Status and conservation of bats in Tasmania

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ABSTRACT

We review the habitat, distribution and conservation status of bat species known to occur in Tasmania. There are eight resident species of native bat in Tasmania; Gould's Wattled Bat *Chalinolobus gouldii*, Chocolate Wattled Bat *C. morio*, Large Forest Bat *Vespadelus darlingtoni*, Southern Forest Bat *V. regulus*, Little Forest Bat, *V. vulturnus*, Eastern Falsistrelle *Falsistrellus tasmaniensis*, Lesser Long-eared Bat *Nyctophilus geoffroyi* and the endemic Tasmanian Long-eared Bat *N. sherrini*. In addition the Grey-headed Flying-fox *Pteropus poliocephalus* is a vagrant, predominantly recorded on the Bass Strait islands. The diversity of species in Tasmania is low compared with mainland Australia reflecting the state's island status, size, location and glacial history. There has been a limited amount of bat research in Tasmania and systematic surveys have not been undertaken across Tasmania. However, based on available information all resident species occur widely throughout Tasmania in a wide range of habitats and none are listed under Tasmania's *Threatened Species Protection Act 1995* or Australia's *Environment Protection and Biodiversity Conservation Act 1999*. The vagrant *P. poliocephalus* is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*.

Key words: distribution, habitat, disease, Lyssavirus, wind farm

Introduction

Eight species of bat, all belonging to the family Vespertilionidae, are known residents of Tasmania while an additional species, the Grey-headed Flying-fox *Pteropus poliocephalus*, is a vagrant to the State (Table 1). There has been a limited amount of research on Tasmanian bats probably because of the State's small (human) population, isolation from mainland Australia and the low diversity of bat species. There has been no systematic survey of bat distribution and habitat requirements across Tasmania, with the majority of bat records presented in this paper from opportunistic observations or collections. However, there have been several regional bat trapping surveys. Taylor and O'Neill (1986) surveyed bat communities by trapping in five forest habitats in south-east Tasmania, Taylor *et al.* (1985) trapped bats in rainforest and eucalypt scrub in the Upper Henty Region of Western Tasmania, and Schulz and Kristensen (1996) surveyed bats in coastal areas of south-west Tasmania. Duncan (1995) and Rhodes (1996) used ultrasonic detectors to survey bats in eastern and south-eastern Tasmania as part of studies investigating use of silvicultural regrowth. Taylor *et al.* (1987) provided the first significant overview of the distribution and habitat of bats in Tasmania and this information was incorporated into a subsequent paper on the distribution of Tasmanian mammal fauna by Rounsevell *et al.* (1991). These two studies suggested, based on limited records, that half of the bat species were probably distributed throughout the State whereas the distribution of the three largest species *C. gouldii*, *F. tasmaniensis* and *N. sherrini*, and the smallest species, *V. vulturnus,* may be limited within the perhumid cold climatic zone of western Tasmania. Koch *et al.* (2008), in their review of hollow-using vertebrate fauna, found similar distribution patterns using much the same distribution data as the two previous reviews of distribution, but did not take into account the surveys of Schulz and Kristensen (1996).

Ecological studies on Tasmanian bats are also limited. Green (1965, 1966) reported observations on breeding, growth and development of *N. geoffroyi* and *V. vulturnus* colonies inhabiting buildings. Perhaps the most significant study to date was an honours study by O'Neill (1984) that formed the basis of publications on composition of bat communities (Taylor and O'Neill 1986), summer activity patterns (Taylor and O'Neill 1988) and the feeding ecology (O'Neill and Taylor 1989) of various Tasmanian bats. Taylor and Savva (1988) reported on the roosting requirements of four bat species in an area of mature eucalypt forest and regrowth and provided information on movements. Taylor *et al.* (1987) provided a review of the distribution and natural history of Tasmanian bats including data on body measurements for each species, which were compared with the same species on the Australian mainland. Dixon (2000) and Dixon and Rose (2003) investigated the thermal energetics of *N. geoffroyi* in southern Tasmania. Two unpublished honours studies by Kincade (1999) and Inada (2006) investigated the reproductive biology and winter activity of bats, respectively.

The aim of this paper is to review the available information on the distribution, habitat and conservation status of bats in Tasmania. A map of Tasmania with place names mentioned in this paper is provided in Fig. 1.

The Tasmanian Environment

Tasmania is a mountainous island with a land area of 68,114 km^2 that occurs at temperate latitudes between 39 and 44°S. It is separated from the Australian mainland by Bass Strait, which is between 230 and 300 km wide. Land connections occurred between Tasmania and mainland Australia during glacial episodes of the Pleistocene, and the last land connection occurred over 8,000 years ago (Blom 1988).

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For the most part, Tasmania has a temperate maritime climate. Mean maximum temperatures range between 18°C and 23°C during summer and between 9°C and 14°C during winter, and in elevated regions the temperatures are about 5°C lower (Commonwealth of Australia 1999). The prevailing westerly airstream leads to a climate gradient across Tasmania. The west coast and highlands are cool, wet and cloudy and the east coast and lowlands are milder, drier and sunnier. Annual rainfall averages over 3,500 mm in some parts of the mountainous west and less than 600 mm in the Midlands (Commonwealth of Australia 1999). This climate gradient across Tasmania together with a gradient from west to east of increasing soil fertility is reflected in the vegetation and its associated fauna. Rainforest, wet sclerophyll forest, buttongrass moorlands and alpine moorlands and heath dominate western Tasmania, whereas dry sclerophyll forest and woodland and coastal heath dominate the east.

In Tasmania, up until 2002, 23% or 1.56 million hectares of land had been cleared since European settlement (Resource Planning and Development Commission 2003). Most of the land clearing has been restricted to the east and north of the State largely because of the mountainous nature of the rest of the island and the low soil fertility in the west. Forty-five percent of the land area of Tasmania is reserved for nature conservation comprising formal reserves (37%), informal reserves (5%) and reserves on private land (1%) (DPIW 2007). Most of this reserved land is in western Tasmania.

