National Recovery Plan for the Southern Bent-wing Bat *Miniopterus schreibersii bassanii*

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This Recovery Plan has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

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Cover photograph: Southern Bent-wing Bat *Miniopterus schreibersii bassanii.* Photo: Terry Reardon and Steve Bourne.

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Abbreviations

ARI	Arthur Rylah Institute for Environmental Research (DELWP, Victoria)
ASF	Australian Speleological Federation
CEGSA	Cave Exploration Group of South Australia
CMA	Catchment Management Authority (Victoria)
DEWNR	Department of Environment, Water and Natural Resources (South Australia)
DELWP	Department of Environment, Land, Water and Planning (Victoria)
EPBC	Environment Protection and Biodiversity Conservation Act 1999
FNCG	Friends of Naracoorte Caves Group
FSA	Forestry South Australia
IUCN	International Union for the Conservation of Nature
NCNP	Naracoorte Caves National Park
NRM	Natural Resources Management Boards (SA)
PIRSA	Department of Primary Industries and Regions South Australia
PV	Parks Victoria
SA	South Australia
SAM	South Australian Museum
VIC	Victoria
VSA	Victorian Speleological Association

Summary

The Southern Bent-wing Bat (*Miniopterus schreibersii bassanii)* is one of only five Australian mammals that is federally listed as Critically Endangered, i.e. it is "facing an extremely high risk of extinction". Implementing the actions in this Recovery Plan is essential to prevent this subspecies declining further in the near future, possibly to extinction.

The Southern Bent-wing Bat was described as a distinct subspecies in 2000, based on genetic and morphological differences, with recent genetic studies suggesting it may warrant full species status. It is an obligate cave-dwelling bat with a restricted distribution, occurring only in south-east South Australia and south-west Victoria. During the non-breeding season individuals are distributed throughout this region roosting in a large number of caves and rock crevices. During the breeding season, however, the majority of the population congregates in just two regularly-used breeding caves, located at Naracoorte in South Australia and Warrnambool in Victoria.

The population size of the Southern Bent-wing Bat has declined dramatically in the last 50 years. In the 1950s and 1960s, there were an estimated 100,000 – 200,000 individuals at the Naracoorte maternity site. By 2001, numbers had declined to 35,000, and in 2009 the estimate was just 20,000 individuals. The numbers in the Warrnambool maternity site declined from approximately 15,000 to 10,000 individuals over the same time period. Due to the severity of this decline and the dependence on just two regularly-used breeding sites, the subspecies was listed as Critically Endangered under the EPBC Act in 2007. It is listed as Endangered in the 'Action Plan for Australian Mammals 2012'. A range of threats have been suggested as potential factors in this decline, including loss and modification of roosting and foraging habitat, human disturbance, pesticides, disease, and drought and climate change affecting food availability. However, there is little empirical evidence to clearly identify the main cause/s of the current decline. Therefore, there is an urgent need to determine the factors contributing to this decline, so that the most effective and targeted management actions can be implemented.

This national Recovery Plan and the Action Plan for Australian Mammals outline the distribution, biology, threats, recovery objectives and actions required to arrest the decline of the Southern Bent-wing Bat. The long-term recovery objective is to ensure that the Southern Bent-wing Bat can survive, flourish and retain its potential for evolutionary development in the wild. The specific objectives of this recovery plan are to:

1. Develop techniques to accurately estimate the population size at the maternity sites and undertake regular assessments of population numbers to thoroughly document population trends.
2. Determine the main cause/s of the recent decline in numbers of Southern Bent-wing Bats, and develop targeted, rapid management responses.
3. Protect the maternity sites and other key non-breeding sites.
4. Protect and enhance foraging habitat around the maternity sites and key non-breeding sites.
5. Clarify the taxonomic status, distribution and population structure of the Southern Bent-wing Bat.
6. Compile and maintain databases to aid in the management of the subspecies.
7. Establish a long term monitoring program for the Southern Bent-wing Bat.
8. Facilitate and promote community interest, understanding and participation.
9. Provide direction and guidance to the recovery of the Southern Bent-wing Bat and review the success of this Recovery Plan.

The implementation of the actions outlined in this Recovery Plan are urgently required to arrest the decline of the Southern Bent-wing Bat and enhance its future conservation prospects.

Species Information

Description and Biology

The Southern Bent-wing Bat *Miniopterus schreibersii bassanii* is currently recognised as a subspecies of the Common Bent-wing Bat *Miniopterus schreibersii.* It is a medium-sized, insectivorous, obligate cave-dwelling bat. The long-fingered bats (*Miniopterus* spp.) have recently been elevated to family status (Miniopteridae), splitting them from the Vespertilionidae (Miller-Butterworth *et al*. 2007; Van Den Bussche and Hoofer 2004).

There are three subspecies of the Common Bent-wing Bat (see Distribution section), which are morphologically similar, but differ genetically and form separate maternity colonies (Cardinal and Christidis 2000). The Southern Bent-wing Bat was described in 2000 based on genetic and skull morphological differences (Cardinal and Christidis 2000). Further genetic analysis suggests it may be reproductively isolated from the sympatric Eastern Bent-wing Bat *M. s. oceanensis* and warrant full species status (Reinhold *et al.* 2000; Wood and Appleton 2010). The Southern Bent-wing Bat is the largest of the three subspecies, having a mean weight of 15.7 g and a mean forearm length of 47.6 mm (Churchill 2008). It is currently not possible to reliably distinguish this subspecies from the Eastern Bent-wing Bat using traditional field-based techniques.

The reproductive pattern of the Common Bent-wing Bat was investigated in the 1960s (Dwyer 1963a; Dwyer 1966b). Although most of this information was collected on the Eastern Bent-wing Bat, it is likely that the Southern Bent-wing Bat follows a similar pattern. Mating occurs in late autumn-early winter and females become pregnant immediately. The implantation of the fertilised egg is, however, delayed until spring, resulting in a gestation period of 6-7 months. Females do not commence breeding until the second year of their life (Dwyer 1963a). In early spring the majority of the population of the Southern Bent-wing Bat commences moving to one of two regularly-used maternity caves (one at Naracoorte in South Australia and the other at Warrnambool in Victoria), using transition caves along the way (Churchill 2008). Breeding females, and a proportion of the males and non-breeding females, congregate in these maternity caves. The Southern Bent-wing Bat is unique in this respect compared to other subspecies, in having males within the maternity caves (Dwyer 1969). Females typically give birth to a single young from mid-November to mid-December, although birthing sometimes occurs as late as January (Kerr and Bonifacio 2009; S. Bourne, pers. comm. 2010; P. Gray, pers. comm. 2000).

The young are born furless at approximately 20% of the mother's body weight (Dwyer 1963a). They are left in clusters in the cave while the adult females forage at night. High temperatures in the maternity chamber help to keep the young warm which is especially important while they are furless and unable to thermoregulate. The young develop rapidly, starting to fly at seven weeks of age and reach adult proportions at 10 weeks (Dwyer 1963a). The young are weaned and independent by February-March, at which time the majority of adults leave the maternity caves, dispersing to non-breeding caves. Some individuals, possibly young of the year, can remain in the maternity caves over winter, especially in the Warrnambool maternity cave.

Southern Bent-wing Bats are long-lived animals: two banded individuals were caught at the Warrnambool maternity cave 20.5 and 18 years after they were initially banded (Lumsden and Gray 2001). Both individuals were reproductively active at the time of recapture. Little is known of the average life span of Southern Bent-wing Bats, however it is likely to be considerably less than these longevity records. Little is known of the survival rates of the various age classes and demographic groups (i.e. males vs. females, juveniles vs. adults).

Distribution

Within Australia there are three subspecies of the Common Bent-wing Bat *M. schreibersii*. The Northern Bent-wing Bat *M. s. orianae* is distributed across the north of Western Australia and Northern Territory; the Eastern Bent-wing Bat *M. s. oceanensis* along the east coast of Australia from Cape York to southern Victoria; and the Southern Bent-wing Bat *M. s. bassanii* in south-west Victoria and south-east South Australia (Cardinal and Christidis 2000). The distribution of the Southern Bent-wing Bat and the Eastern Bent-wing Bat overlap in western Victoria with both subspecies recorded from four caves in the Otways/Camperdown/Lorne area (Cardinal and Christidis 2000).

As an obligate cave-dwelling subspecies, the distribution of the Southern Bent-wing Bat largely reflects the distribution of caves in south-west Victoria and south-east South Australia. The current known distribution of the Southern Bent-wing Bat encompasses the area between Robe, Naracoorte and Port MacDonnell in South Australia, extending eastwards across south-west Victoria. The most easterly sites confirmed by genetic analysis are at Lorne and Pomborneit (Cardinal and Christidis 2000) (Fig. 1). On Fig. 1 this area is shown as the limit of the distribution of this subspecies, as genetic testing of individuals throughout eastern Victoria and southern NSW have not revealed any recent records of Southern Bent-wing Bats outside this range (B. Appleton, pers. comm. 2010). Genetic sampling of bent-wing bats using disused mines in central Victoria revealed only the Eastern Bent-wing Bat, suggesting that the distribution of the Southern Bent-wing Bat does not extend into central Victoria (Lumsden *et al*. 2012). The most northerly site the subspecies has been recorded is Marcollat Cave, 70 km north of Naracoorte (S. Bourne, pers. comm. 2010). Outside this core range, however, there are a number of more distant, old records, some of which are difficult to verify (not shown on Fig. 1). In South Australia, bent-wing bats have been recorded from Melrose (Flinders Ranges), Mount Lofty, Port Adelaide and Brentwood (York Peninsula) (Duncan *et al*. 1999). It has been suggested that some of these may have resulted from bats accidentally transported on ships (Reardon and Flavel 1987). Extensive banding studies were undertaken in the 1960s (Dwyer 1969), and there are several records of individuals moving between the Warrnambool/Naracoorte population and sites north-east of Melbourne and in south-east NSW within the range of the Eastern Bent-wing Bat (Dwyer 1969; Seebeck and Hamilton-Smith 1967). The longest movement recorded was of an adult male banded in 1963 in north-east NSW and recaptured in 1965 at a cave at Panmure, near Warrnambool, a distance of 1300 km (Dwyer 1969). As there are very few of these long distance records compared to the number of recaptures within the normal range, it is assumed that these are not typical but represent vagrant or possibly human assisted movements. The development of field techniques to distinguish between the Southern and Eastern subspecies would assist in determining the distribution of the Southern Bent-wing Bat. Non-genetic techniques could include morphometric or echolocation call differences, as the two subspecies have been shown to call at different frequencies (Conole 2000).

