CONSERVATION AND MANAGEMENT

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The status and conservation of bats in the Northern Territory

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ABSTRACT

The Northern Territory has 36 species of bats including three fruit-bats. For each species we provide a distribution map as well as descriptions of their ecology that is relevant to their conservation and management. With one exception (*Hipposideros diadema inornatus*), all bat species have relatively broad distributions and species diversity is higher in the northern wet–dry tropics compared to the southern arid zone. Three species, *Saccolaimus saccolaimus*, *Macroderma gigas* and *H. d. inornatus*, are listed as threatened and a further three species, *Taphozous kapalgensis*, *H. stenotis* and *Rhinonicteris aurantius*, have been listed as near threatened under Territory, National and/or International legislative and conservation listings.

Since European settlement, no bat species are thought to have become extinct, although there is little historical data available to confirm this pattern. *M. gigas* has undergone a significant decline in range in recent years, but is currently regarded as secure. *H. d. inornatus* has also suffered a localised extinction, but is also regarded as secure. There are indications that *H. stenotis* may be declining and is in need of further assessment. The main recommendations for the future conservation management of bats in the Northern Territory include: targeted surveys for priority species; general surveys of poorly known areas; establishment of longer-term monitoring programs; further autecological research, particularly for the more common species; and further research to assess the importance of riparian zones as areas of conservation significance for bats.

Key words: distribution, habitat, threatened species, wet–dry tropics

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Introduction

The Northern Territory (N.T.) is the third largest Australian State or Territory and extends from the monsoon tropics in the north to the arid Australian interior in the south. Although the landscape is relatively homogeneous (described later) this environmental gradient, combined with the Territory's large area and relatively unmodified landscape, currently supports 36 of Australia's estimated 83 bat species (17 of Australia's 25 genera, based on Van Dyck and Strahan 2008). The greatest number of species occurs in Kakadu National Park. Compared to other regions in Australia, this level of richness is surpassed only by north Queensland Wet Tropics and north-east New South Wales / south-east Queensland. In this paper, we describe the status and conservation of bats in the N.T. by: reviewing the history of bat research in the N.T. from the earliest observations up until recent times; characterising the environmental attributes of the N.T. landscape; discussing features of the ecology of N.T. bat species; and finally identifying some of the conservation priorities and management recommendations for N.T. bats. Three previous publications provide general conservation assessments of the N.T. bat fauna: Parker (1973, which included all terrestrial mammals), Friend and Braithwaite (1986, primarily focusing on bats that occurred in Kakadu National Park) and Thomson (1991).

Historical Review of Bat Research in the N.T.

The first N.T. bat records of any note were collected by Knut Dahl (1897) during a mammal survey of the wet–dry tropics over a two year period between 1893 and 1896 and by the Horn Expedition in central Australia in 1894 (Spencer 1896). Several decades later Hedley Finlayson (1961) collected bat specimens in central Australia during mammal surveys conducted between 1931–1935 and 1950–1956. The next major bat survey was conducted in 1948 as part of the American–Australian Expedition to Arnhem Land (Johnson 1964), where surveys were centred on Groote Eylandt, Oenpelli, Cobourg Peninsula and Darwin. Between 1969 and 1980, John McKean provided a number of important contributions to bat research in the N.T., namely the discovery and description of *Hipposideros diadema inornatus* (McKean 1970) and *Taphozous kapalgensis* (McKean and Friend 1979) and the first recorded observations of *Saccolaimus saccolaimus* (McKean *et al.* 1981). Significant progress was made in the knowledge of species distributions and habits during the CSIRO wildlife surveys of Kakadu National Park during 1980–1983 (Stage I and II: Friend and Braithwaite 1986) and 1988–1989 (Stage III: Woinarski *et al.* 1989). It was during this time that the taxonomy of several N.T. bat species was resolved (Kitchener 1980; Kitchener and Caputi 1985; Kitchener *et al.* 1986; 1987). In the southern N.T. an intensive field search for roosts of the

Pp. 208–225 in *The Biology and Conservation of Australasian Bats*, edited by Bradley Law, Peggy Eby, Daniel Lunney and Lindy Lumsden. Royal Zoological Society of NSW, Mosman, NSW, Australia. 2011.

Ghost Bat was undertaken between July and October 1983 (Churchill and Helman 1990). Bat surveys involving harp traps and mist-nets were included as part of large-scale bioregional surveys from the late 1980s onwards (e.g. Woinarski *et al.* 1992) and a survey of the microbat fauna of Uluru Kata Tjuta National Park was carried out in April 1992 (Coles 1993). The latter survey involved the use of ultrasonic bat detection methods.

It was not until 1983 that the first detailed ecological study of any bat species occurred; Chris Tidemann led research that assessed the foraging behaviour of *Macroderma gigas* (Tidemann *et al.* 1985). This was followed soon after by research on *Rhinonicteris aurantius* (Churchill 1991; 1994; 1995) and *Pteropus alecto* and *P. scapulatus* (Vardon and Tidemann 1998 ; 1999; Palmer and Woinarski 1999; Palmer *et al.* 2000; Vardon *et al.* 2001). Most recently, habitat relationships, activity patterns and feeding ecology of microbats has been a major focus for research (Milne *et al.* 2005a; Milne *et al.* 2005b; Milne *et al.* 2006). Several bat species that occur in the N.T. have only recently been described, specifically, *T. kapalgensis* (McKean and Friend 1979), *T. hilli* (Kitchener 1980), *Pipistrellus westralis* (Koopman 1984), *P. adamsi* (Kitchener *et al.* 1986), *Vespadelus baverstocki* and *V. finlaysoni* (Kitchener *et al.* 1987), *Mormopterus eleryi* (Reardon *et al.* 2008) and *Nyctophilus daedalus* (Parnaby 2009). Other taxa awaiting formal description include: *M. loriae cobourgiana*, *Mormopterus* 'sp.3' and *Hipposideros diadema ornatus*.

Like all the States, the knowledge base for bats in the N.T. is poorer than for other mammalian orders, as reflected in the N.T. Department of Natural Resources, Environment, the Arts and Sport Fauna Atlas (a spatial database of all known records for vertebrate species in the N.T.). Bats represent almost one third (31%) of all terrestrial mammal species that occur in the N.T. (excluding those considered to be extinct), however they represent only 11% of the 38786 (non-extinct) mammal records contained in the Atlas. The distribution of all known bat records is geographically inconsistent (Figure 1). Records are concentrated around Darwin, Kakadu National Park, and the MacDonnell Ranges and are sparsely distributed throughout the remainder of the N.T.

Characteristics of the Northern Territory

The N.T. occupies almost 1 350 000 km^2 or 17.5% of Australia. Temperature and rainfall gradients, in general, decrease from north to south. The average annual daily maximum temperature gradient is moderate and variable and ranges from 27°C to 33°C, whereas the minimum temperature gradient is steep and uniform and ranges from 12°C to 21°C. The rainfall gradient is steep in the north and gradually tapers in the south ranging between 1700 mm and 200 mm respectively (see Bureau of Meteorology 2009 and associated maps). Topographic relief is relatively low with a maximum elevation of 1531m. The main areas of topographic relief include the western edge of the Kakadu escarpment, eastern edge of the Kimberly Ranges and the MacDonnell Ranges (Figure 2). The MacDonnell Ranges are the highest Australian peaks west of the Eastern Highlands (Great Dividing Range). Cattle grazing is the dominant primary industry. Little land clearing has occurred in the N.T. with the total amount of land clearing estimated to be around 0.4% (National Land and Water Resources Audit 2001; Hosking 2002), however there are increasing pressures for clearing to accommodate agricultural development, particularly in the north (Price *et al.* 2003). The two dominant tenure types are Aboriginal freehold (42.5%) and Pastoral leasehold (46.7%). Parks and Reserves account for 4.2% of the N.T. (Figure 3).