Sources of Information

Most of the bat location records used in this paper were obtained from the Queen Victoria Museum and Art Gallery, the Tasmanian Museum and Art Gallery and the Natural Values Atlas (previously known as GTSpoT and TASPAWS) — a database maintained by the Tasmanian Department of Primary Industries, Parks, Water and Environment. Additional records from published and unpublished bat trapping surveys as well as surveys undertaken by the authors (MD and RB) were also entered into the Natural Values Atlas. The vast majority of these bat location records are based on specimens collected by the public and handed in to museums or government departments, usually because the animals had been found in houses, disturbed from their roosts (e.g. firewood collecting) or had been found dead, sick or

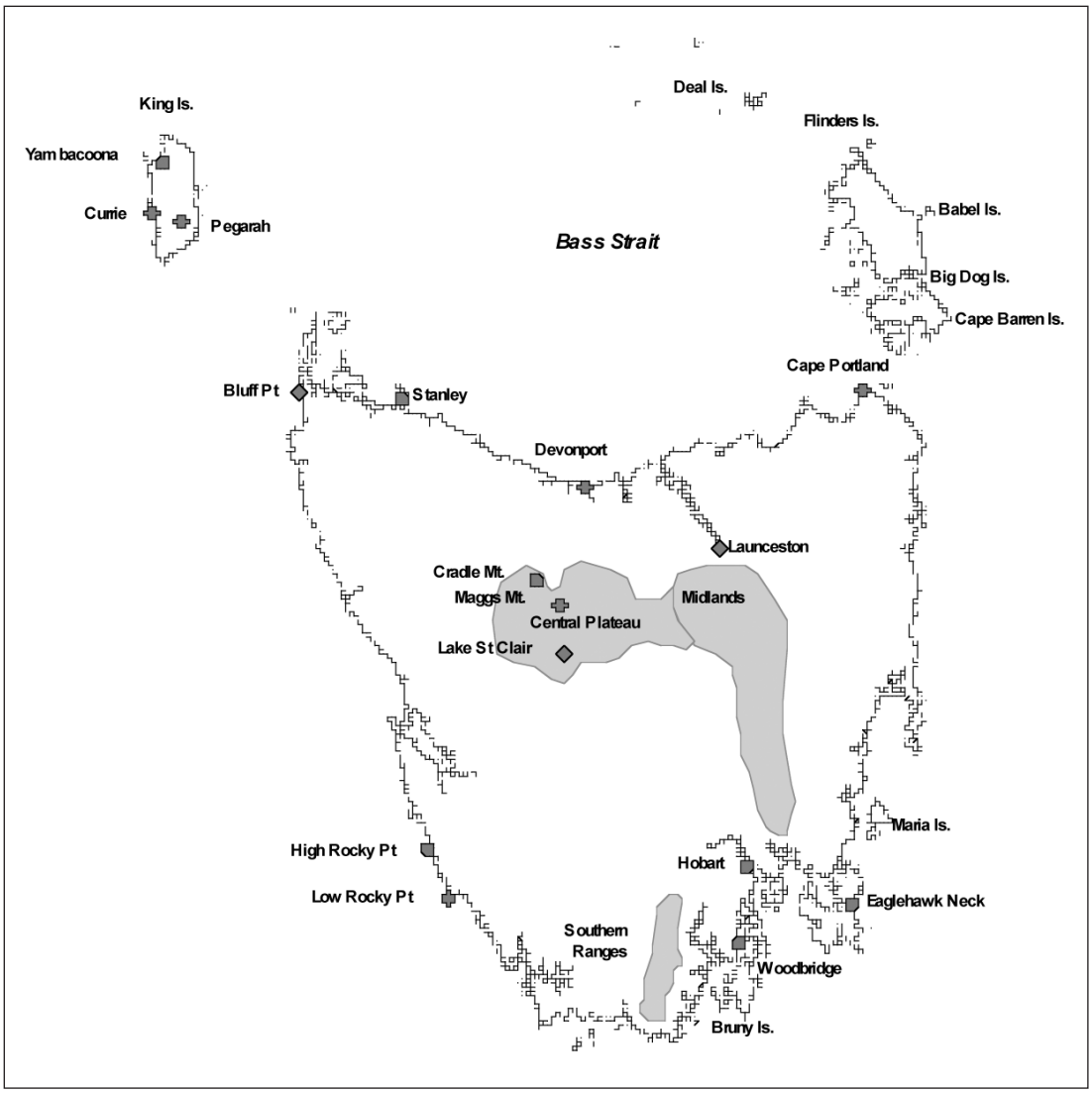


Figure 1. Map of Tasmania with location names mentioned in this paper.

injured. For example, the Queen Victoria Museum and Art Gallery has 56 records with specific information on where the bats were collected; 23 from inside houses/shacks, 18 from felled trees, 8 from wood piles and most of the rest found dead or alive in exposed situations in urban areas (Table 2). As a result, the distribution of bat records in Tasmania (Figs 2a–i) shows a strong bias in all species towards eastern Tasmania, specifically to the major urban and rural centres. The paucity of records in the western portion of Tasmania is largely a product of limited surveys and sparse human occupation in this part of the State.

Nomenclature for scientific and common names of bats follows Churchill (2008).

Tasmanian Bats

Grey-headed Flying-fox *Pteropus poliocephalus* Temminck, 1825

Pteropus poliocephalus appears to be a vagrant in Tasmania with only a handful of observations since about the 1940s, predominantly from the Bass Strait islands (Fig. 2a). In 1938, on King Island near Pegarah, a large bat with a two-foot wing-span, that was presumed to be *P. poliocephalus*, died after becoming caught on a barbed wire fence (Green and McGarvie 1971). Morrison (1941) reported this species from Currie on King Island. In 2000, a *P. poliocephalus* became entangled in netting protecting a fruit tree at Yambacoona on King Island. It was collected by Nigel Burgess (Parks and Wildlife Service) and sent to the Mt Pleasant Laboratories in Launceston where it was tested for Australian Bat Lyssavirus and Hendra virus (refer to section on disease for results).