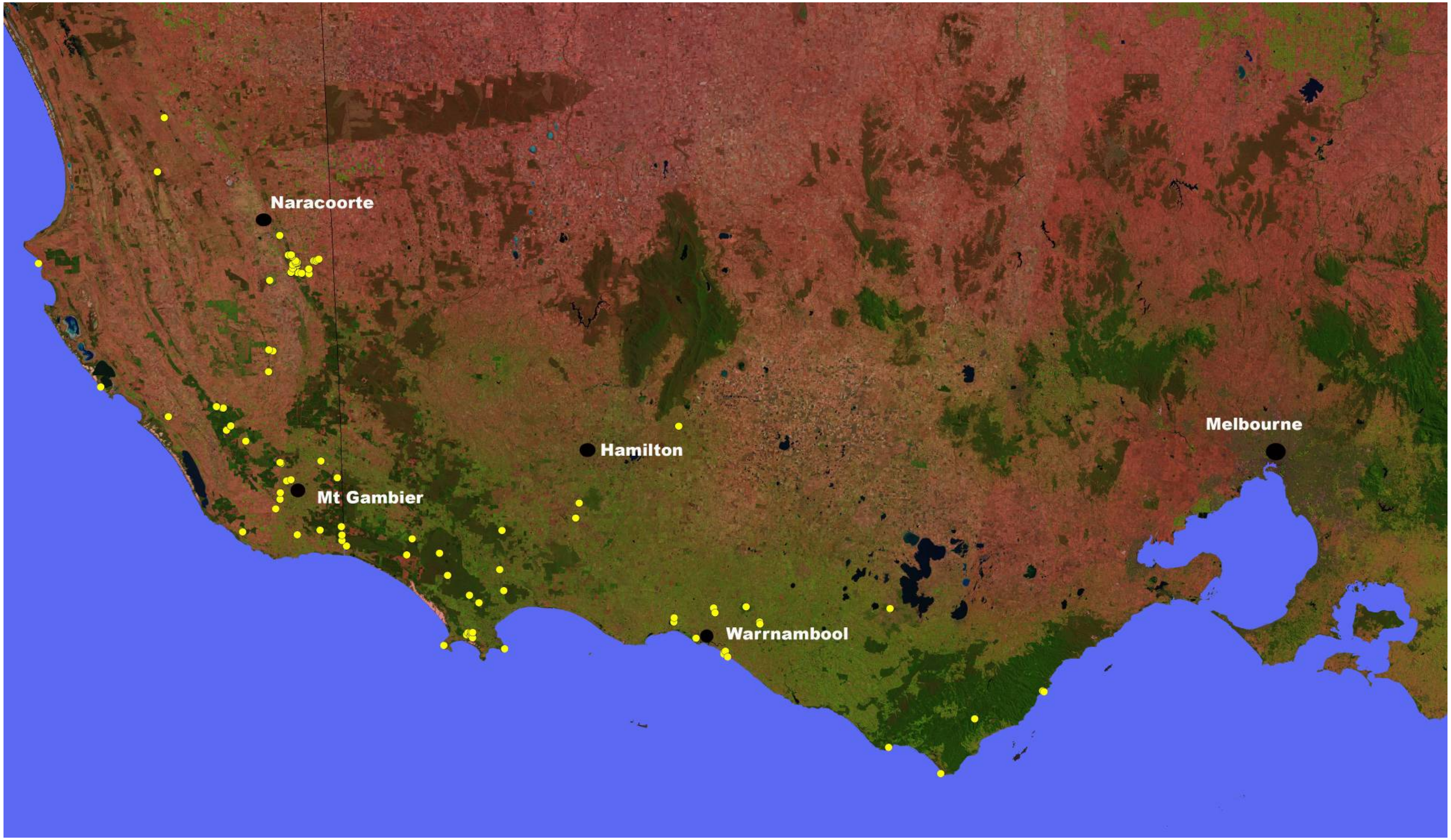

Figure 1 Records of the Southern Bent-wing Bat (*Miniopterus schreibersii bassanii*) in south-eastern Australia.

Habitat

There are two key habitat requirements of the Southern Bent-wing Bat: roost sites and foraging areas. All known roost sites are underground, predominantly in limestone caves but also in lava tunnels, coastal cliff rock crevices and man-made tunnels. Different caves are used seasonally, as the bats seek the appropriate microclimatic conditions.

The only two regularly-used maternity sites are 220 km apart, and migrations between the caves are rare (Dwyer 1969). The maternity site for the Southern Bent-wing Bat population in Victoria is on private land in a cave open to the sea cliff near Warrnambool in western Victoria. The maternity site at Naracoorte in South Australia is within the Naracoorte Caves National Park (Dwyer and Hamilton-Smith 1965). In January 2015, a cluster of well-developed pups were observed in a sea cave near Portland in far southwestern Victoria (T. Mitchell, pers. comm. 2015). Further monitoring will be required to determine if this represents a third true maternity site, or if it is only used occasionally or by transitory animals. Other maternity sites may have been used for limited periods in the past. In 1967, Hamilton-Smith (1967) reported observing 2000 individuals, which included many juveniles, in Thunder Point Blowhole near Warrnambool. The section of the cave in which the bats roosted subsequently collapsed and the site was only used for a few years (E. Hamilton-Smith, pers. comm. 2010). It is now unsuitable as a roost site for bats. There may have been other maternity caves in the region that are now no longer used as breeding sites (C. Grant, pers. comm. 2013).

Colony sizes in non-breeding sites are considerably smaller than those found in maternity caves. Although some sites may contain several thousand individuals, smaller colonies are more typical and individuals may also roost singly. There are 48 known non-breeding caves in South Australia (15 in the Upper South East, 33 in the Lower South East) (Mott and Aslin 2000). Surveys of these non-breeding sites in winter in 1999, 2009, 2010 and 2012 revealed that a subset of these were key roosting sites, containing between 100 and 5000 individuals (Mott and Aslin 2000; Bourne 2010; Lear 2012a). The total number of bats recorded was less than the number recorded at the maternity site during summer. For example, in 2012 the total number of bats recorded during the overwinter census was approximately 15,000, which was 38% of the peak summer count that year (Lear 2012a). If these counts are accurate it indicates that there are as yet unknown alternative over-wintering sites, or obscured areas within known caves. In Victoria, non-breeding sites are spread throughout the southwestern region. Monitoring was undertaken at a number of these key sites in the 2000s (C. Grant, pers. comm. 2010), but the first comprehensive population survey of the Victorian over-wintering sites was undertaken in June 2010. Further information is required on non-breeding sites in both South Australia and Victoria, to locate other important roosts to enable effective management at all sites.

Cave microclimate is an important factor in determining the use of caves by bats. Populations of Southern Bent-wing Bats are dependent on maternity caves that have specific structural characteristics that allow heat and humidity to build up, so as to facilitate the rapid development of the young (Dwyer 1965). High temperatures (approx. 30^{o}C) and high humidity levels (80% RH) have been recorded within the maternity cave at Naracoorte suggesting that the heat produced by the bats themselves increases the temperature by up to 10^{o}C (Baudinette *et al*. 1994). In contrast, during winter bats select cool roost sites that facilitate entry into torpor, where they lower their body temperature to reduce energy expenditure (Hall 1982).

Foraging habitat is also a critical habitat requirement. The Southern Bent-wing Bat has a fast, direct flight pattern and typically forages in open spaces (Dwyer 1965). Where there are trees it typically forages above the canopy, but can fly closer to the ground in more open areas. Limited information is available on foraging habitat used by the Southern

Bent-wing Bat. Individuals radio tracked from the Naracoorte maternity site predominantly foraged along a forested ridgeline within 3-4 km of the cave (Grant 2004). Wetlands are also used extensively, with individuals recorded flying considerable distances to reach these foraging areas. Limited foraging occurred in open pastures and Radiata Pine (*Pinus radiata*) plantations, likely due to the low availability of insects in these habitats during summer when the surveys were performed (Grant 2004). Foraging also occurs over vineyards at times (Bourne 2010). Further south in the Lower South East of SA, wetlands are the preferred foraging habitat, although tracks through both native forest and pine plantations are commonly used (Stratman 2005). Swamps with terrestrial vegetation occurring around the fringes and aquatic vegetation within the swamp itself characterise the wetland habitat used by the subspecies (Stratman 2005). All swamp sites used by the subspecies provided open areas for flight and most were prone to seasonal inundation (Stratman 2005). The typical foraging strategy involves individuals constantly in flight, sometimes meandering between areas after 5-15 minutes of foraging, or flying to a particular foraging area and remaining there for one or more hours (Grant 2004). The Southern Bent-wing Bat can travel long distances from the roost site, with lactating females recorded repeatedly returning to areas 23 – 25 km from the Naracoorte maternity cave (Grant 2004; Bourne 2010). One radio tracked male was recorded 35 km from the roost site (Bourne 2010).

The diet of the Common Bent-wing Bat in eastern Australia consists predominantly of moths, with small quantities of a range of other insect orders also taken (Vestjens and Hall 1977). Little is known of the diet of the Southern Bent-wing Bat, however it is likely that it also feeds predominantly on moths, with moth wings frequently found in the entrances to caves used as roost sites.

Little is known of the impact of fire on bats, although severe wildfire has been shown to reduce the relative abundance of Eastern Bent-wing Bats (Jemison *et al*. 2012). Fire could impact roosting bats if smoke was drawn into caves. Fire could also impact foraging habitat and prey availability for bats, however there is little known on this aspect (Carter *et al*. 2002; Lacki *et al*. 2007). Fire can directly influence insect populations through mortality (McCullough *et al*. 1998) and the removal of vegetation (Webala *et al*. 2011), as well as indirectly as burnt forests regenerate with a different structure from the previous unburnt forest (Webala *et al*. 2011). Large, high intensity fires within foraging range of significant roosting sites could therefore reduce food availability for Southern Bent-wing Bats. Further research is required to gain a greater understanding of the impact of fire on insect populations and its subsequent influence on bat populations.

With the current level of knowledge it is possible to identify some, but not all areas of habitat critical to the survival of this subspecies. The two regularly-used maternity caves are clearly critical to the survival of this subspecies. Non-breeding roost sites used by a significant proportion of the population, or at key times during the yearly cycle, are also considered habitat critical to the survival of the subspecies. A register of important roost sites is being compiled for both states. While the caves themselves are critical, key foraging areas are also considered habitat critical to the survival of this subspecies. However, further work is required to fully define these areas.

Important Populations

Due the severe decline in numbers of the Southern Bent-wing Bat all populations are considered important. Populations are centred around the two regularly-used maternity caves and their associated non-breeding caves. Due to the risk of disturbance to roosting bats, the exact locations of cave-roosting sites are generally not publicised and in keeping with this approach, only general locality references are provided in this Recovery Plan. Detailed locality records are made available directly to land managers.

VIC: Warrnambool maternity cave, plus various caves used as non-breeding roosting sites in south-west Victoria, including in the Lower Glenelg, Bats Ridge, Portland, Byaduk Caves, Yambuk, Grassmere, Panmure, Pomberneit and Otways areas.

SA: Naracoorte maternity cave, plus various caves used as non-breeding roosting sites in south-east South Australia, including Naracoorte Range, Mount Burr Range, Millicent, Mt Gambier and coastal sea cliffs.

Decline and Threats

Declines

The Southern Bent-wing Bat population has declined dramatically in the last 50 years. As the majority of individuals congregate in one of the two maternity caves over summer, estimates of population size at these two locations have been used to estimate the overall population size of this subspecies. While the majority of bats migrate to the maternity caves in the breeding season, not all do, and those roosting in other caves at this time of the year need to be considered to obtain more accurate estimates.

