).
Clearing and modification of foraging habitat	Known past and potential	Historic land clearing and the draining of large wetland complexes have greatly reduced foraging habitat for the Southern Bent-wing Bat. Habitats surrounding all three maternity roosts, as well as non-maternity caves, have been significantly modified and fragmented, with over 90% of the native vegetation removed (TSSC 2007). Further destruction of remaining habitat in these areas could be highly detrimental to the survival of the subspecies (DELWP 2020).

Threat factor	Threat type and status	Evidence base
Disease		
Disease	Known past and potential	There are recorded observations of mortality events attributed to disease or ill health. In 1967, an unidentified virus, combined with a severe drought, reduced the numbers at the Naracoorte maternity site (E. Hamilton-Smith pers. comm. 2010, cited in DELWP 2020). In 2008, there was a high mortality of pups at the Naracoorte site, with some individuals suffering from severe ulcerative skin lesions and malnutrition (Bourne 2010). In 2009, a large proportion of the population was observed with small ulcers that were attributed to parasites and a pox virus (Bourne 2010; McLelland et al. 2013). However, it is unclear whether these lesions and ulcers affected the bats' survival. The extensive health study by Holz (2018) did not find any health issues that would clearly explain significant population declines. However, further work is needed to continue surveillance for disease in the population, as it is difficult to exclude the possibility of long-term impacts of minor diseases and episodic or epidemic disease events. In North America, White-nose Syndrome (WNS) caused by the fungus *Pseudogymnoascus destructans* has resulted in the deaths of millions of cave-roosting bats in North America since 2006 (Puechmaille et al. 2010). It has spread rapidly across the United States of America and Canada and has also been recorded in Asia and Europe (Puechmaille et al. 2010; Zukal et al. 2016). It has not yet been recorded in Australia, but its introduction could have devastating consequences for Australian cave-dwelling bats (DELWP 2020). The entire distribution of the Southern Bent-wing Bat is within the optimal temperature range for growth of the fungus (Turbill and Welbergen 2020). A risk-assessment for bats in Australia concluded that the introduction of WNS into Australia was 'highly likely/almost certain' over the next 10 years, and that the Southern Bent-wing Bat would be the most severely impacted taxon (Holz et al. 2016, 2019c; Turbill and Welbergen 2020). The most likely method of introduction into Australian cave systems is via cavers (e.g. inadvertently introduced via contaminated equipment) (Holz et al. 2019c). The recent discovery that Southern Bent-wing Bats are capable of regular, long-distance flights makes it likely that the Victorian and South Australian populations interact, perhaps sharing non-maternity caves located between the maternity caves. There is a high-level of contact between individuals within each population throughout the year, as they cluster in tightly packed groups and regularly switch between roost caves. If WNS was to infect Southern Bent-wing Bats anywhere in its distribution, it is highly likely that it would spread quickly throughout the entire population. It is also highly likely that if the fungus was introduced, it would not be possible to control its spread.

Threat factor	Threat type and status	Evidence base
Climate change		
Climate change	Suspected past and potential	Drought may affect reproductive success and adult survival by reducing water availability and prey availability, particularly if critical wetland foraging sites dry up. During the 2006 breeding season, drought, in conjunction with unusually low temperatures, is believed to have been the cause of significant mortalities in the Naracoorte maternity cave, with >500 dead pups recorded, and large numbers of emaciated pups observed (Bourne & Hamilton-Smith 2007). Survival analysis undertaken at the Naracoorte maternity cave revealed a 37% lower survival rate of both juveniles and adults during a year of severe drought compared to subsequent years with average rainfall (E. van Harten, pers. comm. 2020). Similarly, low levels of survival and breeding success have been recorded for the Eastern Bent-wing Bat (D. Mills pers. comm. 2019). Periods of low rainfall are likely to increase under ongoing climate change (Grose et al. 2015; Timbal et al. 2015).
Human disturbance		
Human visitation to caves	Known past and current	The Southern Bent-wing Bat is highly susceptible to human disturbance, especially from the use of white lights (Bush et al. 2016). Many caves used by the bats receive significant levels of human visitation, although visitation to the Naracoorte maternity cave is now strictly regulated (DELWP 2020). The young are particularly vulnerable during the breeding season. Disturbance may lead to young being dislodged from the ceiling and falling to the floor, where they are unlikely to be reunited with their mother and will consequently die. Adults in torpor are also vulnerable. If disturbance causes them to arouse from torpor, they use up valuable fat reserves. If this occurs a number of times over the cooler months, bats may starve to death or be in poor condition when they leave the roost site in spring. If disturbance occurs repeatedly, a roost site may be abandoned (Kerr & Bonifacio 2009). In addition to inadvertent disturbance, there have been examples of vandalism at the Warrnambool maternity site, with an attempt to set fire to surrounding vegetation and large timber logs thrown into the caves through the small surface holes.