In April 1955, a *P. poliocephalus* was found feeding on a bag of apples in a shed on Babel Island off the east coast of Flinders Island and was lodged with the Tasmanian Museum, Hobart (Sharland 1962; Green 1969). Green (1969) reported a second individual that was attracted to discarded apples on Big Dog Island off the south coast of Flinders Island in April 1958, which was sent to a private zoo in southern Tasmania. In 1994 a live, female *P. poliocephalus* was found on Flinders Island in netting placed over an apple tree and was shipped to Ian Temby in Victoria for rehabilitation, and another was also sent to Ian in 1994 (Ian Temby, pers comm. Department of Sustainability and Environment, Victoria). On July 3, 2004 Noel Warden (local resident of Flinders Island) found a juvenile alive at the front of his garage following

Table 1. Tasmanian Bat Species and their Conservation Status.

Common Name	Scientific Name	Status		
		Residency	TSP[1]	EPBC[2]
Grey-headed Flying-fox	*Pteropus poliocephalus*	vagrant	nl	V
Gould's Wattled Bat	*Chalinolobus gouldii*	resident	nl	LR (lc)
Chocolate Wattled Bat	*Chalinolobus morio*	resident	nl	LR (lc)
Eastern Falsistrellus	*Falsistrellus tasmaniensis*	resident	nl	LR (lc)
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	resident	nl	LR (lc)
Tasmanian Greater Long-eared Bat	*Nyctophilus sherrini*	resident	nl	LR (lc)
Large Forest Bat	*Vespadelus darlingtoni*	resident	nl	LR (lc)
Southern Forest Bat	*Vespadelus regulus*	resident	nl	LR (lc)
Little Forest bat	*Vespadelus vulturnus*	resident	nl	LR (lc)

[1] TSP = Tasmanian *Threatened Species Protection Act 1995*, nl = not listed
[2] EPBC = *Environment Protection and Biodiversity Conservation Act* 1999, V = vulnerable, LR (lc) = lower risk (least concern) (Duncan *et al.* 1999).

Table 2. Bat records held by Queen Victoria Museum and Art Gallery containing notes about the places where bats were found. Cg = *Chalinolobus gouldii*, Cm = *C. morio*, Ft = *Falsistrellus tasmaniensis*, Ng = *Nyctophilus geoffroyi*, Nt = *N. sherrini*, Vd= *Vespadelus darlingtoni*, Vr = *V. regulus* and Vv = *V. vulturnus*.

Where found	Number of Records							
	Cg	Cm	Ft	Ng	Nt	Vd	Vr	Vv
Live eucalypt tree*	1			2		2	2	7
Dead standing eucalypt tree*	1					1	1	1
Wood piles		1		4	1			2
Urban								
Outside		2						
Unspecified	1			1		1		
Inside houses/sheds/shacks								
Urban/suburban				2				1
Rural				12	1			7
Car radiator		1						
Masked owl pellet			1					

* bats obtained by tree felling

a stormy night. Parks and Wildlife Service officers took measurements and photographs and made arrangements to fly the animal to Melbourne; however it died four days after it was first found and the carcass was disposed of.

Sharland (1962) mentions two further specimens believed to be *P. poliocephalus*. One was found dead in 1946 at Woodbridge, south of Hobart; the other was washed up on a beach at Eaglehawk Neck, south-east Tasmania, in January 1951.

Gould's Wattled Bat *Chalinolobus gouldii* (Gray, 1841)

Chalinolobus gouldii has been recorded from the north-west, south-west coast, south-east and east coast (Fig. 2b). There are also records from the Midlands and urban areas of Hobart and Launceston and it has been recorded on King, Bruny and Maria islands. The species appears to occur mainly in lowland areas near the coast and is generally absent from upland areas on the Central Plateau and the Southern Ranges. It has been recorded at approximately 450 m above sea level near Maggs Mountain, northwest Tasmania. Previous reviews of Tasmanian bat distribution (Taylor *et al.* 1987; Rounsevell *et al.* 1991) have suggested that *C. gouldii* may be absent from the south-west of Tasmania because there were no records at that time; however surveys by Schulz and Kristensen (1996) have shown otherwise.

Chalinolobus gouldii has been recorded from a range of forest types in Tasmania including Blackwood *Acacia melanoxylon* swamp forest, wet eucalypt forest, dry eucalypt woodland and forest, remnant riparian woodland (Taylor and O'Neill 1986; O'Neill and Taylor 1989; Rhodes 1996) and wet scrub (Schulz and Kristensen 1996). Rhodes (1996) found no significant differences in *C. gouldii* activity in various regrowth ages of wet and dry eucalypt forest (4 years–mature), although there was a trend in increasing activity with regrowth age at some sites. *C. gouldii* has been found roosting in both live and dead eucalypt trees cut down for firewood (Table 2) and in a deserted shack (Tyson 1981). Woinarski (1985) recorded two *C. gouldii* roosting for at least five days on the inside wall of a stump used by nesting Forty-spotted Pardalote *Pardalotus quadragintus*.

Chocolate Wattled Bat *Chalinolobus morio* (Gray, 1841)

Chalinolobus morio is widespread in Tasmania. It has been recorded from the south-west, across the Central Plateau, the north-west, north-east, and south-east; however, there are no records from the Midlands (Fig. 2c). The species has been recorded from near sea level to approximately 740 m above sea level at Lake St. Clair on the Central Plateau. *C. morio* has also been recorded from Flinders, Cape Barren and Maria islands.

Chalinolobus morio has been recorded from rainforest, wet sclerophyll forest, dry eucalypt forest and woodland, regrowth wet and dry eucalypt forest (4–80 years) (Taylor *et al.* 1987; Taylor and O'Neill 1986; O'Neill and Taylor 1989; Rhodes 1996), wet scrub (Schulz and Kristensen 1996) and montane eucalypt woodland (M. Driessen; unpublished records in Natural Values Atlas). This species has also been recorded in a cleared agricultural landscape with small remnants of Drooping Sheoak *Allocasuarina verticillata* dominated patches of bushland, in the north-east of Tasmania near Cape Portland (Rhodes 2001). *C. morio* was trapped more frequently in *Acacia melanoxylon* swamp forest, coastal woodland and 12 year old eucalypt regrowth than in dry sclerophyll forest and rainforest (Taylor and O'Neill 1986). In a study of the use of silvicultural regrowth by foraging bats, Rhodes (1996) found no consistent pattern in *C. morio* activity in relation to the age of eucalypt regrowth.