Using the estimates from the maternity sites it is clear that the population at the Naracoorte cave has declined rapidly since estimates were first made in the 1950/1960s. In December 1955, immense numbers were visually estimated to be in the order of 200,000 (E. Hamilton-Smith, pers. comm. 2010). In November/December 1963, based on a mark-recapture study, Dwyer and Hamilton-Smith (1965) estimated there were 100,000–200,000 individuals in the maternity cave. Numbers fluctuated in the 1960s. An epidemic in 1967, coinciding with a drought period, reduced the numbers to approximately 60,000 individuals (E. Hamilton-Smith, pers. comm. 2010). Large numbers of dead bats were observed on the floor of the cave at this time. Veterinary examinations revealed the cause to be an unidentified virus (E. Hamilton-Smith, pers. comm. 2010). The population recovered and in the early 1980s and mid 1990s the population size was assessed qualitatively several times, with estimates suggesting numbers had returned to the early 1960s level (E. Hamilton-Smith, pers. comm. 2010; confirmed by other cavers during this period). In 2000, a mark-recapture study estimated 65,000 individuals, although there were high uncertainty levels around this estimate (Reardon 2001). Due to the imprecise estimates and the disturbance caused to the bats by the mark-recapture method, an alternative technique was developed, with exit counts undertaken using video recording since 2001 (Grant and Reardon 2004). These counts revealed a steady and rapid decline in numbers from 35,000 in 2001, to 20,000 in 2009 (Bourne 2010, Kerr and Bonifacio 2009). The technique for estimating the number of bats leaving the cave was recently refined further using an automated counting system based on thermal imaging technology (Lear *et al*. 2012). Exit counts were undertaken several times a week during the 2011/12 breeding season using this technique. There were regular fluctuations in the number of bats exiting the cave, suggesting that significant numbers of bats were, at times, moving to nearby caves. This indicates that multiple counts are required when estimating yearly population numbers. The results indicate an increase in peak numbers from previous years with counts fluctuating from 25,000 – 37,000 bats during this breeding season (Lear 2012b). Although these figures may suggest an increase in population numbers, this conclusion needs to be treated with caution. It is possible that counts from previous years, which were typically estimated on only one to three occasions per summer, may have been taken at times when a significant proportion of bats had temporarily left the maternity cave, and the figures may not represent a mean for that summer (Lear 2012b).

In the 1960s, the maternity colony at Warrnambool was estimated to contain 10,000-20,000 individuals (Dwyer and Hamilton-Smith 1965). In the 2000s, numbers were estimated from exit counts at 10,000-15,000 individuals (Grant and Reardon 2004; Gray 2000). Video recorded exit counts taken in summer between 2000 and 2004 suggest a decline from 15,000 individuals to less than 10,000 individuals (C. Grant, pers. comm. 2010). Further estimates are required to determine if the population has continued to decline. The Warrnambool maternity colony is comprised of breeding females, non-breeding females and males, with breeding females typically representing 30-40% of adults, non-breeding females 30-40% and males 30% (L. Lumsden and P. Gray, 2001 unpublished data).

In addition to the declines in population size, recent genetic studies have revealed a significant drop in genetic variation within the Southern Bent-wing Bat over the last decade which may have a detrimental impact on the long-term viability of this subspecies (Wood and Appleton 2010).

The severity of the declines in the two populations, and the reliance on just two regularly-used maternity caves has led to the Southern Bent-wing Bat being listed as threatened both nationally and in both states. It was listed as Critically Endangered in 2007 under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999. In Victoria, it is listed as threatened under the *Flora and Fauna Guarantee Ac*t 1988 and considered Critically Endangered (DSE 2013). In South Australia, it is listed as Endangered under the *National Parks and Wildlife Act 1972* (Schedule 7). It is listed as Endangered in the ‘Action Plan for Australian Mammals 2012’, under the revised taxonomic name of *Miniopterus orianae bassanii* (Woinarski et al. 2014). This alternate species name was used as genetic studies have shown that the Australian bats known as *Miniopterus schreibersii* are distinct to those found overseas and a new name is required (Appleton et al. 2004). This species name for the Australian bats is likely to be *orianae*, however this has not yet published and so in this Recovery Plan the earlier name is retained.

Threats

A range of threats have been identified as potentially impacting on the status of the Southern Bent-wing Bat (Kerr and Bonifacio 2009). However, there is little empirical evidence to clearly identify the main cause/s of the current decline. For example, it is not known if factors occurring at the maternity caves, non-breeding caves or in the foraging areas are contributing to this decline, nor if the threats are resulting in increased mortality (e.g. to dispersing young, to adults over summer or during winter) or lower breeding success (e.g. reduced birthing rates, reduced survival of young). Until there is a clear understanding of what factors are causing the decline and how they are impacting on the biology of the subspecies, it is not possible to recommend the most effective mitigation management actions. Due to the rapid decline in numbers, the relative importance of the known or potential threats outlined below needs to be urgently assessed.

<u>Cave management</u>
Previous management of caves has in some cases reduced the suitability of these sites for the Southern Bent-wing Bat. In the 1800s and early 1900s some caves were modified to facilitate the mining of bat guano, by enlarging holes in the roof of the caves (Lewis 1977). This alteration has in some cases significantly changed the microclimate, rendering the cave unsuitable to bats. For example, a cave at Mt Widderin near Skipton in western Victoria, was apparently used by very large numbers of bats in the 1800s, with 6-7 tons of bat guano removed in 1895 (Simpson and Smith 1964). The roof was modified during this process and no bats have been reported using this cave since this time. Some other sites, including the two regularly-used maternity sites, were subject to significant levels of disturbance during guano extraction in the late 19th century (Hamilton-Smith 1998). There is no record of what happened to the bat populations during this period, however the bats returned some time later. Bats did not return to a cave near the Naracoorte maternity cave (Baudinette *et al*. 1994). This cave has recently been restored by capping the hole excavated by the guano miners in the roof of the cave (Baudinette *et al*. 1994), and small numbers of bats have now started roosting in the cave (S. Bourne, pers. comm. 2010). The utilisation of some caves on private land as rubbish dumps has also reduced the availability of habitat for bats (Kerr and Bonifacio 2009).

The intentional closing of caves, either on private property by landholders, on public land for the protection of Aboriginal rock art or as part of a risk mitigation program can also lead to a loss of roosting habitat (Kerr and Bonifacio 2009). In general, bent-wing bats do not tolerate gates installed over exit routes, even those designed with the aim of allowing the movement of bats (Slade and Law 2008).

The Naracoorte maternity cave is managed specifically for the conservation of the bats using it. However, the Warrnambool maternity cave is on private land, with limited conservation management. Recent pasture improvement work using heavy machinery directly above the cave had the potential to collapse the roof of the cave. Had this occurred it would have had catastrophic consequences for the cave and its viability as a breeding site. Discussions are ongoing with relevant stakeholders in an attempt to prevent this occurring in the future. In addition, the location of the Warrnambool maternity site is in a dynamic section of the coast which puts it at risk from collapse. Parts of the cave have collapsed in recent years due to natural weathering. Increased storm frequency as a result of climate change may exacerbate the rate of collapse.

Inappropriate fencing, such as barb wire placed in exit or entry flight paths to a roost cave, may result in locally significant numbers of deaths of individuals. An example of this was observed recently at a cave in Victoria where a tree fall resulted in a change to the bats' flight path, bringing individuals close to a single strand of barb wire on which a number were trapped. The management of vegetation around the entrance of caves can also be an issue with weed growth obstructing flight space.

<u>Human disturbance to roost sites</u>

Many caves used by the Southern Bent-wing Bat receive significant levels of human visitation. Human visitation to the Naracoorte maternity cave is strictly regulated, however the Warrnambool maternity site is at times visited by members of the public. During the breeding season, the young are particularly vulnerable in this cave. If disturbance leads to young being dislodged from the ceiling and falling to the floor of the cave, they are unlikely to be reunited with their mother and will die. This is particularly critical in early summer, when the young are often born in a section of the cave that is only 2-3 m high, leaving them very vulnerable to disturbance. After a couple of days the females shift their young to higher sections of the cave (up to 40 m above the floor of the cave), where they are less susceptible to disturbance. However, large numbers of adults also use this low chamber at times, including over when inactive during the cooler months. Disturbance can have a significant impact, especially from late autumn to early spring when the bats enter torpor to conserve energy. 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 their fat reserves could become depleted before insects are more available in spring, and as a result may starve to death (Kerr and Bonifacio 2009). While physical handling is the greatest risk, lights and noise can also cause significant disturbance to bats in torpor. Activities with the potential to cause catastrophic impacts have occurred occasionally in the past, including shooting and the lighting of fires within roost caves. Abandonment of the roost site may occur if such disturbance occurs repeatedly, or potentially even infrequently (Kerr and Bonifacio 2009). A recent unconfirmed report suggested that a large number of bats had been intentionally killed in a cave near Mount Gambier.

<u>Alteration to the microclimate in the maternity caves</u>

The gathering of large numbers of bats under a domed cave roof assists in increasing and maintaining high temperatures and humidity levels, thus creating an optimal microclimate to increase the survival of the young (Baudinette *et al*. 1994). It is possible that the return of yearling bats to the maternity cave, with the breeding females, is an adaptive strategy that contributes to maintaining this microclimate (E. Hamilton-Smith pers. comm. 2009 in

Kerr and Bonifacio 2009). It is not known if there is a critical population size threshold below which the colony can no longer maintain the required temperatures and humidity for successful breeding (Kerr and Bonifacio 2009).

Impacts on foraging habitat

Since European settlement, approximately 90% of the native vegetation within the distribution of the Southern Bent-wing Bat has been cleared (Department of the Environment Water Heritage and the Arts 2009). As native forested vegetation and wetlands appear to be preferred foraging habitat, especially during the critical breeding period around the Naracoorte maternity cave (Grant 2004; Stratman 2005), these past changes are likely to have significantly impacted on this subspecies. Any recent or future changes to foraging habitat in the foraging range (e.g. within approximately 35 km) of important roosting sites could impact on food availability or diversity, and hence the long-term survival of these populations. Such changes could include draining or modifying wetlands, altering riparian areas, clearing native vegetation, including paddock trees, or inappropriate fire regimes. Habitats surrounding the two regularly-used maternity roosts have already been significantly altered. Extensive vegetation clearance has occurred in the Naracoorte area of South Australia, with remnant vegetation remaining scattered throughout an agricultural and pine plantation matrix, plus there has been extensive draining of wetlands. The clearing of native vegetation for agriculture has been even more severe in the region surrounding the Warrnambool maternity cave, with only small pockets of native vegetation remaining. Further destruction of the remaining habitats in these areas could be highly detrimental to the subspecies survival. In addition to habitat destruction, prey species abundance in foraging areas may also be impacted through agricultural pest control programs. The use of agricultural pesticides may severely reduce the abundance of prey species, such as moths and their larvae.

Pesticides/toxins

Recent studies at both maternity sites have revealed evidence of pesticide residues within bat guano and bats. Concentrations of DDT, DDD and DDE along with other residues were found in both juveniles and adults (Allinson *et al*. 2006; Mispagel *et al*. 2004). DDT has been implicated in significant mortality rates in bats in the USA (Geluso *et al*. 1976). It is not known if these chemicals have contributed to the recent decline in numbers of the Southern Bent-wing Bat. Sub-lethal exposure to DDE (a contaminant and breakdown product of DDT) has been reported to increase metabolic rates. The resulting reduction of body weight and the inability of bats to store sufficient fat reserves for hibernation, may lead to reduced over-winter survival (Allinson *et al*. 2006). DDE may also act as an anti-androgen interfering with sexual development and subsequent fertility of male bats (Allinson *et al*. 2006).