Threat factor	Threat type and status	Evidence base
Introduced predators		
Feral cats (*Felis catus*), European red foxes (*Vulpes vulpes*) and black rats (*Rattus rattus*)	Suspected past and current	The impact of introduced predators on the Southern Bent-wing Bat is unknown. However, feral cats (*Felis catus*) and European red foxes (*Vulpes vulpes*) have been recorded preying on bats as they exit caves, sometimes taking significant numbers (DELWP 2020). A fox and numerous fox scats have been observed in the Warrnambool maternity cave and several non-maternity caves, and feral cats have been trapped in and around the Naracoorte maternity cave (DELWP 2020). Black rats (*Rattus rattus*) have been observed in both the major maternity caves. Dwyer (1966) reported the accumulated remains of 476 Eastern Bent-wing Bats taken by a fox at a cave in NSW over a two-year period, indicating that predation rates can be substantial.
Infrastructure		
Fencing (especially barbed wire fencing)	Known past and potential	Trauma has been identified as the primary cause of death of Southern Bent-wing Bats at a maternity site where fencing and other infrastructure has been positioned around the cave (Holz et al. 2020c). Bats are known to become trapped in barbed wire. Barbed wire fences placed in flight paths to/from a roost site may cause locally significant levels of mortality (DELWP 2020.
Windfarms	Current and potential	The impact of windfarms on the Southern Bent-wing Bat are unknown, but any windfarms close to a roosting site could potentially have a major impact on that population (DELWP 2020). Windfarm developments pose a number of risks to bats, including cave destruction, mortalities due to collisions and barotrauma (a result of changing air pressure around moving blades), and altered access to foraging areas (Kerr & Bonifacio 2009). Southern Bent-wing Bat mortalities have been recorded at wind turbines (Moloney et al. 2019), however, the population-level and cumulative impacts are still being assessed. International studies suggest that there may be cumulative impacts of windfarms on migratory species, with impacts greater at certain times of the year or under certain weather conditions (Johnson et al. 2004; Kunz et al. 2007). The risk increases with proximity of windfarms to important sites, particularly maternity sites or migration paths.
Fire		
Severe bushfire	Potential	The impact of fire on bats is not well understood. Severe bushfire has been shown to reduce the relative abundance of Eastern Bent-wing Bats (Jemison et al. 2012). Fire could directly impact roosting bats if smoke was drawn into the caves, and foraging habitat and prey availability could be negatively affected (DELWP 2020).

Threat factor	Threat type and status	Evidence base
Accumulation of toxins		
Accumulation of pesticides or other toxins	Potential	A range of pesticide residues, including DDT and DDE, have been found in Southern Bent-wing Bats and bat guano at both the major maternity sites (Mispagel et al. 2004; Allinson et al. 2006). It is unknown if these chemicals have contributed to the population decline of the subspecies. However, sub-lethal exposure to DDE has been reported to increase metabolic rates, which may lead to reductions in body weight and overwinter survival (Allinson et al. 2006). Agricultural pesticides may also severely reduce the abundance of prey species such as moths and their larvae (DELWP 2020).

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

(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 A3 (b) (c) (e) for listing as Critically Endangered

Criterion A1 is not applicable to the Southern Bent-wing Bat as the cause of the decline is not yet fully understood or considered to have ceased. Therefore, this assessment focuses on past decline in Criterion A2 and future declines in Criterion A3. No assessment has been made against a combined past and future decline under Criterion A4.