In Tasmania, *C. morio* has been recorded roosting in a range of situations including cracks in the wood of trees, narrow cavities inside the bole of a tree and one individual has been located under a piece of rotting wood on the ground (Taylor and Savva 1988). *C. morio* has been recorded roosting in dead and live eucalypts including Stringybark *Eucalyptus obliqua*, Gumtopped Stringybark *E. delegatensis* and White Peppermint *E. pulchella* (Taylor and Savva 1988) and in wood piles (Table 2).

Eastern Falsistrelle *Falsistrellus tasmaniensis* (Gould, 1858)

Falsistrellus tasmaniensis has been recorded from only about a dozen locations in Tasmania; the central-west coast, north-east, around Launceston, the Central Plateau and the south-east (Fig. 2d). Many of the records are from urban areas (Tables 3 and 4), although little is known about its habitat preferences within these situations. The species has been recorded from lowland and coastal areas at near sea level to approximately 740 m above sea level at Lake St. Clair on the Central Plateau. It has not been recorded from the far north-west, south-west, much of the east coast or any offshore islands.

Falsistrellus tasmaniensis has been recorded from dry and wet sclerophyll forests, including regrowth eucalypt forest (4 – 80 years) (Taylor and O'Neill 1986, Taylor *et. al*. 1987, O'Neill and Taylor 1989; Rhodes 1996) and urban areas (Table 3, see below). Rhodes (1996) found that *F. tasmaniensis* activity was greater in young regrowth than in mature forest. This species has also been recorded in a cleared agricultural landscape with small remnants of *Allocasuarina verticillata* dominated patches of bushland, in the north-east of Tasmanian near Cape Portland (Rhodes 2001). Information on roosting locations in Tasmania is scarce. Philips *et al.* (1985) found a male *F. tasmaniensis* using a stem hole on the main trunk of a live Mountain White Gum *E. dalrympleana*.

Between May 2003 and April 2008, 16 live *F. tasmaniensis* were found in the Hobart CBD and were collected and recorded by staff in the Tasmanian Department of Primary Industries, Parks, Water and Environment (Table 3). The number of bats recorded during this period is an underestimate of the total number reported and collected due to inconsistent recording by staff (M. Driessen personal observation). All *F. tasmaniensis* were found in autumn and early winter—April (six individuals), May (five) and June (four)—with the exception of a single individual in November. Similar numbers of males and females were recorded. In all cases the bats were found in exposed locations mostly in public buildings (Table 3). The reason why they were found at

this time of year is not clear. Perhaps the cooler temperatures at this time of the year may restrict the ability of these bats to return to their roosts while out foraging. Alternatively they may be migrating from higher altitude areas into the city similar to the patterns observed in native bird species that migrate to lower altitude areas during winter (e.g. Crescent Honeyeater *Phylidonyris pyrrhoptera*; Green 1995).

Lesser Long-eared Bat *Nyctophilus geoffroyi* Leach 1821

Nyctophilus geoffroyi is the most frequently recorded species of bat in Tasmania with a widespread distribution from sea level to approximately 900 m above sea level at Cradle Mountain (Fig. 2e). It is commonly recorded in urban areas (Tables 3 and 4; Green 1966). It has been recorded on Maria, King, Flinders, Cape Barren and Deal islands.

This species has been recorded in rainforest, wet sclerophyll forest, *Acacia melanoxylon* swamp forest, wet and dry sclerophyll forest including regrowth (4 – 80 years), dry eucalypt woodland (Taylor and O'Neill 1986; Taylor *et al.* 1987; O'Neill and Taylor 1989; Rhodes 1996), wet scrub, buttongrass moorland (Schulz and Kristensen 1996) and montane eucalypt woodland (M. Driessen; unpublished records in Natural Values Atlas). Taylor and O'Neill (1986) found that capture rates of *N. geoffroyi* were higher in rainforest and *Acacia melanoxylon* swamp forest than in dry sclerophyll forest, coastal woodland and wet eucalypt regrowth. Rhodes (1996) found no significant differences in *N. geoffroyi* activity in various regrowth ages of wet and dry eucalypt forest, although at all study locations there were trends in increasing activity with regrowth age.

In an area dominated by dry sclerophyll forest, Taylor and Savva (1988) recorded *N. geoffroyi* roosting in Black Peppermint *E. amygdalina*, *E. dalrympleana* and *E. delegatensis*, including dead standing trees. They roosted in cracks in the wood of the tree, narrow cavities inside the bole of trees and cracks where the bark has lifted off the tree leaving a gap. They have also been found roosting under bark four metres above the ground in Giant Ash *E. regnans*, in wood piles and they are frequently reported from houses and sheds in both urban and rural areas (Table 2; Green 1966).

Tasmanian Greater Long-eared Bat *Nyctophilus sherrini* Thomas 1915

The taxonomy of this species has caused some confusion in Tasmania because several authors (e.g. Green 1983; Richards 1983) have previously referred to this long-eared bat as *N. gouldi*. Taylor *et al.* (1987) and Parnaby (2009) provide accounts of how this confusion arose. Until recently this species was recognised as a subspecies of *N. timoriensis* (Koopman 1984). However, a revision of the genus by Parnaby (2009), using comparative morphological and morphometric assessment, recognised *N. sherrini* as a species that is restricted to Tasmania.

Nyctophilus sherrini is the least frequently recorded species of resident bat in Tasmania (22 records representing about 18 locations). However, these records are widely distributed from sea level to 740 m above sea level, indicating the species occurs throughout the State (Figure 2f). It has not

Table 3. Details of bats brought into and recorded by Wildlife Enquiries, Department of Primary Industries, Parks, Water and Environment 22/5/2003-9/4/2008. FL = forearm length, Wt = body weight. R = released, D = died.