Environmental impacts and climate change

Drought may impact on the reproductive success and adult survival of Southern Bent-wing Bats by reducing prey availability if critical wetland foraging sites dry up. The Naracoorte area suffered below average rainfall over the 2000s, with 2006 recording the lowest rainfall since records began in 1868 (Bourne and Hamiliton-Smith 2007). The drought in conjunction with unusually low temperatures during the breeding season in November and December 2006 are believed to have been the cause of significant mortalities in the maternity cave. Large numbers of emaciated pups were observed and in excess of 500 dead pups were found on the floor of the cave. It appears that the food available to the adults was severely reduced by the combination of lack of water and unusually cold evenings which led the females to abandon their young, resulting in them starving to death (Bourne and Hamiliton-Smith 2007).

Availability of free water to drink may also impact on the subspecies under drought conditions as water bodies dry up. Bats also access water from within the cave, licking droplets of water from drip sites. During the 2006 drought some of the regular water points in the cave dried up, which led to individuals moving to other caves in search of water (Bourne and Hamiliton-Smith 2007).

In the future, climate change is likely to result in more extremes and variability in climatic conditions, including a reduction in rainfall and greater likelihoods of droughts. This has the potential to increasingly impact on the survival and breeding success of the Southern Bent-wing Bat.

Disease

Little is known of the disease risk to the Southern Bent-wing Bat and if this might be a factor in the current decline. In 2008, at Naracoorte there was a high mortality rate of pups, with some individuals having severe ulcerative lesions as well as malnutrition (Bourne 2010). In 2009, a significant proportion of the population was observed with small raised ulcers that were attributed to parasites and a pox virus (Bourne 2010). It is not known if these lesions and ulcers affected survival.

In North America a newly-emerged disease is currently decimating populations of hibernating, cave-roosting bats. White-nose Syndrome is caused by the fungus (*Pseudogymnoascus destructans)* which presents as a visually conspicuous white fungus growth on the face, ears or wings of bats (Gargas *et al*. 2009; Puechmaille *et al*. 2010). Millions of bat deaths have been attributed to the fungus since 2006, with mortality rates approaching 100% in some caves (Puechmaille *et al*. 2010). This disease is rapidly spreading across the USA and has now also been recorded in Canada and Europe (Puechmaille *et al*. 2010). It has not yet been recorded in Australia. However, were it to be inadvertently introduced, it could have equally devastating consequences for Australian cave-dwelling bat species. The fungus grows optimally at temperatures of between 5^{o}C and 10^{o}C, with an upper growth limit of approximately 20^{o}C (Blehert *et al*. 2008). Many of the over-wintering caves used by the Southern Bent-wing Bat are, therefore, within the temperature range suitable for the fungus. The prevalence of other potential disease-causing fungi is unknown.

Introduced predators

Feral Cats (*Felis catus)* and Red Foxes (*Vulpes vulpes)* have been recorded preying on bats as they exit caves, sometimes taking significant numbers. For example, Dwyer (1966a) reported the accumulated remains of 476 Eastern Bent-wing Bats taken by a fox at a cave in NSW over a two year period, and feral cats have been recorded preying on bats as they exited a maternity cave of Eastern Bent-wing Bats in eastern Victoria. The impact of introduced predators on the Southern Bent-wing Bat is not known, however, a fox has been observed within the maternity cave at Warrnambool, with numerous fox scats located in the birthing chamber (L. Lumsden, pers. obs. 2013). Black Rats *Rattus rattus* have been observed in both maternity caves, and are likely to prey on bats (S. Bourne, pers. comm. 2010; L. Lumsden, pers. obs. 2010). Cats have been trapped in and around the Naracoorte maternity cave (S. Bourne, 2010 pers. comm.).

Wind farm developments

The impact of the recent proliferation of wind farms within the range of Southern Bent-wing Bats is currently unclear, however, it is possible that any wind farm built close to a significant roosting site could have a major impact on that population. International studies suggest there may be cumulative impacts of wind farms on migratory species in particular, with the impacts greater at particular times of the year and under certain weather conditions (Johnson *et al.* 2004; Kunz *et al*. 2007). The risk increases the closer the wind farm is to an important site, particularly a maternity site or migration path. Risks include cave destruction during construction, mortalities due to collisions and barotrauma (death resulting from changing air pressure around the moving blades; Baerwald *et al*. 2008), and altered access to foraging areas (Kerr and Bonifacio 2009).

Populations Under Threat

The scale and rapidity of declines of the Southern Bent-wing Bat across its range suggest that all extant populations are facing a high risk of extinction. As the populations based around both regularly-used maternity sites are in decline, it can be considered that all populations of this subspecies are under threat and require urgent recovery actions.

Recovery Information

Existing Conservation Measures

A number of measures have been undertaken to increase knowledge of the biology of the Southern Bent-wing Bat and improve the effectiveness of the management of its habitat.

There have been a number of studies undertaken on the genetics, biology and ecology of the Common Bent-wing Bat, which include information on, or have relevance to, the Southern Bent-wing Bat (e.g. Baudinette *et al*. 1994; Dunsmore *et al*. 1974; Dwyer 1963a, 1963b, 1966a, 1966b, 1969; Dwyer and Hamilton-Smith 1965; Dwyer and Harris 1973; Grant 2004; Hall 1982; Hamilton-Smith 1965; Hamilton-Smith 1967; Seebeck and Hamilton-Smith 1967). While this information provides a strong base to build on, there are still considerable gaps in knowledge of the current status and the threats impacting on the Southern Bent-wing Bat which need to be clearly understood before the appropriate management actions can be implemented to arrest the decline.

Population monitoring commenced at the maternity sites in the 1950s and 1960s using mark-recapture and visual estimates (Dwyer and Hamilton-Smith 1965). Population estimates were intermittent and qualitative until the early 2000s, however the Naracoorte Caves Reserve literature suggests high population numbers were present (e.g. “250,000” “300,000” and “over 400,000”) which gave the impression that the bats were flourishing. From 2000, population counts became more regular, including video counts of exit flights (Grant and Reardon 2004; Gray 2000). In recent years progress has been made on developing more sophisticated techniques to estimate numbers, using thermal imaging cameras in conjunction with missile tracking technology (Betke *et al*. 2008; Melton *et al*. 2005; Lear *et al*. 2012b), using laser beams, marine radar and three dimensional depth sensors (T. Reardon, pers. comm. 2014). With further development, these systems have the potential to significantly increase the accuracy and efficacy of exit counts, so that even small changes in population numbers can be detected.

Efforts have been made to determine the distribution of the subspecies (Cardinal and Christidis 2000; B. Appleton pers. comm. 2010) and the location of non-breeding roost sites. In 2002-2003, regular surveys of selected roosting caves in the lower south east of South Australia and western Victoria were undertaken (C. Grant, pers. comm., 2010). Concurrent surveys of all known roosting caves of the Southern Bent-wing Bat in South Australia and Victoria were undertaken in June 2010 (S. Bourne and G. Lanman, pers. comm., 2010) and July 2012 (K. Lear and A. Bush, pers. comm., 2012). Similar surveys of all known roosts just in south-east South Australia were undertaken in June 1999 (Mott and Aslin 2000) and June 2009 (Bourne 2010). In Victoria over-wintering surveys of roost sites were undertaken in June 2011 (Y. Ingeme, pers. comm., 2011). Not all individuals documented in the maternity sites over summer could be accounted for during any of the winter surveys, indicating that there are as yet unknown roost sites, or that bats are roosting in other structures at this time of the year. Monitoring has been undertaken in key roosting caves in Victoria 2013-2015, using bat detectors recording most nights, to investigate relative levels of activity and seasonal use of caves (A. Bush, pers. comm. 2014).

There has been a long history of managing the maternity site within the Naracoorte Caves National Park specifically for the conservation of the Southern Bent-wing Bat. Infra-red video cameras were installed within the cave in 1995 to provide an ecotourism experience to park visitors. These have also been used effectively to monitor the status and health of the population (Bourne 2010; Bourne and Hamiliton-Smith 2007). When mortality events have been detected, investigations into the causes have been undertaken (Bourne 2010).

Some management actions have been undertaken at the Warrnambool maternity cave, with fencing around the small surface entrance holes to the second chamber and rabbit control. Fox control has been undertaken in 2014 in an attempt to reduce the impact of foxes accessing the maternity chamber and young bats (A. Bush, pers. comm. 2014).

Collaboration between government departments, landowners and community groups has resulted in efforts to remedy some threats. Recent efforts to restore caves through the removal of rubbish in South Australia have been met with some success. Bats were recorded for the first time to use one of the restored caves as an over-wintering roost in 2009 (Kerr and Bonifacio 2009). Other sites have had entrances fenced to exclude stock and people but allow free access to bats. Arrangements have been put in place with landowners to ensure the integrity of each site is maintained and interpretive signage installed to alert cave users of the bats and their conservation status (S. Bourne pers. comm. 2010).

Other management issues have been investigated to varying extents. Studies have been undertaken on pesticide impacts (Allinson *et al*. 2006; McDougall 2002; Mispagel *et al*. 2004). Attempts have been made to design gates that can be installed over mine or cave entrances to prevent human access while enabling use by bats (Gration 2006; Thomson 2002). However, this species does not readily accept gates and further trials are required.

Recovery Objectives

The long-term recovery objective is to ensure that the Southern Bent-wing Bat can survive, flourish and retain its potential for evolutionary development in the wild. The most immediate objectives are to determine the cause of the recent decline, arrest this decline and increase population numbers.

As numbers have declined rapidly there is great urgency to determine the cause of the decline so that the most effective and targeted management actions can be implemented. As a result, many of the actions listed below focus on trying to determine the cause of the decline. This is essential to enable targeted, effective management actions to be developed and implemented.

With intensive research, however, there is the potential, if not planned thoughtfully, to negatively impact on the subspecies that the research is aiming to protect. Therefore, the impact on the survival of individuals due to the resulting level of disturbance in implementing any recovery actions must be fully assessed. A full risk and benefit assessment needs to be undertaken before any projects that may lead to disturbance are implemented.

Within the duration of this Recovery Plan, the specific objectives for the recovery of the Southern Bent-wing Bat are to:

1. Develop techniques to accurately estimate the population size at the maternity sites and undertake regular assessments of population numbers to thoroughly document population trends.
2. Determine the main cause/s of the recent decline in numbers of Southern Bent-wing Bats, and develop targeted, rapid management responses.
3. Protect the maternity sites and other key non-breeding sites.
4. Protect and enhance foraging habitat around the maternity sites and key non-breeding sites.

5. Clarify the taxonomic status, distribution and population structure of the Southern Bent-wing Bat.
6. Compile and maintain databases to aid in the management of the subspecies.
7. Establish a long term monitoring program for the Southern Bent-wing Bat.
8. Facilitate and promote community interest, understanding and participation.
9. Provide direction and guidance to the recovery of the Southern Bent-wing Bat and review the success of this Recovery Plan.

Program Implementation and Evaluation

This Recovery Plan guides recovery actions for the Southern Bent-wing Bat and will be implemented and managed by the relevant nature conservation agency in each State, supported by other agencies, educational institutions, regional natural resource management authorities and community groups, as appropriate. Technical, scientific, habitat management or education components of the Recovery Plan will be referred to specialist groups on research, *in situ* management, or community education, as required. Contact will be maintained between the State agencies on recovery issues concerning the Southern Bent-wing Bat. The Recovery Plan will run for five years from the date of its adoption, with the most important actions scheduled to be undertaken within two years. At the end of this five year period there will be a formal review to assess the success of this Recovery Plan, however, actions required for the recovery of the Southern Bent-wing Bat will be regularly reviewed throughout this period to ensure that the findings of critical studies can be incorporated with new or revised actions developed and implemented. For information on the priority of different actions, see Table 3.