<u>Assessment against Criterion A2</u>

This criterion considers population trends of mature individuals over the most recent three-generation period (36 years), i.e., from 1984 to 2020. The IUCN defines ‘mature’ as reproductively mature. Southern Bent-wing Bats do not commence breeding until their second year, so juveniles (as well as pups) are excluded from this estimate.

As the majority of individuals congregate at the maternity caves and nearby non-maternity caves in summer, total population numbers can be estimated based on the collective number of individuals at each of these locations at this time.

Population estimates have been undertaken sporadically at the two main maternity caves since the 1960s. However, counting methods and counting frequency have differed markedly over time and varied between caves, making it difficult to accurately assess changes in population numbers. No historical information exists for the newly discovered Portland maternity cave, so it has not been included in this assessment under Criterion A2.

Population estimates in the 1960s at Naracoorte and Warrnambool were based on estimating the number of individuals in roosting clusters inside the caves during the day. Unfortunately, from the 1960s to 2000, no population counts were undertaken. For this period, there are only qualitative estimates based on current day recollections.

From the early 2000s, population estimates were undertaken by counting the number of bats in flight as they emerged from the two main maternity caves on dusk. These counts were conducted at a time when the adults had returned to the maternity caves but before the young of the year were flying. The flyout counts therefore included mature adults and juveniles. Two assumptions underpinned these counts: first, that all or most of the population were in the caves at the time of the counts, and second, that every bat occupying the caves emerged during the flyout counts. For the earlier counts, neither of these assumptions may have been met. The most recent counts have been conducted with new technology (at both main maternity caves), are based on a better understanding of the population distribution in summer and have included any bats that were at nearby caves at the time, or that remained inside the maternity cave after the flyout count (at the Warrnambool cave only). As a result, there is a much higher confidence in the population estimates from recent counts.

Available population estimates from the 1960s onwards, the level of uncertainty around these estimates, and the 2019 estimates, are presented in Appendix 1. There has clearly been a significant decline in numbers, especially at the Naracoorte maternity cave, since the 1960s. Early estimates were in the order of 100 000 to 200 000 bats in the 1960s, with one estimate of 250 000 in the 1970s. In contrast, the most recent estimate of this population was a flyout count of 30 700 individuals in November 2019. Although there is uncertainty regarding the accuracy of the early estimates, the adult population decline at Naracoorte could be as high as 78% since the 1960s.

For the Warrnambool population, the numbers are even less certain. The 1960s estimates were 10 000 to 20 000 individuals, with one estimate of 25 000 individuals. The total population at that time may have been higher still; a nearby sea cave, which has since collapsed, was also recorded as a maternity cave during this time, with at least 2000 pups observed in one year. Current estimates are 17 000 to 18 000 individuals (adults and juveniles) for the Warrnambool maternity cave. However, the techniques for estimating numbers have improved dramatically, and it is difficult to compare these estimates with those of previous years.

The uncertainty in historic estimates, but particularly the absence of estimates from the mid-1980s, means that there is little confidence in estimating a more precise magnitude of decline in the total population over the last 36 years. The latest assessment (Woinarski et al. 2014) concluded that the historic decline met the threshold for Endangered. Investigations by the Southern Bent-wing Bat Recovery Team (Appendix 1) suggest that there is compelling evidence for a substantial population decline over the last 36 years, with the higher estimates possibly meeting the threshold for Endangered under Criterion A2 (b) (c).

<u>Assessment against Criterion A3</u>

The relevant assessment period for this criterion is 2020 to 2056.

There is no evidence to suggest that the past decline has ceased, as numbers have continued to decline over the past 10 years (Appendix 1: Table 2). Therefore, it is assumed that this decline will continue into the future. While threats contributing to the past decline are known to some extent (see Threats section), the relative magnitude of each contributing factor is not fully understood. Attempts are being made to manage some of these threats, but it is not possible to manage all threats. While some of the past decline is likely to be due to land-use changes – especially in South Australia, which has seen the greatest decline in bat numbers – it is likely that there will be further land-use changes in the next 36 years, such as the expansion of vineyards, simplification of grasslands, and further lowering of water tables. In addition, terrestrial insect numbers are declining worldwide (van Klink et al. 2020). If this is occurring within the distribution of the Southern Bent-wing Bat, it may have additional impacts on the population. Based on all available knowledge, the Committee assumes that the population decline of the Southern Bent-wing Bat will continue into the future.