Date	Species	Sex	FL(mm)	Wt(g)	Location	Fate
22/05/2003	*F. tasmaniensis*	M	44.8	21	Shopping centre, Sandy Bay	R
22/05/2003	*F. tasmaniensis*	-	-	-	Law Courts, Hobart	R
28/05/2003	*F. tasmaniensis*	F	52.0	17	Car dealer, Hobart	R
20/06/2003	*F. tasmaniensis*	M	50.0	26	Metro bus exchange, Springfield	R
24/07/2003	*N. geoffroyi*	M	-	6	Montrose	D
10/03/2004	*N. geoffroyi*	-	-	7	Campaignia	D
29/04/2004	*F. tasmaniensis*	-	-	15	Police headquarters, Hobart	R
3/06/2004	*F. tasmaniensis*	-	49.2	19	Wapping apartments, Hobart	R
25/10/2004	*V. vulturnus*	F	29.9	-	Unknown	D
10/11/2004	*F. tasmaniensis*	-	-	-	Private Clinic, Rokeby	R
13/04/2005	*N. geoffroyi*	F	43.6	6	Police headquarters, Hobart	R
13/04/2005	*F. tasmaniensis*	F	50.3	14	Murray St, Hobart	R
9/06/2005	*F. tasmaniensis*	F	-	-	Wellington Lane, Hobart	R
23/04/2007	*F. tasmaniensis*	F	49.9	-	Claremont	R
24/04/2007	*F. tasmaniensis*	F	31.7	-	Apartments, Hobart	R
23/04/2007	*F. tasmaniensis*	M	-	24	Glenorchy	R
18/05/2007	*F. tasmaniensis*	M	48.8	-	Hotel, Hobart	R
8/06/2007	*F. tasmaniensis*	F	48.3	-	Building stairwell, Hobart	R
12/08/2007	*V. vulturnus*	M	30.2	4	Roadside near Campaignia	R
Nov. 2008	*V. vulturnus*	M	29.2		Pipeline Track, Mt Wellington	D
18/02/2008	*V. vulturnus*	F	28.4		South Arm	R
28/05/2008	*F. tasmaniensis*		49.9	27	Jennings lane, Hobart	R
9/04/2008	*F. tasmaniensis*	F	50.0	17	Evans St, Hobart	R

been recorded from any offshore islands. There are no records from the urban areas of Hobart and Launceston, perhaps indicating these areas may be unsuitable for the species. Previous reviews of Tasmanian bat distributions (Taylor et al. 1987; Rounsevell *et al.* 1991) have suggested *N. sherrini* may be absent from south-west Tasmania. However, Schulz and Kristensen (1996) recorded the species at two locations between High Rocky Point and Low Rocky Point on the south-west coast.

This species has been trapped in *Acacia melanoxylon* swamp forest, wet and dry eucalypt forest including regrowth forest, dry eucalypt woodland (Taylor and O'Neill 1986; O'Neill and Taylor 1989; Rhodes 1996), wet scrub (Schulz and Kristensen 1996) and montane *E. amygdalina* forest (M. Driessen; unpublished records in Natural Values Atlas). No consistent pattern in *N. sherrini* activity in relation to age of eucalypt regrowth was found by Rhodes (1996). Limited information is available on roosts. One individual was found roosting in a woodpile and another was found in a timber hut near Stanley, north-west Tasmania (Table3).

Large Forest Bat *Vespadelus darlingtoni* (Allen, 1933)

V. darlingtoni, formerly *Eptesicus sagittula*, is widely distributed throughout Tasmania from sea level to 740 m above sea level at Lake St Clair on the Central Plateau (Fig. 2g). Despite the presence of forest habitat, the species has not been recorded on any of Tasmania's offshore islands. Records of the species from urban areas are scarce with one record from Devonport.

The species has been recorded in rainforest, wet eucalypt forest, *Acacia melanoxylon* swamp forest, dry eucalypt forest and woodland, regrowth wet and dry eucalypt forest (Rounsevell 1980; Taylor *et al.* 1987; Taylor and O'Neill 1986; O'Neill and Taylor 1989; Rhodes 1996), wet scrub (Schulz and Kristensen 1996) and montane *E. amygdalina* forest (M. Driessen; unpublished records in Natural Values Atlas). *V. darlingtoni* was trapped more frequently in 12 year old regrowth wet eucalypt forest and dry forest than in *Acacia melanoxylon* swamp forest, rainforest and coastal woodland (Taylor and O'Neill 1986). Rhodes (1996) found no clear relationship between activity of *V. darlingtoni* and age of regrowth forest. The species has been detected roosting in fissures and under sloughing bark associated with a variety of tree species, including *E. amygdalina, E. obliqua, E. dalrympleana* and *E. delegatensis,* in mature forests (Taylor and Savva 1988) as well as dead standing eucalypt trees (Table 2; Green and Rainbird 1984).

Southern Forest Bat *Vespadelus regulus* (Thomas, 1906)

Vespadelus regulus occurs in most regions of the state including the north-west, south-east, coastal areas of the south-west and the Central Plateau (Fig. 2h). There are no records for the central and north-eastern coastal areas. The species has been recorded from sea level to an elevation of 740 m above sea level at Lake St Clair on the Central Plateau. Despite the availability of suitable habitat, the species has not been recorded on any of Tasmania's offshore islands.

Vespadelus regulus has been recorded in rainforest, wet eucalypt forest, *Acacia melanoxylon* swamp forest, dry eucalypt forest and woodland, regrowth wet eucalypt forest (Green and Rainbird 1984; Taylor *et al.* 1987; Taylor and O'Neill 1986; O'Neill and Taylor 1989; Rhodes 1996), wet scrub (Schulz and Kristensen 1996), montane *E. amygdalina* forest (M. Driessen; unpublished records in Natural Values Atlas) and agricultural and urban landscapes. This species was caught regularly in rainforest, dry sclerophyll forest, coastal woodland and *Acacia melanoxylon* swamp forest, but it was most frequently caught in 12 year old regrowth forest (Taylor and O'Neill 1986). Similarly, Rhodes (1996) recorded reasonably high levels of activity in various ages of regrowth forest (from 4 year to mature). It has been recorded roosting in hollows present in *E. amygdalina, E. obliqua* and dead eucalypt trees (Taylor and Savva 1988; Table 2).