A national Recovery Team will be established to guide the actions needed to recover the Southern Bent-wing Bat. The Recovery Team will be comprised of representatives of key governmental management agencies (as listed in 'Affected Interests'), and representatives of research organisations and special interest groups.

Recovery Objectives and Actions – Detail

Objective 1. Develop techniques to accurately estimate the population size at the maternity sites and undertake regular assessments of population numbers to thoroughly document population trends.

Recovery Criterion: That effective, precise, repeatable, and where possible automated, counting techniques are developed and tested within the first 12 months of the adoption of this Recovery Plan. These techniques are to be employed at the maternity caves on a regular basis (initially at least monthly or more regularly if possible) to provide accurate assessments of population numbers and trends.

<u>Action 1.1</u> Develop techniques to accurately estimate population numbers, survival rates and breeding success.

It is not possible with current methods to accurately determine population numbers, breeding success and survival rates, however these are critical to ascertain current status and population trends, to determine factors causing the decline and to measure the success of this Recovery Plan. Therefore, there is an urgent need to invest in developing new techniques, in three areas. Firstly, develop new, preferably automated, techniques to accurately estimate numbers of bats exiting caves, e.g. thermal imaging automated counting systems, infrared beam system or radar. While some progress has been made on an automated system, further investment is required to fully develop it to the stage that it is operationally effective and efficient. Secondly, investigate the use of PIT (passive inductive transponder) tag technology and innovative recording systems to remotely undertake a mark recapture study that would enable an independent assessment of population size, as well as examine survival rates of various age, sex and reproductive cohorts. Thirdly, develop methods, including remote cameras, for estimating the size of nursery colonies within the maternity caves to assess the survival rate of young from birth to weaning. As part of the development of all three preceding techniques, fully assess the impact of the resulting level of disturbance of their implementation on the survival of individuals. A full risk and benefit assessment needs to be undertaken before any such projects are implemented.

Implementation partners: DEWNR, DELWP

<u>Action 1.2</u> Undertake an intensive program at the maternity sites to regularly estimate numbers, so that current status and population trends can be determined.

Undertake detailed population monitoring at the two regularly-used maternity sites, to determine current status and trends in population size. Monitoring should be undertaken at least monthly at the maternity sites during spring-autumn peak period for the full five year period covered by this Recovery Plan to determine yearly trends and seasonal variation. Where possible, at least initially, these counts should be undertaken on a weekly basis to investigate short term fluctuations. As not all individuals congregate in the maternity caves over summer, concurrent assessments need to also be undertaken at other key roost sites to determine the total population size. Investigate the seasonal and yearly pattern of use of the cave near Portland, where young were first observed in 2015, to determine the importance of this cave as a maternity site.

Implementation partners: DEWNR, DELWP

Objective 2. Determine the main cause/s of the recent decline in numbers of Southern Bent-wing Bats, and identify causal factors to enable targeted, rapid management responses to be implemented.

Recovery Criterion: That the factors causing the decline are identified during an intensive research program, with as many actions as possible undertaken in the first two years after the adoption of this Recovery Plan. That management actions to effectively halt and reverse the decline are identified and implemented.

<u>Action 2.1</u> Monitor the health of individuals in key roosting sites, especially the maternity caves.

Undertake health assessments at key roosts to investigate if ill-health is contributing to the decline. A regular observation program should be developed at the Naracoorte maternity cave using a combination of the infra-red camera system and direct visual assessments, to assess any changes in health or behaviour of bats. Ensure any mass mortality events are detected and investigate causes of mortality of adults or pups (e.g. aborted foetuses, pups dying or being rejected by mothers). Investigate if more cameras are required to ensure all key areas, especially the areas where pups are located, are visible. Trap bats at key sites and collect biological samples to assess health status. Collect any dead or dying individuals from any caves and obtain veterinary diagnosis. Investigate if White-nose Syndrome or other disease-causing fungi are present in roost caves, and assess the risk of introduction. Ensure all observers are alert to the signs of White-nose Syndrome. Develop and publicise a hygiene protocol for White-nose Syndrome for researchers, that can also be used for cavers (see Action 3.7). The impact of disturbance caused during the searches needs to be considered when determining their frequency.

Implementation partners: DEWNR, DELWP, universities

Action 2.2 Determine survival rates of various age and sex cohorts.

Collect demographic data to determine survival rates of both adults and young, especially at the maternity caves, so that overall trends in numbers can be interpreted. Implement the technique developed in Action 1.1 to assess survival rates of each age, sex and reproductive category, i.e. young of the year, breeding females, non-breeding females, adult males. If an automated technique was developed it would be possible to determine survival rates on a daily, weekly, monthly, or yearly basis. This would provide invaluable information to determine if particular cohorts were disproportionably contributing to the current decline and hence enable more targeted recovery actions to be implemented.

Implementation partners: DEWNR, DELWP, SAM

Action 2.3 Undertake direct observations at maternity caves to assess breeding success.

Using infra-red cameras in the maternity cave at Naracoorte, assess the number of young born each year and the proportion surviving to weaning age. Assessing breeding success at the Warrnambool maternity site will be more difficult due to the lack of a monitoring system and the height that the bats typically roost in the cave. However regular observations during the birthing period may provide some information on the number of pups born and carcass searches may provide some indication of mortality rates of pups.

Implementation partners: DEWNR, DELWP

Action 2.4 Determine the microclimatic conditions within the maternity caves.

Collect data on the microclimatic conditions (temperature, humidity and air movement if possible) within the maternity caves. This data would reveal current microclimatic conditions and provide baseline information for future management actions should they be required if conditions in the cave became sub-optimal. Sub-optimal conditions may result from changed conditions in cave, or if a threshold in population size is reached below which the bats themselves cannot generate sufficient heat for successful breeding. If such a threshold was reached determine the feasibility and desirability of artificially increasing the temperature and humidity within the maternity chamber, and implement if appropriate. Assess the use of free water within the cave as a source of water, and the implications if this dries up.

Implementation partners: DEWNR, DELWP

Action 2.5 Undertake a strategic survey program at non-breeding sites to regularly estimate numbers, relative usage and seasonal patterns, so that current status and population trends can be determined.

Separate from the monitoring program at the maternity sites, there is a need to monitor the usage of non-breeding caves, including over-wintering and transition caves, as identified in

Action 6.1. Undertake frequent monitoring at key sites to investigate relative activity levels, movement patterns and seasonal usage. In addition, conduct simultaneous over-wintering counts at all known sites to determine the total known over-wintering population. Any disparity in the over-winter count and the total numbers recorded at the end of the breeding season at the maternity sites will indicate that there are unknown roosts, or that there is a significant die off during the dispersal and/or over-wintering period. This monitoring will aid in understanding the demography and survival rate of bats in these seasonal caves and will contribute to our understanding of the full seasonal cycle of the subspecies.

Implementation partners: DEWNR, DELWP, CEGSA, VSA

<u>Action 2.6</u> Undertake surveys to locate additional unidentified roosting sites.

A systematic search of caves not previously visited in recent winter surveys is required to locate additional roosting sites. Surveys should be undertaken across all seasons. A greater knowledge of all major roosting sites will enhance the understanding of the full seasonal cycle and the subspecies' seasonal migratory pathways, including the use of transition caves (caves which are temporarily occupied during the dispersal to wintering caves and migration back to the maternity sites). While the recent surveys have examined the main known sites, there are many other caves in south-eastern South Australian and western Victoria that have not been surveyed recently for bat activity, some of which are known to have been used by bats in the past. Sites should be checked both for roosting bats and guano piles which would indicate usage even if no bats were present at the time of the inspection. Investigations of cracks and crevices in coastal cliffs may also lead to the identification of new roosting sites. There may also be as yet undiscovered caves throughout this region that may provide roosting habitat.

Implementation partners: DEWNR, DELWP, CEGSA, VSA

<u>Action 2.7</u> Determine availability of foraging resources.

Undertake a range of studies to determine if foraging resources are limiting and if this may be contributing to the decline. Building upon previous studies on foraging behaviour, determine foraging locations, distances traveled to foraging sites, routes taken to reach foraging sites (i.e. are corridors of connecting vegetation required) and prey availability. Conduct habitat preference analysis across all seasons to identify preferred foraging sites. Techniques used in these studies could include a combination of bat detectors, radio tracking and radar. Assess availability and use of free water to determine if this requirement may be limiting. Investigate the impact of fuel reduction burning and wildfire on foraging resources. Predict likely changes to foraging resources under projected climate change scenarios.

Implementation partners: DEWNR, DELWP

<u>Action 2.8</u> Investigate dietary requirements.

An analysis of the dietary requirements of all age, sex and reproductive categories should be undertaken. In addition to using scat analysis to identify prey items, studies should explore alternative identification techniques such as DNA analysis to enable identification to species level. Prey selectivity should be determined by comparing prey to invertebrate samples collected at preferred foraging habitat. Assess body condition of various age classes to provide an indication of whether individuals are obtaining sufficient food for adult survival and for lactating females to produce enough milk to ensure pup survival. The potential for additional key dietary requirements should also be investigated (e.g. mineral requirements).

Implementation partners: DEWNR, DELWP

Action 2.9 Investigate the impact of pesticides.

Undertake targeted research studies on the accumulation and impact of pesticides at the maternity and key roosting sites. Investigations into the link between pesticides and bat decline need to consider the occurrence of pesticides not only in bat faecal material and tissues, but also in the potential source of water and prey.

Implementation partners: DEWNR, DELWP, universities

Action 2.10 Investigate the impact of wind farm developments.

Investigate the potential impact of wind farms on the Southern Bent-wing Bat, including the possibility of undertaking a Population Viability Analysis to assess the cumulative impacts of multiple wind farms within western Victoria and south-eastern South Australia. Extensive data collection will be required (including that outlined in Action 2.2, 2.3) before there is sufficient information to undertake a Population Viability Analysis. Guidelines for pre-construction assessments and post-construction monitoring should be further developed. Results from post-construction mortality monitoring should be routinely reported to state government agencies and collated. Determine if there are regularly used migration routes between key breeding and non-breeding sites and the timing of migration. Undertake regular monitoring of known bat roost caves located within 20 km of existing or planned wind farms. Investigate behaviour of bats in the vicinity of turbines, including the height at which they fly. Funding support from the renewable energy sector should be sought. The establishment of a Southern Bent-wing Bat Scientific Panel, modelled on the Victorian Brolga Scientific Panel, could facilitate the investigation into the impact of wind farms on this subspecies.

Implementation partners: DEWNR, DELWP

Action 2.11 Determine a bat gate design suitable for use on caves

Undertake research to design a gate suitable to install at cave exits to prevent human access that this subspecies will accept, with the dual role of reducing public risk and disturbance levels to the bats. Trials should initially be undertaken on the less threatened Eastern Bent-wing Bat, and once a suitable design has been developed, test this on small colonies of the Southern Bent-wing Bat, monitoring the response closely. If this is successful expand the trial to other sites requiring gating, continuing the intensive monitoring at each location. Trials could be undertaken in conjunction with indigenous groups at caves that have aboriginal heritage values, palaeontological values and bat roosting habitat.

Implementation partners: DEWNR, DELWP, indigenous groups.

Action 2.12 Investigate the feasibility and potential benefits of constructing an artificial maternity cave.