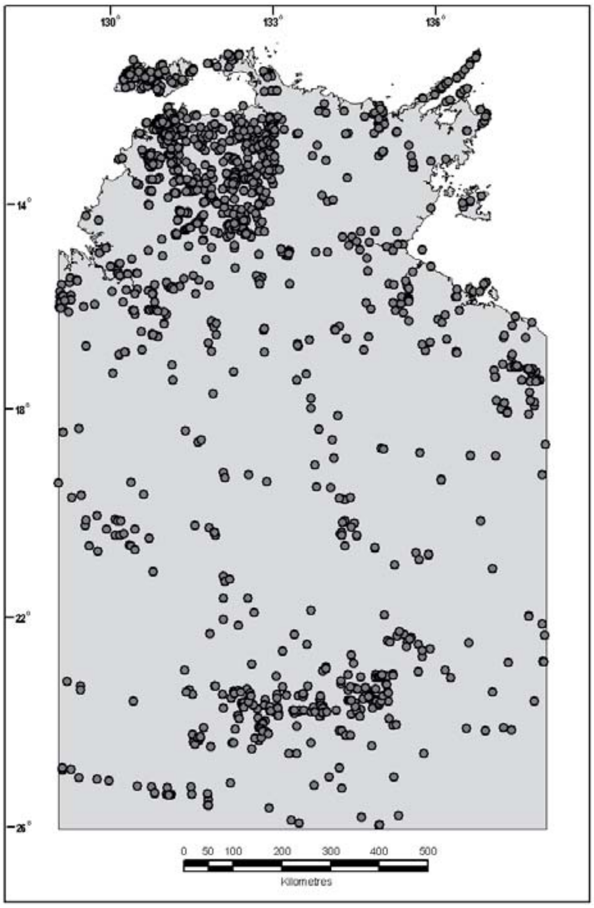

Figure 1. Distribution of all known bat records in the Northern Territory.

The N.T. can be divided into two very broad zones based on temperature and rainfall. These are the wet–dry tropics in the north of the Territory (north of 18° S) and the arid zone (which actually includes arid and semi-arid regions) to the south of this latitude (Figure 3). Descriptions of the wet–dry tropics are provided by Milne (2005a), Woinarski (2000) and Woinarski *et al.* (2005). In summary, average annual rainfall is high and strongly seasonal with most of the rain falling between November and March. Temperature variation is relatively small. Eucalypt forests and woodlands with a grassy understorey dominate 78% of the landscape. Unlike many other tropical regions, the area of monsoon forests is minor occupying just 0.5% of the wet–dry tropics (Fox *et al.* 2001). The southern arid zone is characterised by low average annual rainfall that is highly variable and a steep, north-south temperature gradient. Vegetation is dominated by hummock grasslands (61%). Other major

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vegetation types include *Acacia* woodland/shrubland, including those dominated by Mulga (14%), low Eucalypt woodland (11%) and grasslands (7%) (Wilson *et al.* 1990). Further descriptions of the arid zone environment is provided by Cole and Woinarski (2000), with details of vegetation in Pavey and Nano (2006). Both the wet–dry tropics and arid zone are significantly influenced by the effects of fire and grazing which in turn impact vegetation structure and condition; however, the effects of these on the biota are poorly understood.

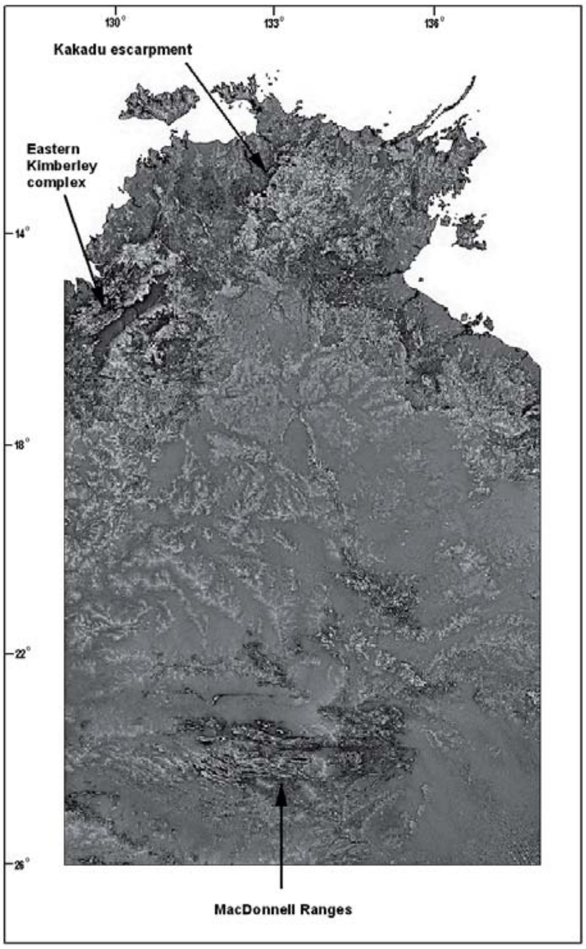

Figure 2. Topography of the Northern Territory (modified from image provided by the Northern Territory Department of Resources).

General Characteristics of Bats

The bat fauna of the N.T. comprises three species of megachiroptera and 33 species of microchiroptera (or according to the recent taxonomic classification of bats proposed by Hutcheon and Kirsch (2006); eight species of Pteropodiformes and 28 species of Vespertilioniformes). The richness of bats is significantly higher in the northern wet–dry tropics (30 species) than the southern arid zone (14 species). Also of interest is the delineation of bat species distributions between these two zones. Species are either widespread across the N.T. (9 species), or are generally limited to either the wet–dry tropics (22 species) or southern arid zone (5 species) (Figure 4). With one exception (*H. d. inornatus*), all bats that occur in the N.T. have relatively broad east–west distributions. Only *H. d. inornatus* is endemic to the N.T. *Taphozous kapalgensis* was previously considered to be endemic, but was recently recorded in far north-east Western Australia (Lumsden *et al.* 2005). Other species that have distributions centred on the N.T. include *H. stenotis* and *N. walkeri*. Three species, *S. saccolaimus*, *M. gigas* and *H. d. inornatus* are regarded as threatened under various listing processes. Three species, *T. kapalgensis*, *H. stenotis* and *Rhinonicteris aurantius* are classified as near threatened (Table 1). No species is currently known to be extinct.

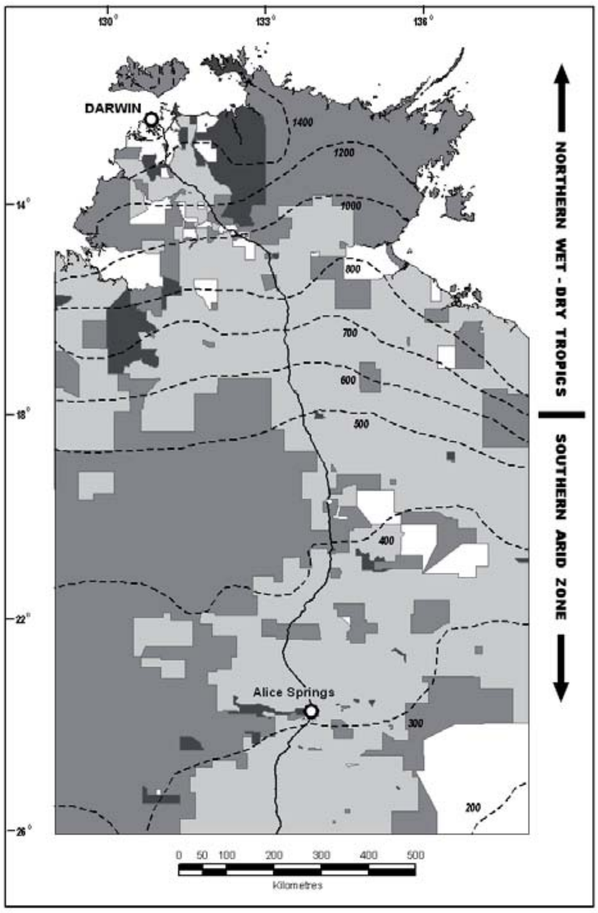

Figure 3. Major land tenure types in the Northern Territory; Parks and Reserves (dark grey), Aboriginal freehold (mid grey), Pastoral leasehold (light grey) and all other tenure types (white). The division between the northern monsoon tropics and the southern arid zone is shown at 18° latitude. Dashed lines indicate average annual rainfall isohyets (mm). Note graduations change from 100 mm to 200 mm above the 800 mm isohyet.

No general assessments (other than descriptive) have been made of the entire N.T. bat fauna, however, in studies of microbats in the wet–dry tropics (Milne *et al.* 2005a; Milne *et al.* 2006) there were, in general, weak associations between species and assemblages and habitats. Higher species diversity was associated with areas of high rainfall and high habitat complexity that mainly included riparian (and surrounding) zones and/or areas with high topographic variability. These same studies identified differences with the bat assemblages of the wet–dry tropics compared to bat assemblages elsewhere in Australia and found that microbat diversity was not associated with waterbodies and vegetation structural complexity in the wet–dry tropics (Milne *et al.* 2005a; Milne *et al.* 2006).