Little Forest Bat *Vespadelus vulturnus* (Thomas, 1914)

The majority of *V. vulturnus* records are from northern and eastern Tasmania including the Midlands, Flinders Island and Maria Island (Fig 2i). The species has not been recorded from central and south-western regions of the state with only a few isolated records from the central western coast. It has been frequently recorded in urban areas around Hobart and Launceston. As has been noted previously (Green and Rainbird 1984; Taylor *et al.* 1987) this species is most common in coastal lowland regions with few records above 400 m elevation. The highest recorded altitude is 460 m above sea level at Mt Hobbs, south-eastern Tasmania (Taylor and O'Neill 1986).

Vespadelus vulturnus has been recorded in rainforest, wet and dry eucalypt regrowth forest, *Acacia melanoxylon* swamp forest, dry eucalypt forest and woodland (Taylor and O'Neill 1986; O'Neill and Taylor 1989; Rhodes 1996) and wet scrub (Schulz and Kristensen 1996). The species was caught more frequently in *Acacia melanoxylon* swamp forest than in rainforest, dry sclerophyll forest, coastal woodland and 12 year old regrowth (Taylor and O'Neill 1986). Rhodes (1996) found no clear relationship between activity of *V. vulturnus* and age of regrowth forest. It has been found roosting in live and dead eucalypt trees, timber piles and in buildings (Table 2; Green 1965; Green and Rainbird 1984).

Tasmanian Bat Species Diversity and Habitats

The low diversity of bat species in Tasmania compared with the Australian mainland States reflects the tropical origins of bats (Strahan 1983; Churchill 2008), the low species diversity that is typical of island biota's (Gorman 1979), the State's land area, and the position of the island—where the only likely route of bat migration is from the north. Tasmania's glacial history has probably also contributed to this lack of bat diversity by limiting the availability of suitable habitat for bats. During glacial episodes in the Pleistocene, conditions in Tasmania were much drier than present; much of the island was glaciated and lowland areas, including the Bassian Plain, were probably only sparsely forested and predominantly arid (Bowler 1982; Hope 1978; Jackson 1999).

Tasmania has an abundance of cave systems (Jennings 1975), however bats are not known to permanently roost in them. *Chalinolobus morio* and *F. tasmaniensis* have been found roosting in caves on the Australian mainland and dead specimens of *N. geoffroyi* have also been found in caves (Churchill 2008). In Tasmania, the remains of approximately 20 bats comprising *C. morio*, *V. regulus* and *V. darlingtoni* were recorded on the cave floor and attached to the cave wall in Judd's Cavern in the Cracroft (Savva and Taylor 1986; Clarke 1988), although it is not known how long the bones had been there. The remains of *V. regulus* have also been recorded in caves in Mt Weld karst (Clarke 1988).

There is a general perception that bats do not occur in caves in Tasmania because the temperature inside them is too cool for roosting (e.g. Doran *et al.* 1997; Richardson *et al.* 1997). However, bat species do occur in caves on the Australian mainland where the temperatures are likely to be similar and even cooler than in Tasmania, such as caves in the Snowy Mountains region of south-eastern New South Wales, around Canberra and highland areas of Victoria. Cave-dwelling species such as the Eastern Bent-winged Bat *Miniopterus orianae oceanensis* and the Large-footed Myotis *Myotis macropus* have a widespread distribution on mainland Australia and occur in caves in coastal Victoria where the climate is similar to northern Tasmania.

Similarly, forest-dwelling bats that are widely distributed in southern mainland Australia in habitats found in Tasmania are also absent from the State, such as the White-striped Free-tailed Bat *Austronomus australis*, Eastern Free-tailed Bat *Mormopterus ridei*, Gould's Long-eared Bat *Nyctophilus gouldi* and the Eastern Broad-nosed Bat *Scotorepens orion*.

Factors other than climate, such as food resources and/or barriers to dispersal, must therefore also be involved in restricting the migration of these cave- and forest-dwelling bats to Tasmania. Bat dispersal to Tasmania may have been limited by Bass Strait during interglacial periods and by the now-submerged Bassian Plain—which was dominated by a large treeless plain and a large brackish lake—during the last glacial periods (Hope 1978; Blom 1988). Why some species colonised Tasmania and others did not would make an interesting topic for future study.

However, given the limited amount of research and survey work on bats in Tasmania, the possibility that additional Australian mainland forest-dwelling species (e.g. *N. gouldi*; Parnaby 2009) occur in Tasmania or at least on the Bass Strait Islands cannot be completely ruled out.