In addition to the ongoing threats outlined above, there is an emerging risk of the introduction of White-nose Syndrome (WNS). A recent risk assessment concluded that it was "highly likely/almost certain" that WNS will be introduced into Australia in the next 10 years and that it was "likely" that Australian bats will be exposed to it (Holz et al. 2016, 2019c). The most likely method of introduction into Australian cave systems is via cavers (e.g. inadvertently introduced via contaminated equipment) (Holz et al. 2019c). The Southern Bent-wing Bat was the Australian taxon considered most likely to be impacted by this disease, as 100% of its distribution is within the optimal temperature zone for the growth of the fungus that causes the disease (Holz et al. 2019; Turbill and Welbergen 2020). The disease was assessed as likely to have moderate consequences for the subspecies, defined as small population decline (<30%) in multiple caves or moderate population decline (30–50%) in one cave (Holz et al. 2016). The timeframe for the likelihood of introduction was 10 years and so a similar timeframe can be used for the consequences assessment; the impact is likely to be soon after introduction into cave systems. In North America, there have been population declines from WNS of up to 98% in some caves, and similarly high declines may be possible in Australia. However, as the hibernation period for Southern Bent-wing Bats is shorter than that of North American species, the mortality rate is likely to be lower. As individual Southern Bent-wing Bats are highly mobile and regularly move between caves even during winter when the fungus is more prevalent, it is highly likely that if it was introduced into one cave it would rapidly spread to all other roost cave systems across the subspecies' range. Further data are required on torpor/hibernation behaviour, food availability in winter, immune response during torpor, and response to the fungal infection to fully assess the likely impacts of introduction of WNS to the Southern Bent-wing Bat.

Drought has severely impacted Southern Bent-wing Bat populations in the past (E. van Harten pers. comm. 2020). Under future climate change scenarios, the frequency and severity of droughts are likely to increase (Grose et al. 2015; Timbal et al. 2015), placing increasing pressure on populations. It is difficult to quantify the impact of future increased droughts, however, survival analysis undertaken between 2016 and 2019 on the Naracoorte population revealed that survival rates in 2016 were 37% lower than in the two following years, with this lower survival rate attributed to the severe regional drought experienced in 2016 (E. van Harten pers. comm. 2020).To assess the likely future decline, the Southern Bent-wing Bat Recovery Team undertook modelling using Population Viability Analysis (PVA) software (Vortex; Lacy & Pollack 2018). Models were run using the new information on survival rates and female reproduction rates together with the frequency and effects of both drought and WNS. Two models were run: a conservative model that used the higher survival rates and lower impacts of drought and WNS, and a less conservative model that used the lower survival rates and higher impact levels from drought and WNS (for details see Appendix 1). The two models were used to calculate the number of mature adults predicted to be alive in 2056 and thus determine an overall population decline. When applied to both the South Australian and Victorian populations, the models revealed a total population decline of 84% to 97%.

Calculations of future population decline were based on the best available data, including survival rates from Naracoorte, proportion of adult females breeding each year in each of the maternity caves, total population sizes, and the proportional representation of each cohort. While knowledge on these aspects has increased markedly in recent years, it was necessary to make assumptions in the calculations (Appendix 1). While it is possible that some of the assumptions are not valid, the assumptions and associated caveats have been clearly outlined.

Modelling undertaken by the Southern Bent-wing Bat Recovery Team demonstrates that the subspecies is eligible for listing as **Critically Endangered under Criterion 1 A3 (b) (c) (e)**, with a predicted population decline of ≥80% due to a decline in area of occupancy, extent of occurrence and/or quality of habitat, as well as the effects of an introduced pathogen.

Criterion 2.	Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy		
	Critically Endangered Very restricted	**Endangered Restricted**	**Vulnerable Limited**
B1. Extent of occurrence (EOO)	**< 100 km²**	**< 5,000 km²**	**< 20,000 km²**
B2. Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
AND at least 2 of the following 3 conditions indicating distribution is precarious for survival:			
(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:

Eligible under Criterion 2 B2 (a) (b)(i, iii ,v) for listing as Critically Endangered

Extent of Occurrence (EOO) is estimated at 19 500 km^2, which meets the threshold for Vulnerable under Criterion B1. The EOO is based on the mapping of roost sites from 1998 to 2018, obtained primarily from state governments and museums (DoEE 2018), and calculated using a minimum convex hull.