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Species Accounts

Species data (Figure 4) were obtained from the N.T. Department of Natural Resources, Environment, the Arts and Sport Fauna Atlas, which was rigorously assessed for errors by the authors. The number of records (n) is the number of geographically unique locations where the species was identified. Common names follow Armstrong and Reardon (2006).

Macroglossus minimus (n = 40)

The Northern Blossom Bat occurs in the northern wet–dry tropics (Figure 4a) and is common in monsoon forests, mangroves, riparian areas and adjacent woodlands. There are few roosting observations for this species, but it has been recorded in bamboo thickets and rolled-up young leaves of banana trees (Webber 1992 and references therein).

Table 1. Northern Territory bat species and their conservation status under four assessment schemes. Abbreviations: TPWCA, N.T. *Territory Parks and Wildlife Conservation Act 2000*; IUCN, IUCN 2006 *Red List of Threatened Species*; EPBC, *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. With the exception of the EPBC assessment scheme, classification codes are based on the IUCN Red List Categories and Criteria version 3.1 (2001)

Species	Bat Action Plan	TPWCA	IUCN	EPBC
Macroglossus minimus	LR/lc	LC	LR/lc	–
Pteropus alecto	LR/lc	LC	LR/lc	–
Pteropus scapulatus	LR/lc	LC	LR/lc	–
Saccolaimus flaviventris	LR/lc	LC	LR/lc	–
Saccolaimus saccolaimus	CR/A1a	DD	LR/lc	–
Saccolaimus saccolaimus nudicluniatus	–	–	–	critically endangered
Taphozous georgianus	LR/lc	LC	LR/lc	–
Taphozous hilli	LR/lc	LC	LR/lc	–
Taphozous kapalgensis	DD	NT	LR/lc	–
Macroderma gigas	LR/nt	DD	VU/C1	–
Hipposideros ater	LR/lc	LC	LR/lc	–
Hipposideros diadema	–	–	–	–
Hipposideros diadema inornata	DD	VU	VU/D1	–
Hipposideros stenotis	DD	NT	LR/lc	–
Rhinonicteris aurantius	LR/lc	NT	LR/lc	–
Chalinolobus gouldii	LR/lc	LC	LR/lc	–
Chalinolobus morio	LR/lc	LC	LR/lc	–
Chalinolobus nigrogriseus	LR/lc	CL	LR/lc	–
Miniopterus schreibersii	–	–	–	–
Miniopterus schreibersii orianae	LR/lc	LC	–	–
Myotis macropus	LR/lc	LC	LR/lc	–
Nyctophilus arnhemensis	LR/lc	LC	LR/lc	–
Nyctophilus bifax	–	–	LR/lc	–
Nyctophilus daedalus	LR/lc	LC	–	–
Nyctophilus geoffroyi	LR/lc	LC	LR/lc	–
Nyctophilus walkeri	LR/lc	LC	LR/lc	–
Pipistrellus adamsi	LR/lc	LC	LR/lc	–
Pipistrellus westralis	LR/lc	LC	LR/lc	–
Scotorepens balstoni	LR/lc	LC	LR/lc	–
Scotorepens greyii	LR/lc	LC	LR/lc	–
Scotorepens sanborni	LR/lc	LC	LR/lc	–
Vespadelus baverstocki	LR/lc	LC	LR/lc	–
Vespadelus caurinus	LR/lc	LC	LR/lc	–
Vespadelus finlaysoni	LR/lc	LC	LR/lc	–
Chaerephon jobensis	LR/lc	LC	LR/lc	–
Mormopterus beccarii	LR/lc	LC	LR/lc	–
Mormopterus eleryi	DD	LC	DD	–
Mormopterus loriae	DD	–	LR/lc	–
Mormopterus loriae cobourgiana	–	LC	–	–
Mormopterus "sp.3"	LR/lc	LC	LR/lc	–
Tadarida australis	LR/lc	LC	LR/lc	–

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Pteropus alecto **(n = 288)**

The Black Flying-fox is restricted to the wet–dry tropics (Figure 4b) where it has been recorded across a variety of environments; however, floodplains, mangroves, monsoon rainforests, *Melaleuca* open-forest and *Eucalyptus miniata / E. tetrodonta* woodland and open forest have been identified as important environments (Vardon *et al.* 2001). It roosts individually or in camps comprising up to 20 000 individuals (Tidemann *et al.* 1999). Its main roosting habitats include bamboo, mangroves and rainforests (Palmer and Woinarski 1999). Such habitats are restricted in extent and patchily distributed. Although currently secure, the main threat to the Black Flying-fox comes from land clearing, particularly of rainforests. Clearing of rainforest patches increases distances between patches which reduces the ability of Black Flying-foxes to access suitable roosting habitats in relation to variable seasonal food resources.

Pteropus scapulatus **(n = 271)**

The Little Red Flying-fox occurs throughout the tropical N.T., but there are only scattered records from the arid zone. The species forms camps that are usually associated with monsoon rainforest and riverine environments; however, both its spatial and temporal distribution varies dramatically throughout the year. There is a general migration pattern from north to south during the mid–late dry season (July–October) (Vardon and Tidemann 1999), but during the mating and birthing season (November–May), Little Red Flying-foxes can form massive localised congregations in areas such as Mataranka and Flora River Nature Reserve, with upper estimates of over one million individuals (R. Plowright pers. comm.).

Saccolaimus flaviventris **(n = 206)**

The Yellow-bellied Sheath-tailed Bat has been recorded throughout the N.T. (Figure 4c) and across all habitat types. It is patchily distributed in the arid zone, probably due to the relatively low number of trees with large hollows that are suitable for roosting. However, it is particularly common in the wet–dry tropics where it is one of the most frequently detected species using Anabat detectors. It mainly roosts in tree hollows, but has also been recorded in disused animal burrows in the ground and under a rock slab in a creek (Thomson 1991 and references therein). A group of approximately 10 individuals has been observed roosting in a large hollow tree stag (D.M. pers. obs).

Saccolaimus saccolaimus **(n = 9)**

Until recently, the Bare-rumped Sheath-tailed Bat was known from just two locations; two records collected at nearby locations in Kakadu National Park in 1979 and 1980 (McKean *et al.* 1981) and a colony of about 40 individuals found in a tree after it was felled near Berry Springs (50 km south of Darwin) (Churchill 2008 and pers. comm.). In late 2006 a colony of about 100 bats was discovered in and around a hollow tree that had fallen during a storm on a rural property at Howard Springs, about 27 km south-east of Darwin. Genetic and morphological analysis of several individuals led to the subsequent detection of a further nine previously misidentified museum specimens from five locations across the Top End (Figure 4d) (Milne *et al.* 2009). The Howard Springs colony occupied a 12 m tall dead stag with an internal diameter of 25 cm near the top. The presence of several neonate and juvenile bats indicated that it was probably a maternity colony. The echolocation call for *S. saccolaimus* is very similar to *S. flaviventris* (using Anabat detectors) and cannot be used to survey for the species. Given that *S. saccolaimus* has been misidentified as *S. flaviventris* in the past, and diagnostic features to distinguish the two species have since been established (Milne *et al.* 2009), it is likely that *S. saccolaimus* will be detected more frequently in future and be more common that previously thought.

Taphozous georgianus **(n = 162)**

The Common Sheath-tail Bat is common throughout the wet–dry tropics (Figure 4f). It is mainly associated with rocky areas where it is usually observed in groups of around five to ten individuals but occasionally congregations of up to 50 individuals will occur. It is regarded as a cave roosting bat, but also roosts in more exposed areas such as rock cracks and well protected rock overhangs. This gives the Common Sheath-tail Bat a much wider roosting niche compared to many other 'cave' roosting bats.

Taphozous hilli **(n = 76)**

Hill's Sheath-tailed bat is relatively common in rocky range habitat in the arid N.T. Most records come from the MacDonnell Ranges bioregion (Figure 4g), but it also occurs in caves at Uluru Kata Tjuta National Park (Coles 1993) and areas to the north. Rocky overhangs, crevices and caves are used as day roosts and it is often located in relatively well-lit areas of caves. The species forages above the canopy of riverine woodland and Acacia shrubland at night. Although some large roosts containing hundreds of bats are reported, the majority of sites contain 10 or less individuals.

Taphozous kapalgensis **(n = 19)**

Until recently, the Arnhem Sheath-tailed Bat was known from just a hand-full of records collected from Kakadu National Park and near Darwin. More recent surveys, including identification of individuals using echolocation recording technology (Anabat), have increased the total number of sites where this species is known to occur to 19. It has only been recorded from the western half of the wet–dry tropics (Figure 4h), but potentially occurs in the eastern wet–dry tropics as well (Milne *et al.* 2003).