Management Issues

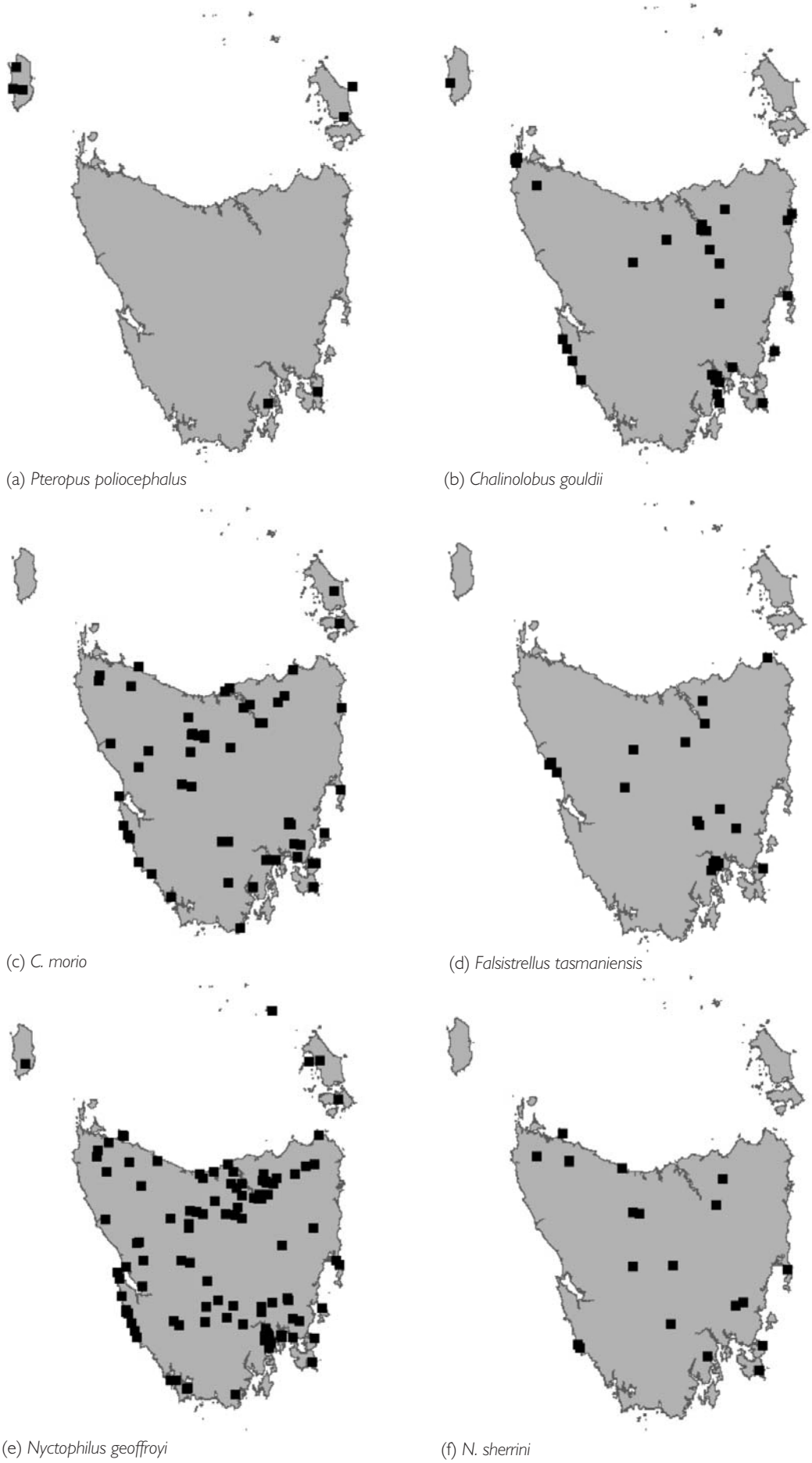
Habitat loss

Habitat loss is likely to affect the distribution and abundance of bats, particularly the loss of key habitat features such as tree hollows, which provide suitable roost sites, and foraging habitat (Lumsden *et al.* 1995). The main causes of loss of tree hollows in Tasmania have been native forest silviculture, firewood collection, tree dieback, and the clearing of native forest for plantation establishment or agriculture. In the period 1997-98 to 2005-06, 110,644 hectares of native forest in Tasmania were cleared mainly for plantation establishment or agriculture (Forest Practices Authority 2006). Although the *Forest Practices Code,* which prescribes the manner in which forest practices are to be conducted, provides for the protection of the natural and cultural values of Tasmanian forests, including hollow trees, the cleared forest would have provided foraging habitat and included trees with hollows suitable for roosting bats. Recent changes to the *Australian Forestry Standard* (AFS) (AS 4708) to not allow the broad-scale conversion of native forests to plantation or non-vegetation cover will probably result in only very limited areas of native forest being converted to plantation in the future. Both the government's forestry business enterprise and the major private forest company in Tasmania are certified to meet the Australian Forestry Standard.

There have been few studies investigating the use of regrowth forest (produced by clearfelling) by bats in Tasmania and most were poorly designed with little or no replication, consequently our understanding of the use of this habitat by bats is unclear. Taylor and O'Neill (1985) found that some bats species were more common in a regrowth forest than in other forest types, whereas other species were less common. Duncan (1995) found that bat activity was greater in mature dry eucalypt forest than in even aged young regrowth, but found no difference in bat activity between mature wet eucalypt forest and regrowth forest of various ages. In general, Rhodes (1996) found that bat activity was greater in mature forest types (both wet and dry eucalypts), but some species appeared more active in younger regrowth. Taylor and Savva (1988) studied the roosting requirements and movements between foraging areas and roost sites in four Tasmanian bat species. Although they captured many bats in regrowth forest, all roost sites found were in mature forest suggesting that patches of mature forest need to be retained in forestry landscapes to ensure a shortage of roosts does not occur as more areas of mature forest are converted to production landscapes.

The removal of trees with hollows has also occurred in farmland areas where remnant vegetation and paddock trees have been cleared for agriculture, particularly with the increasing trend towards the installation of pivot irrigators for watering crops and pastures. These require the removal of all remnant trees within the paddock to allow the irrigator, which is fixed at a central point, to travel in a circle around the paddock. Paddock trees frequently are large old trees with hollows that are suitable for roosting bats. Law *et al.* (2000) recorded five species of bats using hollows in paddock trees and remnant woodland in farmland in northern New South Wales. Similarly, Lumsden and Bennett (2005) highlighted the value of remnant trees and woodlands as foraging habitat for eleven species of bats in rural landscapes of south-eastern Australia.

Lumsden *et al.* (1995) suggested that there is no evidence of regional extinctions of bats in northern Victoria in the past 150 years and that while the clearing of woodland habitat has resulted in a decline in overall abundance most species are still widespread and common. They suggested that the ability of bats to fly,



(a) *Pteropus poliocephalus*

(b) *Chalinolobus gouldii*

(c) *C. morio*

(d) *Falsistrellus tasmaniensis*

(e) *Nyctophilus geoffroyi*

(f) *N. sherrini*

Figure 2. Known location records for bats in Tasmania.

have overlapping foraging areas, use colonial roosts and tolerate other species are factors that have enabled bats to live within an agricultural landscape as long as key resources are available. These resources are; trees with hollows suitable for roost sites, such as paddock trees, and foraging habitat provided by woodland, forest, and riparian remnants (Lumsden *et. al*. 1995; Lumsden and Bennett 2000, 2005). The results of the bat studies in northern Victoria may also be relevant to Tasmania and explain why the bat fauna is still widespread despite habitat loss and fragmentation in rural agricultural areas and wood production areas. Studies on the use by bats of remnant patches of trees in rural and forestry landscapes in Tasmania would be valuable for bat conservation.