Area of Occupancy (AOO) is estimated at 8 km^2, which meets the threshold for Critically Endangered under criterion B2. The AOO was calculated using 2 x 2 km grid cells around the two major maternity caves (Naracoorte and Warrnambool) (based on the IUCN Red List Guidelines 2017), since these are the 'smallest area essential at any stage to the survival of existing populations'.

The inclusion of the newly discovered Portland maternity cave (which accounts for about 3% of the entire breeding population) would increase the AOO from 8 km^2 to 12 km^2. This AOO is at the extreme low end of the range for Endangered (which ranges from 10 km^2 to 500 km^2) and very close to the threshold for Critically Endangered, especially as the maternity caves themselves cover a much smaller area than the 2 x 2 km grid cell allocated for each. The third maternity roost was only recognised 5 years ago, and it is unknown if it is a newly formed maternity roost or whether it has been used for some time. There is uncertainty as to whether it will continue to be used as a maternity roost in the future. Expert advice received during the consultation period (L. Lumsden, pers. comm. 2019) recommended that a precautionary approach be taken regarding the newly discovered maternity cave and its inclusion in the calculation of AOO, given the uncertainty as to its importance and longevity as an essential breeding area.

The term 'location' is defined in the IUCN Red List Guidelines 2017 as a geographically or ecologically distinct area in which a single threatening event (based on the most serious plausible threat) can rapidly affect all individuals of the taxon present. Although there are three maternity sites for the Southern Bent-wing Bat, a single threat – the potential introduction of WNS – could rapidly and severely impact the whole population. This assessment is based on the subspecies' entire distribution being within the optimal temperature zone for growth of the fungus, and the extensive movements of the bats between caves throughout the entire range. Consequently, the subspecies is classified as occurring in a single location, which qualifies it for listing as Critically Endangered under sub criterion (a). The range is fragmented, but not severely fragmented, as there are few subpopulations.

There is a projected continuing decline in the EOO, number of mature individuals, and extent/quality of foraging habitat due to likely impacts from climate change and disease (as outlined under Criterion 1). The subspecies therefore meets the requirements for listing under sub criterion (b) (i, iii, v). In addition, it is possible that the AOO may decline in the future, as the modelling conducted by the Southern Bent-wing Bat Recovery Team reveals a considerable projected population decline over the next 36 years, such that it is possible that one of the maternity caves may no longer be viable as a maternity site (Appendix 1).

The subspecies is not known to undergo extreme fluctuations and therefore does not meet the requirements for listing under sub criterion (c).

Taking into account expert advice received during the consultation process (L. Lumsden, pers. comm. 2019), the Committee has elected to take a precautionary approach regarding the uncertain status of the third maternity cave, and consider the AOO of the subspecies to be 8 km^2. The Committee therefore considers that the subspecies is eligible for listing as **Critically Endangered under Criterion 2 B2 (a) (b) (i, iii, v).**

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 generations (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

The total population of the Southern Bent-wing Bat is estimated to be **44 300** mature individuals, which exceeds the threshold for listing in the Vulnerable category.

The subspecies is therefore not eligible for listing under Criterion 3.

Criterion 4. Number of mature individuals			
	Critically Endangered Extremely low	**Endangered Very Low**	**Vulnerable Low (Medium-term future)[1]**
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.

Evidence:

Not eligible

The total population of the Southern Bent-wing Bat is estimated to be **44 300** mature individuals, which exceeds the threshold for listing in the Vulnerable category.

The subspecies is therefore not eligible for listing under Criterion 4.