It appears to prefer floodplain and coastal environments as well as adjacent woodland areas. Habitat modelling for this species detected a strong preference for low elevation (usually <50m) landscapes (Milne *et al.* 2006). The roosting preferences for this species are unknown, however some Aboriginal people claim the species roosts in the base of pandanus leaves (Milne and McKean 2008). Records suggest it is sparsely distributed; however *T. kapalgensis* is difficult to detect and is probably more common than records suggest. Floodplain environments are particularly prone to disturbance in the wet–dry tropics via weed infestation and buffalo activities and these processes are probably indirect and minor threats to this species.

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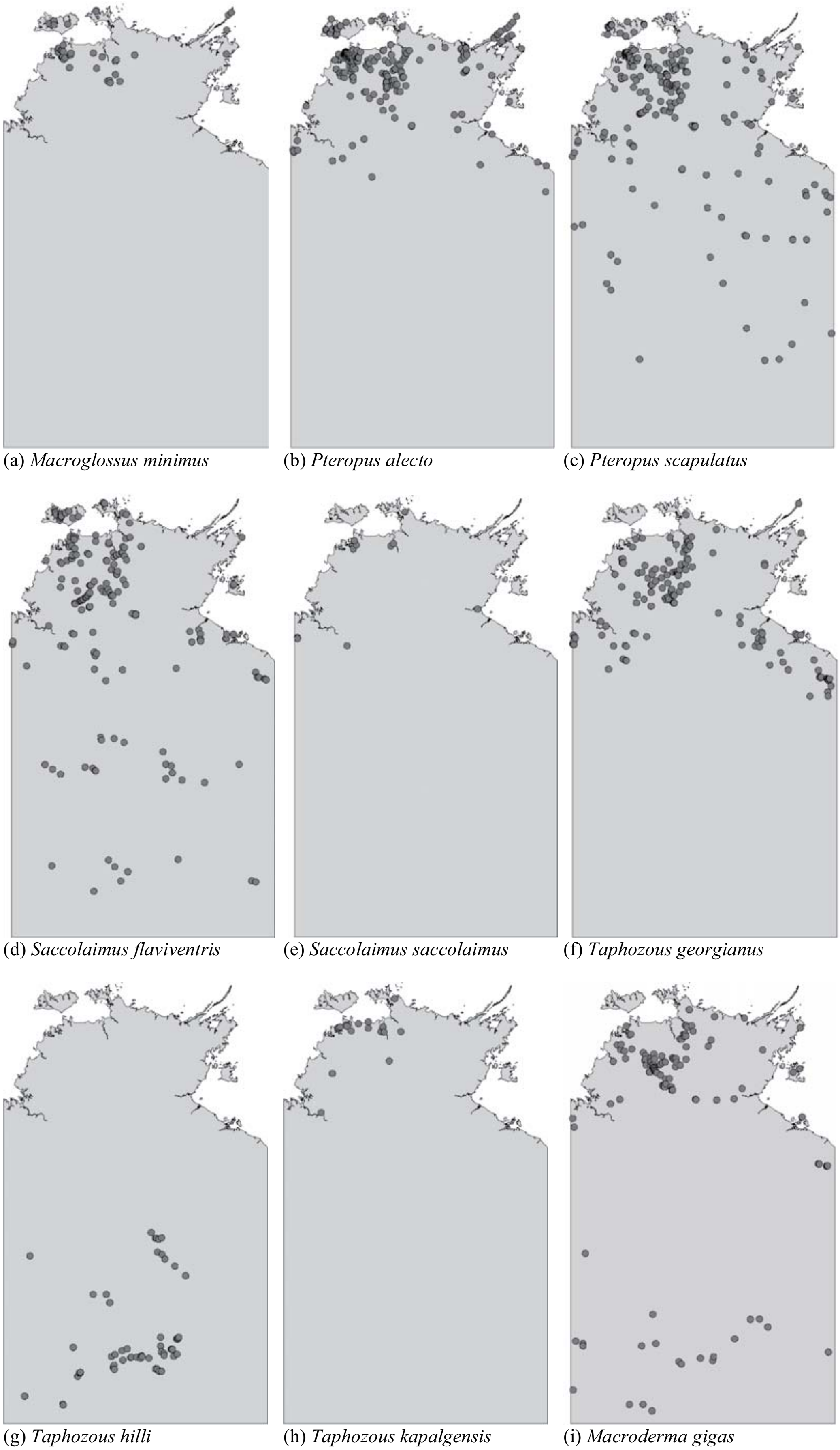

Figure 4. **Distribution maps of each bat species in the Northern Territory.**

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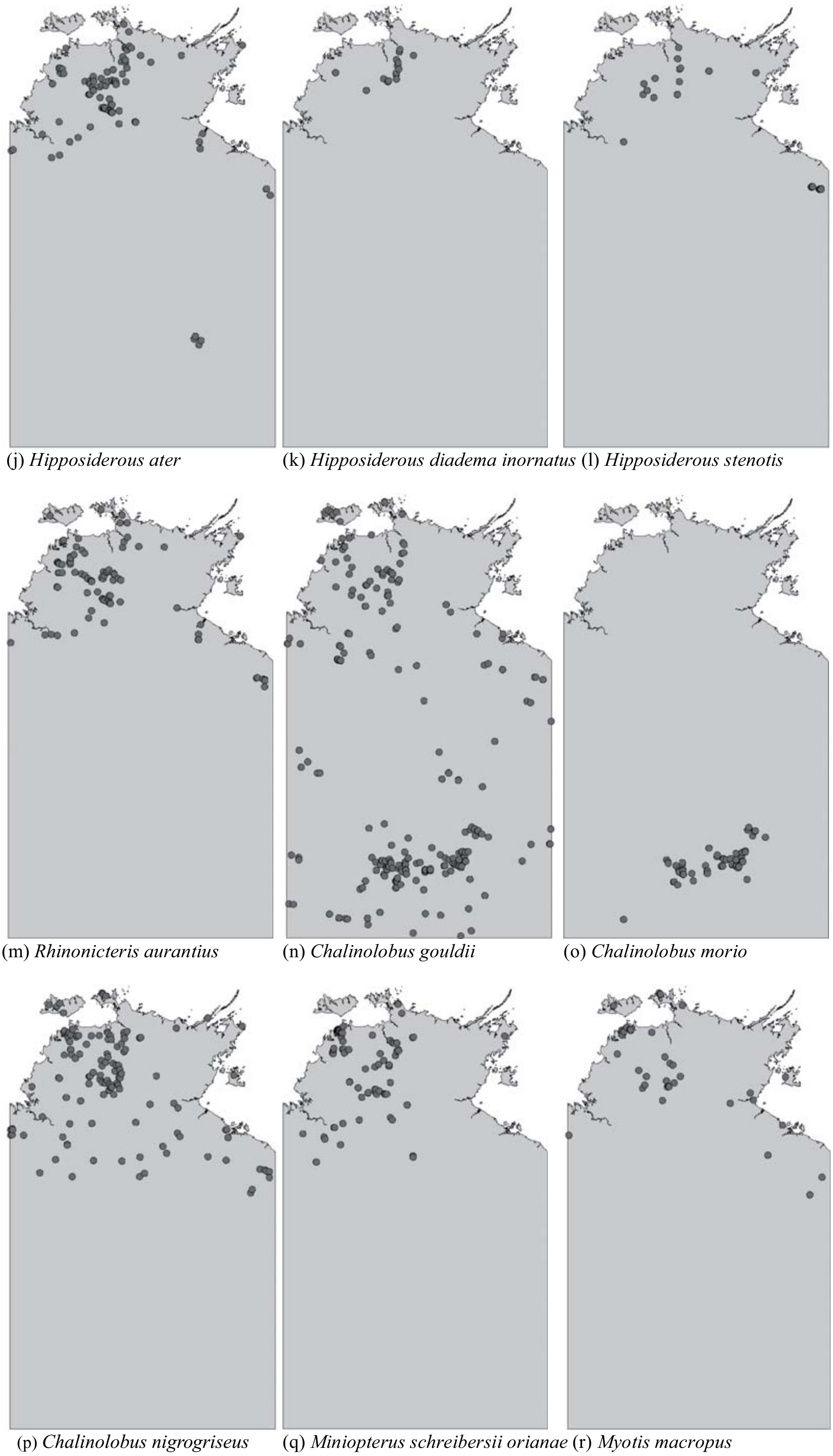