Investigate the feasibility and potential benefits and risks of constructing an artificial maternity cave. This will inform any decision to respond to circumstances where geotechnical investigations or other factors suggest that there is a high risk of collapse of the Warrnambool maternity cave or other factors indicate the need for additional maternity caves. Although there are a few examples of artificial caves being constructed for bats in North America, it is not known if a suitable design could be developed or if it would be used by Southern Bent-wing Bats, especially as a maternity site. Consideration would need to be given to the location, geotechnical suitability, land tenure and security of the site, as well as the design and internal microclimate of the chamber and any potential negative impacts on existing colonies. Therefore, a feasibility study would be required before any artificial cave construction was considered.

Implementation partners: DELWP, geotechnical experts

Action 2.13 Undertake a risk assessment to establish which are the most pressing threats, identify additional priority actions or refine proposed actions to address the key threats, and develop an implementation plan.

As the main factors causing the current decline are unknown, it is not possible to currently list all the management actions that will be required during the life of this Recovery Plan. Due to the rapid rate of decline in the recent past, it will be essential, however, to commence implementing the actions resulting from the above investigations prior to the development of the next five-year Recovery Plan. Therefore, at the end of the first two years of intensive investigation, undertake a risk assessment to identify the most serious threats and develop actions to address these. Establish a process using an adaptive management framework, such that as new knowledge is obtained, management actions are developed or refined, and implemented.

Implementation partners: DEWNR, DELWP, Southern Bent-wing Bat Recovery Team

Objective 3. Protect the maternity sites and other key non-breeding sites.

Recovery Criterion: That the Naracoorte maternity sites continues to be managed for the conservation of this subspecies; that all management actions agreed to by the landowner are implemented at the Warrnambool maternity and that the protection of this site is improved; that plans or agreements have been prepared for other key non-breeding sites; and that all important sites are managed to facilitate the conservation of the Southern Bent-wing Bat.

Action 3.1 Implement active management to protect the maternity sites.

Continue to implement management actions agreed to by the landholder at the Warrnambool maternity site, including maintaining the fence around the surface entrances of the second chamber, controlling rabbits to reduce erosion and fox baiting to reduce predation. Investigate options for improving land security to improve conservation objectives at the Warrnambool maternity site. Continue the current management of the Naracoorte maternity site where the key focus is the conservation of this subspecies (see http://www.environment.sa.gov.au/managing-natural-resources/Park_management/Management_plans/Adopted_management_plans). Develop and implement any required management at the cave near Portland once its status as a maternity site has been assessed.

Implementation partners: DELWP, DEWNR

<u>Action 3.2</u> Prepare and implement management plans/agreements for all key non-breeding sites.

Once the region-wide register of roosting sites has been fully compiled and the most important sites identified (Action 6.1), consult with land managers and landholders to develop management plans or agreements to address management issues at each site, for example, removal of rubbish, weed control, tree growth blocking entrances, modification of inappropriate fencing or reducing human disturbance. Investigate and include, where possible, actions for restoring caves that were used in the past, but were rendered unsuitable by historic guano mining or more recent management actions, as identified in Action 6.1. Consult with indigenous groups where caves have aboriginal heritage values.

Implementation partners: DEWNR, DELWP, FSA, PV, landholders, indigenous groups

<u>Action 3.3</u> Control introduced predators.

Regular monitoring for evidence of predation by introduced predators (fox, cat and rat) should be undertaken at maternity sites and important non-breeding sites. Appropriate predator control measures should be undertaken as required. Private landowners should be offered incentives, if necessary, to extend their pest control efforts.

Implementation partners: DEWNR, DELWP, FSA, PV, landowners

<u>Action 3.4</u> Erect/maintain signs to restrict or discourage access to important cave roosting sites

Information signs at important breeding and non-breeding sites should be erected to educate the public of the risk to the bats from human disturbance. Signs should be placed in appropriate locations for each site, as to not draw increased attention to the site. The signs should also contain general educative information, including the threatened status of the Southern Bent-wing Bat and its role in consuming insects.

Implementation partners: DEWNR, DELWP, FSA, PV, landowners

<u>Action 3.5</u> Provide information and advice to local councils for inclusion in planning processes

Ensure local government authorities continue to be aware of the significance of the two regularly-used maternity sites and have incorporated the need to protect these sites into their municipal strategic statements and planning schemes. Once a list of the key non-breeding sites has been completed (Action 6.1), inform local councils of this information for inclusion in planning processes.

Implementation partners: DEWNR, DELWP, local councils

Action 3.6 Provide information to state government agencies for inclusion in fire planning processes.

Ensure relevant state government authorities, and their partners (Victorian Country Fire Association and South Australian Country Fire Service) are aware of the significance of all key roosting sites on public land and establish buffers around these sites when planning fuel reduction burning, or protection from wildfire. Avoid burning from late autumn to early spring when bats are in torpor. If possible, undertake burning so that smoke blows away from cave entrances not into them. Develop specific prescriptions to minimise the impact of prescribed burning on key foraging habitat.

Implementation partners: DELWP, DEWNR, PV

Action 3.7 Develop and promote a code of conduct for cave visits.

In conjunction with caving organisations (ASF, CEGSA, VSA), develop a detailed code of conduct for people visiting sites containing bats to minimise levels of human disturbance. This code needs to fully assess the risk of disturbance to the bats for all proposed activities. The national code governing caving behaviour and the Minimal Impact Caving Code developed by the Australian Speleological Federation Inc. could form the basis of this code of conduct. Proactively promote this code of conduct both within the caving community and more broadly with the general public. Develop and publicise a hygiene protocol for White-nosed Syndrome outlining hygiene requirements when moving between caves, including for cavers travelling from the USA, Canada or Europe.

Implementation partners: DEWNR, DELWP, ASF, CEGSA, VSA

Objective 4. Protect and enhance foraging habitat around the maternity sites and key non-breeding sites.

Recovery Criterion: That there is no loss of key foraging habitat and that opportunities for restoring or enhancing foraging habitat are explored and undertaken where possible.

Action 4.1 Protect key areas of foraging habitat.

Once key foraging areas are identified around the maternity caves (Action 2.7), discuss the importance of these specific areas with the land managers / landowners and ensure these areas are not cleared or deleteriously modified, using incentives if required. For other areas within the foraging range of maternity or key non-breeding sites, highlight their importance for this subspecies with the aim of ensuring all native vegetation is retained in good condition, using state-based planning mechanisms.

Implementation partners: DEWNR, DELWP, FSA, PV, local councils, CMAs, NRMs

Action 4.2 Restore and enhance foraging habitat.

Identify priority locations for restoring wetlands, woodland, forest and coastal vegetation to provide foraging habitat, or corridors between maternity sites and key foraging areas. The location of these priority sites should avoid areas in close proximity to wind farms. Local landholders or Landcare groups should be encouraged to target these priority areas for revegetation. Options for restoring wetlands in the vicinity of key roosting sites should be explored to increase the availability of foraging habitat. This is likely to involve hydrological assessments and broader discussions at a landscape and multi-disciplinary scale that is outside the scope of this Recovery Plan. However, the requirements of the Southern Bent-wing Bat should contribute to these discussions.

Implementation partners: DEWNR, DELWP, CMAs, NRMs, Landcare groups

Objective 5. Clarify the taxonomic status, distribution and population structure of the Southern Bent-wing Bat.

Recovery Criterion: That information is acquired on the taxonomic status, distribution and population structure of the Southern Bent-wing Bat, and that informed management actions are implemented as a result of this knowledge.

<u>Action 5.1</u> Clarify the taxonomy of bent-wing bats in southern Australia.

Undertake further genetic studies to determine if the Southern Bent-wing Bat is sufficiently distinct to warrant full species recognition.

Implementation partners: universities, in conjunction with DELWP, DEWNR and SAM

<u>Action 5.2</u> Clarify the extent of geographic range based on genetic studies.

Collect and analyse genetic samples from across Victoria, especially in central and western Victoria, to refine the distribution of the two subspecies (*M. s. bassanii* and *M. s. oceanensis*) and fully determine the extent of their ranges.

Implementation partners: universities, DELWP

<u>Action 5.3</u> Develop a field identification tool to distinguish between the two subspecies.

Develop field-based methods to enable the identification of the two subspecies during general survey work to contribute to defining the distribution. This could involve a quick genetic tool, morphometric or echolocation call differences. Develop a reliable automated identification key for Southern Bent-wing Bat echolocation calls.

Implementation partners: universities, SAM, DELWP

<u>Action 5.4</u> Improve understanding of population structure to inform recovery actions.

Investigate population structure by undertaking genetic analyses using nuclear, mitochondrial and microsatellite loci. This information will provide insights into the population structures (both past and present), migration patterns and aspects of the sociobiology of the Southern Bent-wing Bat such as sex-biased dispersal, philopatry and kin-biased roosting behaviour. Further investigate the implications of the recently reported low level of genetic variation. Use genetic heterozygosity as one of the measures of population health over time (see Action 7.1).

Implementation partners: universities, in conjunction with DELWP, DEWNR and SAM

Objective 6. Compile and maintain databases to aid in the management of the subspecies.

Recovery Criterion: That comprehensive, up-to-date information is available to determine the most important roosting sites and management actions to direct priority setting and funding allocation.

Action 6.1 Compile, maintain and assess information on bat roosting sites.

Continue to develop a register of roosting sites used by Southern Bent-wing Bats (caves, rock crevices, tunnels etc) in Victoria and South Australia. The register would contain a range of information relating to the site including the need for intensive management such as weed removal or vegetation management. It would also be a repository for monitoring information on population numbers at each site. Ensure data from monitoring is entered into centralised wildlife databases (the Victorian Biodiversity Atlas and the Biological Databases of South Australia). As part of this process, identify the most important roosting sites, and those that require the most urgent management attention. Also identify caves that were used in the past, but have been rendered unsuitable by historic guano mining or more recent management actions.

Implementation partners: DEWNR, DELWP, CEGSA, VSA

Action 6.2 Develop a project register.

Develop a site-specific register of projects related to on-ground habitat management on both public and private land, and research/monitoring requirements for the Southern Bent-wing Bat. Prioritise the projects to direct funding to the most urgent tasks. The register could also be used to respond to requests for potential offsets resulting from wind farm developments.

Implementation partners: DELWP, DEWNR

Objective 7. Establish a long term monitoring program for the Southern Bent-wing Bat.

Recovery Criterion: That a long term monitoring program is established to facilitate the adaptive management of the subspecies.

Action 7.1 Design and implement a long term monitoring program within an adaptive management framework.

Design a long-term monitoring program, including determining the most appropriate measures of population health (e.g. increase in population size, increase in numbers of breeding females, increase in genetic diversity), to assess changes in the status of the subspecies over time and to evaluate the success of management actions. Using an adaptive management framework, apply knowledge gained from monitoring and other studies to identify and implement the most appropriate management actions.

Implementation partners: DEWNR, DELWP

Objective 8. Facilitate and promote community interest, understanding and participation.

Recovery Criterion: That there is a greater awareness in the general community of the Southern Bent-wing Bat and its current status; and that all relevant community groups feel part of the recovery program.

<u>Action 8.1</u> Develop and implement a communication plan to raise awareness in the general community and with stakeholders.