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:

Insufficient data to determine eligibility

A Population Viability Analysis is currently being developed for the Victorian component of the Southern Bent-wing Bat population to examine the cumulative and population-level impacts of collisions with wind turbines (G. Heard, DELWP pers. comm. 2020). However, key parameters required for the model (especially survival rates) are not available for Victoria. As a result, it has been necessary to use the survival rates from the Naracoorte maternity cave (E. van Harten pers. comm. 2020) and assume that survival rates are the same in Victoria. However, as outlined in the evidence provided for Criterion 1, past declines are not thought to have been as severe in Victoria as they have been in South Australia, and it is more likely that the survival rates in Victoria are different. Using the South Australian survival rates for Victoria in the PVA results in a similar pattern of decline seen in the simpler models developed by the Southern Bent-wing Bat Recovery Team (Appendix 1). The preliminary PVA models taper off close to extinction but never fully reach extinction (i.e. zero animals remaining) over 36 years, and so do not meet the thresholds for this criterion.

Although PVA software was used to predict total adult population declines for Criterion 1, a complete PVA for Criterion 5 was not attempted because of uncertainties surrounding survival rates for the Victorian population, as well as the following effects that would all likely result in a higher rate of decline:

- Potential disease outbreaks other than White-nose Syndrome, as have occurred in the past;
- Density dependence, i.e. habitat carrying capacity and future potential changes;
- The potential for the subspecies to reach a tipping point in population size that would lead to a steeper path to extinction (Allee effect);
- Windfarm mortality; and
- Disturbance and vandalism of key roost sites.

Conservation Actions

Recovery Plan

A National Recovery Plan for the Southern Bent-wing Bat has been prepared by the Victorian Department of Environment, Land, Water and Planning (DELWP 2020). The Recovery Plan was adopted by the Minister for the Environment on 19 October 2020 and came into effect under the EPBC Act on 5 November 2020.

The following Conservation Actions are based on the actions in the Recovery Plan.

Primary conservation actions

1. Protect all maternity sites, key non-maternity sites, and key foraging areas.
2. Search for new maternity caves, which if found would increase the Area of Occupancy, and/or investigate the feasibility of artificially establishing a new maternity cave.
3. Undertake long-term monitoring to assess changes in population status, evaluate the success of management actions, and inform adaptive management.
4. Determine the main cause(s) of population decline.

Conservation and Management priorities

- **Habitat loss and modification**
  - Protect all maternity sites and key non-maternity sites from loss, damage, and disturbance.
  - Regularly monitor all key roosting sites and remove vegetation encroaching over the entrances that restricts flight space.
  - Protect all key foraging areas from clearing and degradation.
  - Implement management actions to increase the condition and extent of foraging habitat, especially within foraging range of key roosting sites.
  - Establish conservation covenants or management agreements on private land containing important roost or foraging sites.
  - Provide details of the locations of all maternity sites, key non-maternity sites, and key foraging areas to local councils for inclusion in their planning processes.
  - Investigate and trial options for restoring caves previously used by the Southern Bent-wing Bat but rendered unsuitable due to guano mining or other anthropogenic activities.
  - Investigate the feasibility and potential benefits of constructing an artificial maternity cave(s).

- **Disease**
  - Develop, publicise and implement biosecurity protocols for disease prevention (including White-nose Syndrome) for cavers, researchers, and the general public.
  - Invest in prevention and preparedness activities for introduction of White-nose Syndrome into Australia, e.g. pre- and post-border activities and education campaigns.
  - Undertake disease surveillance, both to obtain baseline health data and detect disease events.
- **Climate change**
  - If microclimatic conditions within the maternity caves become suboptimal, artificially modify the temperature and humidity (if feasible).
  - Increase the extent and quality of foraging habitat to provide additional resources during times of drought.
- **Human disturbance**
  - Erect and maintain signs to restrict or discourage human access to roost sites and educate the public regarding the subspecies' threatened status and risks from human disturbance.
  - In conjunction with caving organisations, develop and promote a code of conduct for cave visits which includes an assessment of the risk of disturbance to the Southern Bent-wing Bat for all proposed activities.
- **Introduced predators**
  - Control introduced feral predators at maternity sites and important non-maternity sites where regular monitoring indicates that control measures are required.
- **Infrastructure**
  - Avoid positioning wind turbines near important roost and foraging sites or potential flight routes.
- **Fire**
  - Provide the locations of maternity sites and key non-maternity sites to fire management authorities for inclusion in their planning processes.
  - Manage risks to maternity sites, key non-maternity sites, and key foraging habitat from fuel reduction burning within the context of relevant state bushfire risk management policies.
- **Accumulation of toxins**
  - Constrain the use of pesticides that have secondary impacts on the subspecies.
  - Implement a public relations campaign to change perceptions of landowners towards pesticide use and promote the use of alternatives.