Figure 4. (Cont'd) **Distribution maps of each bat species in the Northern Territory.**

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(s) *Nyctophilus arnhemensis* (t) *Nyctophilus daedalus* (u) *Nyctophilus geoffroyi*

(v) *Nyctophilus walkeri* (w) *Pipistrellus adamsi* (x) *Pipistrellus westralis*

(y) *Scotorepens balstoni* (z) *Scotorepens greyii* (aa) *Scotorepens sanborni*

Figure 4. (Cont'd) **Distribution maps of each bat species in the Northern Territory.**

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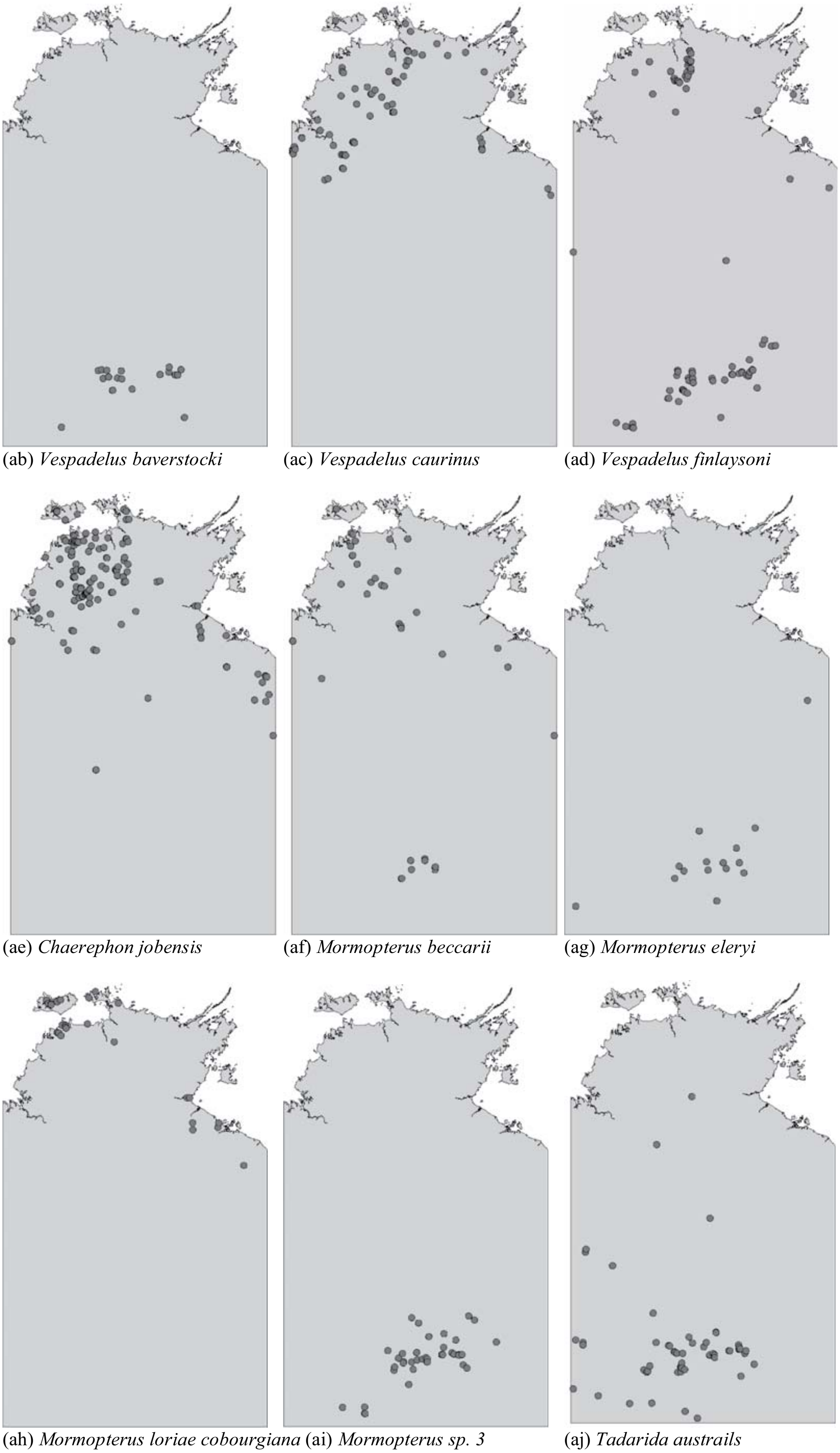

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Macroderma gigas **(n = 129)**

Ghost Bats roost in caves and disused mines and have also been observed in the huts of an abandoned forestry camp at Murgenella, near Cobourg Peninsula, during the northern wet season (DM pers. obs.). The largest known colony is in a disused mine at Pine Creek, 200 km south of Darwin, where on one occasion, 2000 individuals were recorded (Conservation Commission of the Northern Territory, unpublished report). The Ghost Bat occurred in two discrete populations; one in the tropics of the Top End and another in the arid south (Figure 4i). It was probably absent through the central latitudes due to a lack of suitable roosts. The southern population is now extinct and the species has also disappeared from arid regions of Western Australia and South Australia. The last positive record in the arid zone is from Warburton, W.A. in 1961 (Churchill and Helman 1990). The Ghost Bat is still relatively common and secure in the wet–dry tropics. Its disappearance from the arid zone occurred at the same time as the decline and extinction of terrestrial marsupials and rodents (e.g. McKenzie *et al.* 2007). However, in contrast to these species, the range contraction of the Ghost Bat is hypothesised to be associated with climate change in the late Holocene and driven in part by the limited availability of suitable roost sites (Worthington Wilmer *et al.* 1999). Significantly, the Ghost Bat is the sole Australian representative of the Megadermatidae, which is the only Australian bat family in which torpor has not been recorded (Geiser 2006). Torpor is a significant energy saving mechanism in arid environments and an inability to enter torpor could be a significant limitation to survival in areas that experience temporal variation in availability of food resources.

Hipposideros ater **(n = 99)**

The Dusky Leaf-nosed Bat is distributed across the wet–dry tropics of the N.T. A small isolated population was discovered, well to the south of this region, at four localities in the Dulcie Ranges in 1987 and at an additional two localities in 2006 (Figure 4j). It occurs throughout a variety of habitats wherever there are rocky hills and escarpments. It prefers relatively deep caves or disused mines for roosting, but in other parts of its range it has been recorded using a variety of other roost sites including tree hollows. The species shows a preference for foraging close to vegetation.

Hipposideros diadema inornata **(n = 16)**

The Arnhem Leaf-nosed Bat is currently only found in Kakadu National Park where it has been recorded along the Kakadu escarpment and associated gorges (Figure 4k). A small colony of Arnhem Leaf-nosed bats was also known from a cave in Litchfield National Park around 100 km south of Darwin (McKean and Hertog 1979), however several targeted searches of the area have not detected its presence since 1983. Therefore, it may now be locally extinct, probably as a result of human disturbance of the roost site which is likely to be the main threatening process. Only two other roost sites have ever been recorded; a sandstone cave and a disused mine adit. It is therefore classified by the N.T. *Territory Parks and Wildlife Act* as 'Vulnerable'. The Bat Action Plan (Duncan *et al.* 1999) classifies it as 'Data Deficient' and the IUCN classification and EPBC Act do not address this sub-species of *H. diadema*. Despite this, based on capture records and echolocation recording data, the Arnhem Leaf-nosed Bat appears to be relatively secure within its known range.

Hipposideros stenotis **(n = 24)**

The Northern Leaf-nosed Bat occurs sparsely across the wet–dry tropics (Figure 4l) around sandstone hills and escarpments. They roost in caves, boulder piles and road culverts and disused mines (Churchill 2008) and forage close to the ground (Thomson 1991). Classified as 'Near Threatened' by the NT *Territory Parks and Wildlife Act* and IUCN, 'Data deficient' by the Australian Bat Action Plan and unlisted by the EPBC Act, there are some indications that *H. stenotis* may be declining and, therefore, that its conservation status should be upgraded. There are only 24 records for the Northern Leaf-nosed bat, just five of those collected in the last 10 years. Modelling by Milne *et al*. (2006) suggests areas of suitable habitat are highly fragmented making local populations prone to extinction. A series of recent intensive surveys that included targeted searches of rocky hills and escarpments detected its presence at just two locations (Palmer and Churchill 2000; Milne *et al.* 2005a; Woinarski unpublished data). However, the Northern Leaf-nosed Bat is a difficult species to detect and vast areas of potentially suitable habitat have not been surveyed and therefore its current N.T. classification is probably appropriate, but in need of attention.