Develop an integrated communication strategy to raise awareness of the Southern Bent-wing Bat in the general community and with stakeholders. Define communication objectives in the plan and the key messages to be conveyed throughout all communication activities. Such messages may encompass the Southern Bent-wing Bat's threatened status, conservation requirements and the subspecies benefits to the local community. A wide range of communication activities should be explored to achieve communication objectives. These could include print, radio, social networking, electronic media, talks to community groups, presentations to schools, farmer groups, developers and the compilation of information packages. As a part of the communication plan, explore opportunities to make the Southern Bent-wing Bat an icon species for the Naracoorte and Warrnambool regions. Continue and strengthen the Naracoorte Caves bat interpretation program. Support Zoos Victoria's 'Fighting Extinction' program which lists the Southern Bent-wing Bat as one of its 20 priority species.

Implementation partners: DEWNR, DELWP, CMAs, NRMs, Zoos Victoria

<u>Action 8.2</u> Change perceptions of landowners towards pesticide use.

The use of pesticides in agricultural districts within the foraging range of the subspecies is suspected as one of the causes of the Southern Bent-wing Bat population decline. Changing landowners perception of pesticide use will be a major challenge and will require a protracted public relations campaign. Alternatives to traditional agricultural practices (such as use of pesticides) should be identified and promoted in the region. Examples of alternatives are biological farming, organic farming and biological pest control. The introduction of market-based instruments to reward/penalise produce based on evidence of pesticide use could be considered.

Implementation partners: DEWNR, DELWP, DPI, PIRSA, CMAs, NRMs

<u>Action 8.3</u> Maintain and strengthen partnerships with community organisations interested in caves and the conservation of the Southern Bent-wing Bat.

Maintain and strengthen partnerships with cave-focused community groups by involving them in actions outlined in this Recovery Plan, such as compiling a register of bat roosting sites (Action 6.1), register of management actions (Action 6.2), over-wintering counts (Action 2.5) and research projects (e.g. Action 2.2 and 2.6).

Implementation partners: DEWNR, DELWP, CEGSA, VSA, FNCG, PV

<u>Action 8.4</u> Increase broader community participation in revegetation of foraging habitat and the protection and restoration of roosting caves.

Investigate engaging the broader community in undertaking on-ground works such as revegetating areas to provide foraging habitat or movement corridors, and the protection and restoration of roosting sites such as cleaning rubbish out of caves.

Implementation partners: DEWNR, DELWP, PV, FSA, CMAs, NRMs, Landcare groups, FNCG

Action 8.5 Develop closer links with indigenous groups to ensure multi-objective management is undertaken at caves with cultural heritage values.

Continue to consult with traditional owners about the conservation of the Southern Bent-wing Bat, especially where bats are roosting in caves that have cultural heritage values. Involve indigenous groups in the monitoring of any management actions undertaken at these sites. Together develop funding proposals to enable the indigenous community to be involved and undertake on-ground monitoring actions.

Implementation partners: DEWNR, DELWP, indigenous groups

Objective 9. Provide direction and guidance to the recovery of the Southern Bent-wing Bat and review the success of this Recovery Plan.

Recovery Criterion: That an effective, functioning Southern Bent-wing Bat Recovery Team is formed which provides direction and impetus to ensure the actions in this Recovery Plan are funded and implemented; and that at the end of the five year period the Recovery Plan is reviewed and found to have successfully arrested the decline and improved the long-term viability of the Southern Bent-wing Bat.

Action 9.1 Establish a Southern Bent-wing Bat Recovery Team.

Establish a Recovery Team that includes representatives from all responsible organisations and interested parties, potentially including DEWNR, DELWP, Department of the Environment, SAM, PV, FSA, CEGSA, VSA, relevant universities, consultants and private landholders. The Recovery Team would oversee the implementation of the Recovery Plan. It would proactively establish formal links with organisations that have influence over the successful delivery of the recovery plan. An early task of the Recovery Team would be to determine a threshold population size, where if the total population fell below this number it would trigger more intensive recovery actions.

Implementation partners: DEWNR, DELWP, in conjunction with other organisations.

Action 9.2 Conduct a mid-term review of the implementation of the Recovery Plan to assess if the recovery is on-track.

At the end of the third year of the implementation of this Recovery Plan, undertake a review to assess if the proposed actions require revision or modification. Reassess the population size to determine if the subspecies has continued to decline, and if the threshold has been reached for more intensive conservation measures.

Implementation partners: Southern Bent-wing Bat Recovery Team

Action 9.3 Review the implementation of the Recovery Plan and re-assess the status of the subspecies at the end of the five-year period.

Review the implementation and effectiveness of the actions in this Recovery Plan, and commence revising the plan for the following five year period.

Implementation partners: Southern Bent-wing Bat Recovery Team

Management Practices

The conservation of the Southern Bent-wing Bat needs to be a high priority in the management plans of parks and reserves that contain key caves used as roosting sites. Where there have been limited direct management actions aimed at the conservation of this subspecies, greater emphasis should be directed towards protecting it and its habitat in the future. Closer monitoring of the population numbers in caves is required, as well as monitoring and reducing impacts from human disturbance, predation by introduced predators and encroachment by weeds.

The Naracoorte Caves National Park is a key site for the long-term survival of this subspecies. There has been a considerable focus on the conservation of the Southern Bent-wing Bat for many years with the protection of the cave, monitoring of the population directly and with the infrared camera system, and the public education role. However, despite these efforts the population has continued to decline. It is clear, therefore, that relying on protecting this and other key sites is not sufficient and that more needs to be done to arrest the decline and ensure long-term survival. The actions outlined in this Recovery Plan need to be undertaken urgently to increase the likelihood that the decline can be reversed and the situation improved.

Management practices should aim to prevent any further native vegetation removal in terrestrial or wetland environments throughout the range of the Southern Bent-wing Bat. Vegetation clearance processes should be closely adhered to, with the aim that no vegetation within foraging range of any important roosting sites is cleared. Other management actions, such as planned burning, should be undertaken in such a way as to minimise impact on foraging habitat. There should also be an aim to increase the amount of foraging habitat in the vicinity of key roost sites. As these may include large scale wetland restoration projects, this is outside the scope of this Recovery Plan. A multidisciplinary approach is needed to assess the possibility of restoring the long term hydrological balance of wetlands, especially in the Naracoorte region, to improve the insect productivity of these areas and hence increase foraging habitat (C. Grant pers. comm., 2010). Forest and woodland areas are also important foraging habitat. Efforts to expand this foraging habitat should be addressed through dryland revegetation in the area. Revegetation projects should be specifically designed with bats in mind and address the need for corridors between key roosting sites and foraging areas.

National quarantine protocols should continue to strictly enforce restrictions on items that may contain soil or other materials capable of carrying the fungus that causes White-nosed Syndrome, especially caving equipment.

Liaison with indigenous groups should continue where issues arise over the management of caves with cultural heritage values that also provide habitat for bats. Full consultation is required before any management actions are implemented.

Any activities that have the potential to significantly impact the Southern Bent-wing Bat should serve as a trigger under the EPBC Act. Recent examples of activities that have the potential to become a trigger include agricultural practices that risk the collapse of the Warrnambool maternity cave, and wind farm developments. The first step in wind farm development planning should be to avoid any key areas used by the Southern Bent-wing Bat. These areas would be defined by state government authorities. If wind farms are, however, built close to an important site, or potentially within a migration route, then extensive post-construction monitoring is required, and mitigating actions developed, to be used as required. As the full extent of the impact of wind farms is not yet known, including cumulative effects from multiple developments, all wind farms within the range of the Southern Bent-wing Bat should undergo rigorous pre-construction assessments and post-construction monitoring, so that any impacts can be detected. Any known roosting caves located within close proximity of wind farms (e.g. within 10 km) should be regularly monitored for changes in population numbers. New techniques for improving preconstruction assessments should be explored and developed, e.g. radar (Gration 2011). All mortality data should be shared between relevant parties so that it can be used to improve scientific understanding of threats to the subspecies. To facilitate this, information from wind farm monitoring should be collated into a central state government registry in each state.

Affected Interests

Table 1: *The agencies or organisations that will, or could, be affected by the actions of this Recovery Plan*

Agency/Organisation	State	Involvement
Department of the Environment	National	Responsible for the National Recovery Plan, including the funding of its implementation actions. In addition, any action that will have, or is likely to have, a significant impact on the subspecies requires approval from the Environment Minister.
Department of Environment, Water and Natural Resources	South Australia	DEWNR is the primary agency involved in threatened species management on public and private land in SA.
Department of Environment, Land, Water and Planning	Victoria	DELWP is the primary agency involved in threatened species management on public and private land in Victoria.
ForestrySA	South Australia	ForestrySA has responsibility for implementing appropriate management actions in Native Forest Reserves in SA.
Department of Primary Industries and Regions South Australia	South Australia	PIRSA manages the sustainable use of SA's agriculture and forestry.
Parks Victoria	Victoria	PV has responsibility for implementing appropriate management actions in the parks and reserves system in Victoria.
Natural Resources Management Boards (NRM)	South Australia	NRM boards are responsible for managing natural resources in SA.
Catchment Management Authorities (CMA)	Victoria	CMAs are responsible for managing natural resources in Victoria.
Local government	South Australia	Responsible for planning controls.
Local government	Victoria	Responsible for planning controls, particularly in relation to the retention native vegetation.
Cave Exploration Group of South Australia	South Australia	An association whose aim is to promote exploration, preservation and study of karst areas in South Australia.
Friends of Naracoorte Caves Group	South Australia	A Friends group established to support the management of the Naracoorte Caves National Park and World Heritage Area.
Victorian Speleological Association	Victoria	VSA is an association whose aims are to explore and foster the conservation of caves in Victoria.
Australian Speleological Federation	National	ASF is a national organisation with the primary objective of protecting the cave and karst environment of Australia.
Australasian Bat Society	National	A society whose aim is to promote the conservation of all populations of all species of bats in Australasia.
Zoos Victoria	Victoria	Has listed the Southern Bent-wing Bat as one of their priority species for their Fighting Extinction program.

Biodiversity Benefits

This Recovery Plan includes a number of potential biodiversity benefits for other species and ecological communities in south-eastern South Australia and western Victoria. Protection of cave roosting sites and restoring population numbers of Southern Bent-wing Bats will provide protection for the diverse cave-dwelling invertebrate fauna found in conjunction with, and dependant on, bat guano (Bellati *et al*. 2003). The protection, management and restoration of foraging habitat will benefit a wide range of species. The proposed communication actions could provide a broader public education role as threatened mammals have the potential to act as 'flagship' species for highlighting broader nature conservation issues in terrestrial habitats.

There are no anticipated negative impacts to non-target native species as a result of the actions in this Recovery Plan. Any potential impacts, such as disturbance to guano invertebrate fauna during monitoring, will be minimised.

Role and Interests of Indigenous People

The Southern Bent-wing Bat's known distribution occurs across the traditional land of several registered aboriginal parties. Advice was sought from DELWP and DEWNR indigenous facilitators as to the relevant indigenous groups in each state. These groups were contacted and invited to participate in the development of the Recovery Plan. An information kit about the subspecies and the Recovery Plan process was provided, along with an offer to meet with each group. The aim of the consultation was to respect the traditional owners of the land; to seek any traditional or recent knowledge of bats in caves; and to discuss any concerns they may have with the proposed management of caves in their areas.