Stakeholder engagement

- Continue to work with the managers of key roosting sites on private land to implement management actions, including measures to reduce impacts from human access and invasive predators.
- Increase public awareness (but do not publicise locations of individual roosting sites) of the Southern Bent-wing Bat, including its threatened status, conservation requirements, and benefits to the community.
- Involve community groups in the implementation of conservation actions.

- Develop closer links with Indigenous groups to ensure multi-objective management is undertaken at caves with cultural heritage values.

Survey and Monitoring priorities

- Undertake regular minimal disturbance monitoring to assess population size and population trends:
    - During the breeding season – monitor numbers using flyout counts at the two main maternity sites at least monthly, with concurrent monitoring at other key roost sites where applicable, to determine total population size. Monitor the Portland maternity cave and nearby non-maternity caves concurrently at least once during the breeding season;
    - Outside the breeding season – monitor numbers at the maternity and other key roost sites to determine the total overwintering population, relative usage of each site, patterns of use, and movement between the roosts.
- Undertake systematic surveys of caves, across all seasons and using minimal disturbance methods, to locate additional roosting sites.
- Regularly monitor the health of individuals (across different age, sex and reproductive classes) at the three maternity sites and key roosting sites to determine if ill-health, disease, pesticides, or malnutrition are contributing to the population decline. Monitor sites for the presence of White-nose Syndrome or other disease-causing fungi. Care is required to minimise disturbance during the health assessments.
- Annually monitor breeding success (numbers born and proportion surviving to weaning age) at the maternity sites.
- Collect demographic data on the survival rates of different age, sex and reproductive classes in the maternity caves. Continue the monitoring project at the Naracoorte maternity cave and instigate a similar project at the Warrnambool maternity site.
- Continue to collect baseline data on microclimatic conditions in the maternity caves and monitor over time.

Information and Research priorities

- Continue to refine monitoring techniques to more accurately estimate population numbers, survival rates, and breeding success, while minimising disturbance.
- Determine whether particular age, sex, or reproductive cohorts are disproportionately contributing to population declines.
- Determine the main cause(s) of population declines and assess the relative impact of each threat to the subspecies.
- Investigate factors that would assist in determining the potential impact of White-nose Syndrome, such as hibernation ecology, immune response, and susceptibility to the fungus that causes the disease.
- Assess the effectiveness of measures taken to reduce disturbance and apply best practice protocols at all sites.
- Identify key foraging areas, particularly within foraging range of the maternity sites and key non-maternity caves.
- Identify nightly distances flown and routes taken and investigate the heights at which Southern Bent-wing Bats fly over different habitats.
- Investigate the subspecies' dietary requirements and important invertebrate prey items. Determine whether foraging resources are limiting.

- If conditions in the maternity caves become sub-optimal, examine the feasibility of artificially modifying the temperature and humidity to increase survival and breeding success. Assess the use of free water as a water source within the caves and the implications of water sources drying up.
- Investigate the cumulative and population level impacts of collisions with wind turbines and the effectiveness of potential mitigation measures.
- Undertake research into possible designs for gates that can be installed at cave exits to prevent human access and undertake trials to assess effectiveness.
- Develop a field identification tool to distinguish between the Southern Bent-wing Bat and the Eastern Bent-wing Bat.
- Collect and analyse genetic samples in central and western Victoria to refine the distribution of the Southern Bent-wing Bat and Eastern Bent-wing Bat.
- Undertake genetic analyses to improve understanding of the subspecies' population structure and movement patterns and the implications of low genetic variation. Investigate whether genetic material can be obtained from faecal matter in order to minimise disturbance.
- Maintain a database for each roosting site that includes: location, condition, management needs, and monitoring information (e.g., population size range). Identify the most important roosting sites, those that require the most urgent management attention, and caves that were used in the past but have since been abandoned.

Recommendations

(i) The Committee recommends that *Miniopterus orianae bassanii* be retained in its current listing status of Critically Endangered in the list referred to in section 178 of the EPBC Act.

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

Threatened Species Scientific Committee

25/02/2021

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