Rhinonicteris aurantius **(n = 92)**

Opinions over the status of the Orange Leaf-nosed Bat have varied over the past four decades (Parker 1973; Ride and Wilson 1982; Churchill *et al.* 1987; Duncan *et al.* 1999), but it is now considered to be relatively common. It has been recorded across the wet–dry tropics (Figure 4m) and generally occurs around rocky hills and escarpments and roosts in hot and humid caves and disused mines in colonies of up to 25000 individuals (Churchill 1991). They have also been recorded in houses and a disused tank stand (Thomson 1991). Roosting colonies are susceptible to disturbance and will readily abandon roost sites if interference occurs. It has been detected tens of kilometres from any known cave (D.M. pers. obs.) lending weight to the suggestion that they may, at times, use trees for roosting (Churchill 2008).

Chalinolobus gouldii **(n = 277)**

Gould's Wattled Bat is common and widespread in the N.T. (Figure 4n). It occupies a wide range of foraging habitats in forest, woodland and shrubland. Roosts in the Alice Springs district are typically in hollows in Eucalypts, particularly River Red Gums (*E. camaldulensis*), along river channels and creeklines. Individuals in the far northern tropics (distinct from the disputed *C. g. venatoris*: refer Chruszcz and Barclay 2002 and references therein) are smaller and have a higher call frequency and may be a distinct sub-species.

Chalinolobus morio **(n = 87)**

A disjunct population of the Chocolate Wattled Bat occurs in the southern N.T. and is centred on the mountain ranges of central Australia (Figure 4o). The species is one of the

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most common bats in central Australia, including in and around Alice Springs. For example, it was the most frequently captured species in harp traps and mist-nets during a survey of the West MacDonnell Ranges (Gibson and Cole 1993) and the second most commonly captured species during a survey in the eastern McDonnell Ranges (Gibson *et al.* 1992). The Chocolate Wattled Bat forages in a variety of vegetation associations including riparian woodland and Acacia shrubland. It generally flies below canopy height and often close to vegetation where it captures flying insects.

Chalinolobus nigrogriseus **(n = 135)**

Records for the Hoary Wattled Bat occur neatly above the latitude line of 18°S (Figure 4p). It is common and displays no preference for any habitat type, although it is less common close to the coast (Milne *et al.* 2006). Only one roosting observation has been made; one individual was found in a small hollow of a dead tree branch.

Miniopterus schreibersii orianae **(n = 93)**

The Northern Bent-winged Bat is probably the most common bat encountered in human-made structures such as sheds and houses, storm-water drains and road culverts, giving the impression that it is an abundant species. The largest known colony occurs in storm water drains in Darwin. However, it is sporadically captured in harp-traps and mist-nets in natural environments and appears less abundant than most other microbat species (Friend and Braithwaite 1986; Woinarski *et al*. 1989; Milne *et al*. 2005a). Therefore it is regarded as locally common, but patchily distributed. Records for the Northern Bent-winged bat are located in the western wet–dry tropics (Figure 4q), however its general absence from eastern areas is likely due to a lack of sampling in these areas. As well as man-made structures, it occurs in caves and disused mines and occurs throughout a variety of environments generally in association with rocky hills and escarpments.

Myotis macropus **(n = 43)**

The Large-footed Myotis occurs at very low densities in the wet–dry tropics (Figure 4r), where it is trapped only very occasionally in mist-nets and harp traps, but its status is probably secure. It is associated with areas of open fresh water, but appears to prefer permanent creeks with relatively dense surrounding vegetation. It roosts in caves, under bridges and road culverts and in storm water drains.

Nyctophilus arnhemensis **(n = 94)**

The Northern Long-eared Bat is common and secure across the wet–dry tropics, particularly in the far north (Figure 4s). It occurs across a variety of habitat types, but favours riverine and monsoonal vegetation as well as coastal environments. Churchill (2008) reports the Northern Long-eared bat as roosting under loose bark of *Melaleuca leucadendra*, amongst rainforest foliage and *Pandanus* leaves and has also been found in a house.

Nyctophilus daedalus **(n = 47)**

The total number of records for the Pallid Long-eared Bat is relatively low, suggesting it occurs sparsely across its range. Although distributional modelling (Milne *et al.* 2006) suggests that it is likely to be more prevalent in the north-eastern wet–dry tropics, very little survey work has been conducted in that area. It is probably secure. Very little habitat information and no roosting information are available for this species in the N.T. It has been detected on creeklines with riverine vegetation (paperbark *Melaleuca* and *Lophostemon*) associated with rocky hills (D.M. pers. obs.), as well as predominantly open forest habitats (Woinarski *et al.* 1989)

Nyctophilus geoffroyi **(n = 162)**

The Lesser Long-eared Bat occurs throughout the N.T. (Figure 4u). Interestingly, there are virtually no records of this species north of Pine Creek (200 km south of Darwin) prior to 1983. It has been recorded from the edge of *Avicennia* mangrove forest adjacent to floodplains, creeklines associated with rocky hills (pers. obs.), predominantly open forest habitats (Woinarski *et al.* 1989), denser forests and grasslands / sedgelands (Friend and Braithwaite 1986). In the arid N.T. the species occupies riparian woodland and Acacia shrubland. It roosts mainly in trees, but has also been recorded in caves and rock crevices (Parker 1973).

Nyctophilus walkeri **(n = 81)**

Although described in 1892, the Pygmy Long-eared Bat has only been detected with any regularity since 1980. The increased reporting rate coincides with the regular use of harp-traps within its range (Tidemann and Woodside 1978) in which Pygmy Long-eared Bats are readily caught. It mainly occurs along creeks and rivers with habitat modelling revealing a preference for escarpment areas (Milne *et al.* 2006). They have been observed roosting under dead fronds of *Livistona* palms. The Pygmy Long-eared bat is now regarded as common and is found across the wet–dry tropics of the N.T. (Figure 4v).

Pipistrellus adamsi **(n = 79)**

The Forest Pipistrelle occurs in the wet–dry tropics north of approximately 15°S (Figure 4w). As with many other species, its apparent absence from most areas of Arnhem Land is most likely due to a lack of surveys in that area. It is common and is found throughout a variety of habitats, however its distribution suggests that it prefers the taller woodlands and forests that occur in the more northerly areas of the wet–dry tropics. No roost sites have been recorded, but the species is likely to roost in tree hollows.

Pipistrellus westralis **(n = 20)**

Although there are only 20 records from the north-east coast and mouth of the Roper River (Figure 4x), the Northern Pipistrelle is probably common around most of the wet–dry tropics coastline. It occupies mangroves, floodplains, riverine forests and adjacent woodlands. Habitat modelling for this species shows a strong association with lowland (usually <30m) areas (Milne *et al.* 2006). No roost sites have been found, but it is highly likely to roost in tree hollows.

Scotorepens balstoni **(n = 123)**

The Inland Broad-nosed Bat is relatively widespread in the arid N.T. (Figure 4y) and is one of the more common bats in locations such as the MacDonnell Ranges and the

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Finke bioregion (Gibson *et al.* 1992; Gibson and Cole 1993, C. Pavey, unpublished data). It generally forages above the canopy of woodland and shrubland and has a fast to moderate flight. Pregnant females have been recorded in the MacDonnell Range bioregion in September and October (Gibson *et al.* 1992). It mostly roosts in tree hollows, but has also been observed in roofs of buildings and a length of water pipe (Thomson 1991).

Scotorepens greyii (n = 158) and *Scotorepens sanborni* (n = 2)

The Eastern Broad-nosed Bat S. *greyii* and the Northern Broad-nosed Bat *S. sanborni* cannot be readily identified from each other (Churchill 2008), therefore their distribution and status are unclear. Based on confirmed identifications of 64 specimens from 16 localities (Kitchener and Caputi 1985), it is assumed that *S. sanborni* is restricted to the north-east of the wet–dry tropics and that *S. greyii* is distributed throughout the entire N.T. (Figures 4z and 4aa). This is likely to hold true for *S. greyii* where 48 specimens from 14 localities have been confirmed from throughout the N.T. *S. sanborni,* however, was identified from just six specimens collected at two localities, which is inadequate to ascribe distribution. It is also highly likely that several other records are erroneous due to misidentifications. Given that *S. sanborni* occurs in both northern W.A. and northern Queensland the likelihood that *S. sanborni* occurs in other areas of the wet–dry tropics is high. Further, claims by McKenzie & Muir (2000), that the species are allopatric are likely to be incorrect as in one instance, Kitchener and Caputi (1985) identified both species at the same site. Although no roost sites have been observed, both species most likely roost in tree hollows.