Table 2: *The indigenous groups consulted during the development of this Recovery Plan*

Group Name	Area represented	Consultation / Discussion
South East Aboriginal Focus Group	South-east South Australia	Sent information and met with group. Made presentation at SEAFG meeting and discussed management issues. The group was concerned about the impact of bats on rock art and requested regular monitoring of the rock art in caves used by bats. The community asked to be involved in the management and that rock art specialists could contribute. They requested funding to enable the aboriginal community to be involved and undertake on-ground assessments.
Gunditj Mirring Traditional Owners Aboriginal Corporation	Gunditj Mirring Appointed RAP* area (Glenelg – West Wimmera – Southern Grampians)	Sent information and met with group. Discussed the subspecies, its conservation and management actions. The group requested a presentation to field staff.
Framlingham Aboriginal Trust	South west Victoria	Sent information and met with a representative of group. Discussed the subspecies, its conservation and management actions.
Kuuyang Maar Aboriginal Corporation	Warrnambool – Lorne area	Sent information and followed up by phone conversation with a representative of the group. Discussed the subspecies, its conservation and management actions. No further consultation was

		requested.
Wadda Wurrung Aboriginal Corporation	Wadda Wurrung RAP application area (Apollo Bay – Werribee – Beaufort)	Sent information and outlined process over the phone – no further consultation was requested.
Wathaurung Aboriginal Corporation	Wathaurung RAP application area (Anglesea – Werribee – Beaufort)	Sent information and outlined process over the phone – no further consultation was requested.

* RAP – Registered Aboriginal Parties with Aboriginal Affairs Victoria, Department of Planning and Community Development in 2009/10 when the consultation was conducted.

Social and Economic Impacts

The implementation of this Recovery Plan, while potentially impacting on some people, is unlikely to cause significant adverse social or economic impacts. One of the two most important sites is within the Naracoorte Caves National Park where management for biodiversity conservation is already a high priority. The other is on private land, and hence there will be minor economic impacts to this landowner with the fencing off of a small area (< 0.1 ha) of productive farmland over the second chamber, although the area around the full footprint of this cave is not fenced. Improving the management of this site would have benefits for the landowner in reducing safety risks to people and stock. Other important sites on private land will be considered for protection through negotiation and voluntary agreements with landowners, supported where possible by the provision of incentives available through regional natural resource management authorities.

Many of the most immediate actions in this Recovery Plan are designed to achieve a greater understanding of the cause of the decline which will lead to appropriate mitigating management actions. The consideration of re-establishing foraging habitat, such as wetlands, may have implications if water is diverted from other projects. These areas are likely to be on public land or, if on private land, financial incentives would be available to landholders. If studies on pesticides revealed these are contributing to the decline of the Southern Bent-wing Bat, changes to the use of pesticides could have economic impacts. Where the findings of investigations recommend changes to management regimes that may have social and economic impacts, comprehensive consultation will be undertaken as part of the implementation process.

The identification of key sites on local government planning schemes will place some restrictions on changes to landuse, such as the building of housing developments or wind farms, where these are in close proximity to sites critical for the survival of this subspecies. The impact on the Southern Bent-wing Bat is currently considered in planning applications for wind farm developments which can place limitations or conditions on where wind farms can be built and potentially how they operate. Conversely, offset requirements from wind farm developments may have positive benefits to local communities or landholders if funding was provided to implement on-ground management actions, such as cleaning rubbish out of caves.

Social impacts may result from differences in management objectives for bat conservation and rock art protection. At the sites where this may be an issue there will be extensive consultation between the land management agency and the traditional owners of the site to develop a satisfactory outcome. A monitoring program would be established to assess the success of this management.

Restricting access to some important bat roosting sites may impact on people wanting to explore caves. Members of caving organisations are generally already responsible with respect to reducing impact on roosting bats, however, other groups or individuals may be impacted by restrictions on access to some caves. This will be approached by increasing awareness of the importance of these sites and the impact of human disturbance, with the aim of voluntary compliance. There may be social and economic benefits through involving the community in the protection of caves and the monitoring of bat populations. The increased awareness of the Southern Bent-wing Bat may, for example, bring more visitors to the Naracoorte Cave National Park and its unique bat viewing facility.

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Estimated Costs and Priority of Recovery Actions

Table 3: *Priority, responsibility and estimated costs ($'000s) of recovery actions. Priority categories are: 1 (essential), 2 (highly desirable), 3 (desirable).*

Action	***Description***	***Priority***	***Responsibility***	***Cost estimate***					
				Year 1	***Year 2***	***Year 3***	***Year 4***	***Year 5***	***Total***
1	**Develop techniques to accurately estimate the population size at the maternity sites and undertake regular assessments of population numbers to thoroughly document population trends.**								
1.1	Develop techniques to accurately estimate population numbers, survival rates and breeding success.	1	DEWNR, DELWP	200	40				**240**
1.2	Undertake an intensive program at the maternity sites, and other key sites, to regularly estimate numbers, so that current status and population trends can be determined.	1	DEWNR, DELWP	80	60	60	60	60	**320**
2	**Determine the main cause/s of the recent decline in numbers of Southern Bent-wing Bats, and identify causal factors to enable targeted, rapid management responses to be implemented.**								
2.1	Monitor the health of individuals in key roosting sites, especially the maternity caves.	1	DEWNR, DELWP	40	40	20	20	20	**140**
2.2	Determine survival rates of various age and sex cohorts.	2	DEWNR, DELWP, SAM	150	50	50	50	50	**350**
2.3	Undertake direct observations at maternity caves to assess breeding success.	1	DEWNR, DELWP	20	20	20	20	20	**100**
2.4	Determine the microclimatic conditions within maternity caves.	3	DEWNR, DELWP	20	20	10	10	10	**70**
Action	***Description***	***Priority***	***Responsibility***	***Cost estimate***					

				Year 1	Year 2	Year 3	Year 4	Year 5	Total
2.5	Undertake a strategic survey program at non-breeding sites to regularly estimate numbers, relative usage and seasonal patterns, so that current status and population trends can be determined.	2	DEWNR, DELWP, CEGSA, VSA	50	50	50	50	50	**250**
2.6	Undertake surveys to locate additional unidentified roosting sites.	2	DEWNR, DELWP, CEGSA, VSA	30	30	30	30	30	**150**
2.7	Determine availability of foraging resources.	2	DEWNR, DELWP	150	150	100			**400**
2.8	Investigate dietary requirements.	1	DEWNR, DELWP	100	100	100			**300**
2.9	Investigate the impact of pesticides.	2	DEWNR, DELWP, universities		75	75			**150**
2.10	Investigate the impact of wind farm developments.	2	DEWNR, DELWP	150	100	100			**350**
2.11	Determine a bat gate design suitable for use on caves.	3	DEWNR, DELWP, indigenous groups		40	40			**80**
2.12	Investigate the feasibility and potential benefits of constructing an artificial maternity cave	3	DELWP				10		**10**
2.13	Undertake a risk assessment to establish which are the most pressing threats, identify additional priority actions or refine existing actions to address the key threats, and develop an implementation plan.	1	DEWNR, DELWP, Southern Bent-wing Bat Recovery Team			30			**30**
3	**Protect the maternity sites and other key non-breeding sites.**								
3.1	Implement active management to protect the maternity sites.	1	DELWP, DEWNR	30	20	20	20	20	**110**

Action	Description	Priority	Responsibility	Cost estimate					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total
3.2	Prepare and implement management plans/agreements for all key non-breeding sites.	1	DEWNR, DELWP, FSA, PV, landholders, indigenous groups		20	20	20	20	**80**
3.3	Control introduced predators.	1	DEWNR, DELWP, FSA, PV, landowners	15	15	15	15	15	**75**
3.4	Erect/maintain signs to restrict or discourage access to important cave roosting sites.	1	DEWNR, DELWP, FSA, PV, landowners	15	15	5	5	5	**45**
3.5	Provide information and advice to local councils for inclusion in planning processes.	1	DEWNR, DELWP, local councils	5	10				**15**
3.6	Provide information to state government agencies for inclusion in fire planning processes.	1	DEWNR, DELWP, PV	5	5				**10**
3.7	Develop and promote a code of conduct for cave visits.	1	DEWNR, DELWP, ASF, CEGSA, VSA	10	10				**20**
4	**Protect and enhance foraging habitat around the maternity sites and key non-breeding sites.**								
4.1	Protect key areas of foraging habitat.	1	DEWNR, DELWP, FSA, PV, local councils, CMAs, NRMs		20				**20**
4.2	Restore and enhance foraging habitat.	1	DEWNR, DELWP, CMAs, NRMs, Landcare groups		20	20			**40**

Action	Description	Priority	Responsibility	Cost estimate					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total
5	**Clarify the taxonomic status, distribution and population structure of the Southern Bent-wing Bat.**								
5.1	Clarify the taxonomy of bent-wing bats in southern Australia.	3	universities in conjunction with DELWP, DEWNR	25					**25**
5.2	Clarify the extent of geographic range based on genetic studies.	2	universities, DELWP	70	70				**140**
5.3	Develop a field identification tool to distinguish between the two subspecies.	2	universities, SAM, DELWP	20		50			**70**
5.4	Improve understanding of population structure to inform recovery actions.	3	universities in conjunction with DELWP, DEWNR and SAM	80	80				**160**
6	**Compile and maintain databases to aid in the management of the subspecies**								
6.1	Compile, maintain and assess information on bat roosting sites.	1	DEWNR, DELWP, CEGSA, VSA	20					**20**
6.2	Develop a project register.	3	DELWP, DEWNR		20				**20**
7	**Establish a long term monitoring program for the Southern Bent-wing Bat.**								
7.1	Design and implement a long term monitoring program within an adaptive management framework.	1	DEWNR, DELWP	40	30	30	30	30	**160**

Action	Description	Priority	Responsibility	Cost estimate					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total
8	**Facilitate and promote community interest, understanding and participation.**								
8.1	Develop and implement a communication plan to raise awareness in the general community and with stakeholders.	2	DEWNR, DELWP	30	30	10	10	10	**90**
8.2	Change perceptions of landowners towards pesticide use.	3	DEWNR, DELWP, DPI		30	10	10	10	**60**
8.3	Maintain and strengthen partnerships with community organisations interested in caves and the conservation of Southern Bent-wing Bat	1	DEWNR, DELWP, CEGSA, VSA, FNCG	10					**10**
8.4	Increase broader community participation in revegetation of foraging habitat and the protection and restoration of roosting caves.	2	DEWNR, DELWP, PV, FSA, CMAs, NRMs, FNCG	40	40	30	30	30	**170**
8.5	Develop closer links with indigenous groups to ensure multi-objective management is undertaken at caves with cultural heritage values.	2	DEWNR, DELWP, indigenous groups	10	10	10	10	10	**50**
9	**Provide direction and guidance to the recovery of the Southern Bent-wing Bat and review the success of this Recovery Plan.**								
9.1	Establish a Southern Bent-wing Bat Recovery Team.	1	DEWNR, DELWP in conjunction with other organisations	10					**10**
9.2	Conduct a mid-term review of the implementation of the Recovery Plan to assess if the recovery is on-track.	1	Southern Bent-wing Bat Recovery Team			10			**10**

Action	*Description*	*Priority*	*Responsibility*	*Cost estimate*					
				Year 1	***Year 2***	***Year 3***	***Year 4***	***Year 5***	***Total***
9.3	Review the implementation of the Recovery Plan and re-assess the status of the subspecies at the end of the five-year period.	1	Southern Bent-wing Bat Recovery Team					20	**20**
Total				**1425**	**1220**	**915**	**400**	**410**	**4,370**

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