Vespadelus baverstocki (n = 32)

The distribution of the Inland Forest Bat in the N.T. is restricted to the arid zone with its range centred in the woodland and shrubland of the MacDonnell Ranges bioregion (Figure 4ab). This species is apparently an obligate hollow-rooster and it forages below canopy height. It is a relatively common bat within the suburbs of Alice Springs.

Vespadelus caurinus (n = 78)

The Northern Cave Bat is common across the rocky hills and escarpments of the wet–dry tropics (Figure 4ac). It is a cave roosting species, but has also been found in concrete structures such as bridges and road culverts as well as under elevated houses. It prefers smaller cracks and crevasses rather than deep caves, which provides greater roosting opportunities for the Northern Cave Bat compared to other species that require true caves. Colony size is variable but seems to average around 20 individuals.

Vespadelus finlaysoni (n = 104)

Finlayson's Cave Bat is found across most of the N.T., but is apparently absent from the Victoria River region (Figure 4ad). Like the Northern Cave Bat, it roosts in caves and mines and is common wherever there are rocky hills and escarpments. Until recently, it has largely been overlooked in the far north where it has probably been confused with the morphologically similar *V. caurinus*. The species is the most abundant cave roosting bat in the southern N.T. Major roosts are located in caves and disused mines around Alice Springs and in the MacDonnell Ranges. It also occurs in caves at Uluru Kata Tjuta National Park (Coles 1993).

Chaerephon jobensis (n = 152)

The Northern Freetail-bat is largely restricted to the wet–dry tropics where it is common and widespread (Figure 4ae). It is the most frequently detected species using Anabat detectors. It mainly roosts in large hollow trees where congregations of up to 100 individuals have been observed. It has also been observed roosting in other wooden structures including buildings, bridges and jetties. A small colony was also recorded from a crack in a rock wall (Begg and McKean 1982).

Mormopterus beccarii (n = 43)

Beccari's Free-tailed Bat is uncommon and occurs sparsely across the N.T. A disjunct population appears to occur in the Alice Springs region (Figure 4af), however this likely reflects the lack of bat sampling throughout central regions of the N.T. It most likely roosts in trees.

Mormopterus eleryi (n = 15)

The Bristle-faced Free-tailed Bat is a poorly known species that occurs in the arid N.T. (Figure 4ag). It is a relatively small species that is likely to roost in hollows in trees and shrubs. The echolocation calls of this species were recorded for the first time from a specimen captured at the Desert Park in Alice Springs (D.M. and C. P. unpublished data). The animal was released with a light tag attached and it flew at moderate speed, low to the ground (<5 m) in open space.

Mormopterus loriae cobourgiana (n = 26)

The Little Western Free-tailed Bat has been recorded across the northern and western wet–dry tropics within 100 km of the coastline (Figure 4ah), mainly from Anabat recordings. It occurs across a variety of habitats. Although no roosting sites have been observed it is likely to share the same roosting preferences as individuals in Western Australia where it roosts in trees (Milne *et al.* 2008). This species is currently undergoing taxonomic revision.

Mormopterus sp. 3 (n = 50)

The Inland Free-tailed Bat is restricted to the arid zone within the N.T. (Figure 4ai). It is likely to be relatively common within this area, although taxonomic confusion with this genus means that it is currently impossible to be certain. This is a hollow-roosting species that forages in fast flight in open space both above and below the canopy. Most records are from riparian woodland and adjacent shrubland.

Tadarida australis (n = 67)

The majority of records of the White-striped Free-tailed Bat from the N.T. are from the arid zone (Figure 4aj). This large bat flies in open spaces with a fast, direct flight. Its echolocation clicks are regularly heard above river channels and adjoining floodplains in the MacDonnell Ranges bioregion. The species also occurs at Uluru Kata

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Tjuta National Park (Coles 1993) and has been recorded from cave deposits at Uluru (Baynes 1989). Although no roosts are known in central Australia, it is likely to favour hollows in River Red Gums as diurnal roosts. The White-striped Free-tailed Bat was recorded in the tropics of the N.T. for the first time in 1999 (Milne and Nash 2003) with one additional record since then.

Additional species

Taphozous troughtoni

It is considered likely that a *T. georgianus* specimen held by the Australian Museum (M.8550) is *T. troughtoni* (Reardon and Thomson 2002). Although not examined by the authors, data associated with the specimen reported a forearm length of 75 mm which is larger than the maximum forearm length for *T. georgianus* (based on Churchill 2008). The specimen (excluded from Figure 4f) was collected from the Barkley Tableland region at a location approximately 250 km south of any other known *T. georgianus* record in the N.T. and approximately 350 km west of the nearest confirmed *T. troughtoni* record (Reardon and Thomson 2002) and would represent a range extension for either species. Examination of the specimen is required to confirm the forearm measurement and its specific identity.

Vespadelus vulturnus

The Little Forest Bat was reported by Thomson (1982) from six individuals collected near Alice Springs in 1980. This report represents a significant range extension, but (probably due to the large extent of this range extension) has not been recognised in any subsequent literature. DM reviewed the specimens that were available (four) referred to by Thomson. The dichotomous key provided in Churchill (2008) was used to determine the species. Three of the specimens were male, however the baculum had been removed from each specimen so penis morphology could not be used for identification, only phalanx measurements were used. Two of the specimens were identified as *V. vulturnus*, one was identified as *V. baverstocki* and one could not be determined. Further examination of these specimens is required to confirm identification. Due to these uncertainties it is not considered further in this account.

Discussion

With the exception of *M. gigas* and possibly *H. stenotis*, no bat species are known to have undergone significant declines in range or abundance in the N.T. notwithstanding a lack of historical information. This pattern contrasts with the significant declines experienced by other mammalian orders, particularly among the marsupials and rodents (Cole and Woinarski 2000). We have an incomplete picture of the current distribution of almost every species of bat in the N.T. As a result, maps that depict the current range of bats in the N.T. (e.g. Churchill 2008; Van Dyck and Strahan 2008), to a large degree, are based on the expertise and knowledge of the authors involved rather than specimens or accurate observations. Modelling of species distributions has addressed these problems to some degree, but there are several issues associated with this method as well (Milne *et al.* 2006).

The issue of inadequate data is not restricted to bats. It was also identified as a major problem with rodents in the N.T. (Cole and Woinarski 2000; Woinarski 2000). Similar recommendations are applicable here; perhaps more so given that the available data for bats is even poorer than it is for rodents. We recommend the following as potential future actions for N.T. bats:

- more surveys are required throughout the N.T. especially areas outside of the Darwin region, Kakadu National Park, and the MacDonnell Ranges;
- targeted surveys for poorly known species and/or species of conservation significance, namely *S. saccolaimus*, *H. d. inornatus*, *H. stenotis*, *T. kapalgensis*, *S. sanborni* and all of the *Mormopterus* species;
- establishment of long term monitoring sites (particularly at significant cave and/or mine roosts) to monitor population sizes.

Unlike the rodents, however, bats are not included in systematic fauna surveys in the N.T. Since 1989 the N.T. Department of Natural Resources, Environment, the Art and Sports (NRETAS) (or previous incarnations) have been conducting terrestrial vertebrate surveys using a standardised sampling methodology for the N.T. Currently around 5000 sites have been surveyed using this method and it is an important source of information for numerous ecological assessments and plans of management (e.g. Brennan *et al.* 2003; Price *et al.* 2003; Woinarski *et al.* 2003; Woinarski *et al.* 2004). Across much of this survey program, bats were not sampled or sampled unsystematically, a deficiency at least partly redressed through a specific project aiming to document the broad distributional patterns of bats in the Top End (Milne *et al.* 2005a, 2006)

Monitoring of bat populations in the N.T. is very limited. Bats have several attributes that make them useful as indicators of environmental change: they are diverse and abundant, occupy virtually every trophic level, and many have specialised diets and select specific habitats for roosting and foraging. Changes within the environment are likely to be reflected in one or more of these attributes (Medellín *et al*. 2000). However, only four studies have reported trends in bat populations over relatively short term periods (<5 years) (Churchill 1991; Vardon and Tidemann 1999; Vardon *et al.* 2001; Milne *et al.* 2005b). In addition, most bat surveys that have been carried out are usually unsystematic and, unlike the standardised fauna survey method described previously, are ill-suited for resampling as part of a monitoring program. No study has systematically monitored all bat species. The most comprehensive systematic surveys are those conducted by Milne *et al.* (2005a) on echolocating bats, however the method described could be used to include fruit-bats also. There are also several complex issues that must be considered when monitoring bat populations, particularly associated with temporal variations (Milne *et al.* 2005b). Electronic counters have also been used for estimating population sizes of bats entering and exiting caves and mines (Churchill 1991; Conservation Commission of the Northern Territory, unpublished report). Although the method cannot be used to identify species and is mostly limited to cave roosting species, it is an accurate means of monitoring local bat populations,

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and is probably the most achievable means of monitoring bats that is available to researchers in the N.T. in lieu of other more comprehensive, but logistically difficult and expensive alternatives that would primarily involve physical trapping. Elsewhere, echolocation recording systems (e.g. Anabat, Titley Scientific, Ballina, N.S.W.) have, and are, also being adopted as a relatively inexpensive means of monitoring microchiropteran bats (e.g. Broders *et al.* 2006; Williams *et al.* 2006; Griffiths 2007, B. Law pers. comm.). In addition, automated call identification systems (e.g. Gibson and Lumsden 2003) allow large volumes of data to be processed relatively quickly. However, such systems (depending on the purpose) are usually reliant on accurate and comprehensive libraries of reference calls.

Further autecological research is required, particularly for the more common microbat species that have not been studied in detail elsewhere such as *S. flaviventris*, *C. nigrogriseus*, *P. adamsi*, *P. westralis*, *S. greyii*, *C. jobensis* and *V. caurinus.* As was demonstrated in the previous section (species accounts), even the most basic information, such as roosting habits, is unknown for several species. Such information is likely to provide insights into the ecological requirements of similar bats species in both tropical and arid environments.

There are a number of other issues associated with flying-foxes (*P. alecto* and *P. scapulatus*) in the N.T. First, large roosts of flying-foxes sometimes form in towns and other settlements, and are considered to be a public nuisance by some. This has been an issue in the Top End town of Katherine (300 km south of Darwin) where large annual influxes of *P. scapulatus* have caused issues associated with smell, noise, and defoliation of trees; however management intervention has alleviated this issue in recent years (Northern Territory Department of Natural Resources, Environment, the Arts and Sport 2010). Second, flying-foxes are also the known cause of some power outages due to contact with power lines as well as losses associated with damage to fruit at orchards. There is a significant horticultural industry in the Top End and, as in other tropical regions; the benefits of fruit-bats to natural systems are not widely appreciated by growers. Third, Australian Bat Lyssavirus (ABL) has also been identified in flying-foxes in the N.T. The prevalence of ABL in the N.T. is low; of 89 randomly tested flying-foxes in the N.T., none were infected and four were shown to have been previously infected with ABL (Field 2004). In addition, of 205 flying-foxes that were (non-randomly) tested for ABL by the N.T. Department of Regional Development, Primary Industry, Fisheries and Resources, one bat was infected with the virus (L. Melville pers. comm.). There have been no recorded transmissions to humans in the N.T. In contrast to the situation in Queensland, N.T. flying-foxes have so far not been implicated in the spread of other emerging infectious diseases such as Hendra virus and Nipah virus. Last, the impact of Indigenous harvesting on flying-foxes is not well understood. One (conservative) estimate put the total harvest of *Pteropus* spp. in the wet–dry tropics at 179 000 individuals (Vardon *et al.* 1997). It is unclear from the text, but this is assumed to be an annual harvest figure. Vardon *et al*. go on to state that, although surveys are lacking, there has been no obvious or reported decline in the N.T. or in the harvest areas. Further, such harvesting is of importance to Indigenous people in maintaining their culture and connections to their land.

As mentioned previously, less than 0.5% of the N.T. has been cleared, therefore the environment is often regarded as largely 'unmodified' and 'intact'. As a consequence, many of the major threatening processes faced by microbats at a national level (Hall 1990; Richards and Hall 1998 and references therein), including deforestation, insecticide poisoning, roost disturbance and destruction of caves and mines, are not of major concern in the N.T. However, there are indications that this situation may be changing. For instance, the rate of land clearing in the wet–dry tropics is increasing with the area cleared of trees estimated to have increased four-fold in the period 1995–2000 compared to 1990–1995 (Hosking 2002). Invasive weed species are also rapidly spreading in some areas (Braithwaite *et al.* 1989; Kean and Price 2003). Of particular concern are introduced pasture grasses that can increase fuel loads and thereby cause intense, frequent fires that can kill trees and shrubs. This is also an issue in the arid zone where the introduced pastoral species Buffel Grass, *Cenchrus ciliari*s, is causing a similar impact that leads to the loss of roost sites for hollow-dwelling species. In addition, in the Top End there has been a trend away from traditional Aboriginal burning practices of continuous, low intensity dry season (April–November) fires, to a regime of intense and extensive late dry season (October–November) fires (Russell-Smith *et al.* 2000; Yibarbuk *et al.* 2001; Preece 2002). The effects of these changes in the N.T., although largely unknown, are considered to be having a catastrophic effect on at least some aspects of the environment (Russell-Smith *et al.* 2000; Andersen *et al.* 2003). Therefore, it is important to enact appropriate management practices to ensure the long-term conservation of microbats in the N.T.

Riparian and adjacent surrounding environments have been identified as areas that support high bat diversity in the wet–dry tropics (Milne *et al.* 2005a; Milne *et al.* 2006). This is also likely to be the case in the arid zone where the majority of species roost in trees. These areas are particularly prone to disturbance because they usually have higher quality soils that are desirable for clearing for agriculture and are a focus for livestock that cause soil erosion. In the arid zone, floodplains are the initial site of establishment of pasture grasses, especially Buffel Grass and Couch Grass, *Cynodon dactylon*, and these suffer the most from increases in fire frequency and intensity. There are currently plans for major agricultural development on at least one major river system, the Daly River (Price *et al.* 2003). It is unknown what effect disturbance to these areas will have on bats, however given that habitat complexity (i.e. riverine environments and escarpments) is an important component (Milne *et al.* 2005a), management practices should aim to maintain riparian vegetation as well as the adjacent vegetation around these zones. Therefore, areas being cleared of native vegetation require adequate buffers that extend beyond the immediate vicinity of rivers and associated riparian environments. Currently, N.T. clearing guidelines prevent (in most cases) clearing of native vegetation from occurring within 25 m of any drainage line, 100 m of

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creeks and 250 m of rivers (Northern Territory Planning Scheme 2010). However, until a clear understanding of the association between microbat diversity and riparian areas is gained, the effectiveness of these guidelines as a surrogate for conserving bats is unknown.

Escarpments and areas of high topographic relief also support high bat diversity, particularly for cave roosting species, and should be protected. However, hills and escarpments are not as prone to disturbance as riparian areas and are not under significant pressure from agricultural or pastoral development. Moreover, large areas of escarpments and associated ranges occur within National Parks and Reserves including the vast western Arnhem Land escarpment that is protected within Kakadu and adjacent Nitmiluk National Parks. There are still potential threats to bats in these areas, most notably changes in fire regimes that have had deleterious effects on fire-sensitive vegetation associated with sandstone plateaus (Russell-Smith *et al.* 2002). In addition, mining activities are generally concentrated in these areas and can physically damage or destroy caves and crevices that are used by roosting bats. Fortunately, areas impacted by mining are relatively small in extent.

Three species of bat in the Northern Territory are classified as threatened from one or more of four lists reviewed in Table 1. As previously discussed *M. gigas* has disappeared from its southern range, but is considered to be secure throughout the wet–dry tropics. *T. kapalgensis* was assessed by Milne *et al.* (2003) and regarded as 'Near Threatened', however it is probably more common and widespread than this work suggests. *H. d. inornatus* has the most limited distribution of any N.T. bat species, but surveys suggest it is reasonably secure within its range. Given the paucity of records for *S. saccolaimus*, and the likelihood that it is a difficult species to detect, its status is unknown. Targeted surveys for this species should be conducted to determine its status. The status of *H. stenotis* is potentially the most precarious. As mentioned, there are very few records and despite some intensive surveys recently it has only been detected twice in recent times. It appears to be absent from at least two previously known roost sites and models of its distribution suggest its preferred habitat is highly fragmented (Milne *et al.* 2006). Targeted surveys of these areas as well as at previously known sites should be a focus of action.

Acknowledgements

Thanks to Alex Kutt, Brad Law, Lindy Lumsden and John Woinarski for their helpful comments on the manuscript.

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