Wind farms

Bat fatalities have been caused by collisions with wind turbines. Studies of bat mortalities at wind farm facilities in the United States of America found average fatality rates estimated to be 3.4 bats per turbine per year (ranging from 0.1 to 47.5 bats per turbine per year) (National Wind Coordinating Committee 2004). The highest bat mortality estimate of 47.5 bats per turbine per year was related to a large number of mortalities in 2003 at a wind farm in West Virginia (National Wind Coordinating Committee 2004). Studies at wind farms in the United States of America have found that bat mortality is seasonal and there is little or no bat collision mortality at wind farms during the breeding season (Erickson *et al.* 2002). The available data indicate that most bat mortality involved migrant or dispersing bats in late summer and autumn (Erickson *et al.* 2002).

In Australia, there have been only a small number of records of bats colliding with wind turbines. However, most wind farms are not being monitored for collisions. Monitoring for bird and bat strikes at Bluff Point Wind Farm in north-west Tasmania has been carried out since

(g) *Vespadelus darlingtoni* (h) *V. regulus*,

(i) *V. vulturnus*.

Figure 2. (Cont'd) Known location records for bats in Tasmania.

the first six turbines were commissioned in 2002. There are now 37 wind turbine generators with a blade diameter of 66 m at Bluff Point Wind Farm of which 10 turbines are regularly monitored. A 100 m radius fenced area around each turbine is monitored once per fortnight all year round except in December and seven weeks in autumn when they are monitored twice per week. The bird and bat monitoring program has found that on average nine bats are recovered per year from the 10 monitored turbines (Chris Simms, Roaring 40s, unpublished data). This number of bat collisions with turbines should be considered as a minimum estimate because the turbines are not monitored daily all year round, the bats are small and can be overlooked, and the bats may be taken by aerial scavengers before detection by observers. All the bats found have been of one species, *Chalinolobus gouldii*, and all have been recovered in late summer and autumn which is consistent with the studies in the USA.

Wind farms in Tasmania may have an impact on local populations, for example the *C. gouldii* population at Bluff Point Wind Farm. Without knowledge of the size of the local population, and some details of the bats themselves that are colliding with wind turbines (e.g. age and sex) the impact is difficult to assess. However, given that the bat species in Tasmania are widespread and apparently common it appears unlikely that any one species will be significantly affected at a regional or state level given the relatively low mortality rates recorded at Bluff Point Wind Farm.

Disease

The emergence in Australia of two bat diseases, Hendra virus and Australian Bat Lyssavirus has had a significant impact on human and animal health. Hendra virus, (previously known as Equine Morbilivirus) is a novel paramyxovirus first described in 1994, which has caused the death of two people and a number of horses in Queensland (Halpin *et al.* 2000). Flying-foxes are a natural reservoir host for Hendra virus (Halpin *et al.* 2000). Australian Bat Lyssavirus (ABL) is a previously undescribed Lyssavirus genetically similar to the rabies virus. It was first isolated from Australian bats in May 1996 and has been detected in four species of flying fox and the Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris* (AUSVETPLAN 1999). ABL has caused the death of two people in Queensland.

From January 1997 until March 2007, 23 bats were presented to the Tasmanian Department of Primary Industries, Parks, Water and Environment's Mt Pleasant Laboratories for ABL testing. In only six of the cases were the bats identified to species; *C. gouldii* (four cases) *N. geoffroyi* (one) and *P. poliocephalus* (one). ABL was not detected in any of the bats tested. The *P. poliocephalus* was collected from King Island and was also tested for Hendra virus. The serology test was positive for Hendra virus indicating the animal had been exposed to the virus and as a result had built up antibodies. However the pathology test was negative indicating the animal had no signs of infection. No other diseases were found in the bat species presented for testing.

Conservation Status

The Tasmanian *Threatened Species Act 1995* (TSP Act) recognises three categories of threat status, Endangered (including Extinct), Vulnerable and Rare. In comparison with the Commonwealth's *Environment Protection and Biodiversity Protection Act 1999* (EPBC Act), the categories of Extinct, Endangered and Vulnerable and their criteria are similar to the TSP Act. However, the percentage population decline required to meet the Vulnerable criteria under the TSP Act is 20% compared with 30% (or 50% where causes of the reduction are reversible and understood and ceased) for the EPBC Act. The EPBC Act recognises a higher category of threat status, Critically Endangered, which falls within the TSP Act's definition of Endangered.

The major difference between the two acts is the recognition in the TSP Act of a lower category of threat status, Rare. The aim of this Rare category is to protect taxa with naturally small population sizes in Tasmania, resulting in a substantial number of species recognised under State legislation that are not recognised under Commonwealth legislation.

All Tasmanian bat species, including *P. Poliocephalus,* are protected under *the Nature Conservation Act 2002*. *Pteropus poliocephalus* is also listed as vulnerable under the EPBC Act because of declines in their abundance on the Australian mainland and possible future declines due to projected habitat clearance (Australian Government 2007). No other bats species recorded from Tasmania are listed under the EPBC Act and no bat species is listed under the TSP Act. Given our current knowledge of their distribution, habitat requirements and current threats, together with significant areas of reserved land in Tasmania it is unlikely that any of the Tasmania species will qualify for listing in the near future.

Future Research

Given the limited amount of research that has been undertaken on bats in Tasmania there is considerable scope for further research. We have mentioned a few areas of future research above and we provide others below that arose during the preparation of this paper.

Bat species in Tasmania occur at the southern limits of their Australian distributions. Comparisons of bat ecology and physiology between Tasmanian and mainland Australian populations would provide information on adaptations to cool climates. Initial studies have already revealed some interesting differences in reproductive biology (Kincade 1999) and energetics (Dixon and Rose 2003). All previous studies on the ecology of Tasmanian bat species have focused on eastern Tasmanian populations. Studies on western Tasmanian bat populations living in cooler, wetter environments with low soil fertility and comparing them with eastern Tasmanian or mainland Australian populations would also provide valuable information on their ecology.

Stranded *F. tasmaniensis* have been found in urban areas during autumn and early winter and dead *C. gouldii* have been recovered from the base of wind turbines in north-western Tasmania during late summer and autumn. An understanding of why these events occur at these times of

the year would provide a valuable insight into the ecology of these species and could potentially lead to management options to minimise bat deaths. Are these events associated with dispersing first year individuals, seasonal migrations or foraging individuals caught out by abrupt declines in temperature during this time of the year? Further research into bat mortality at wind farms may help to establish whether it is site factors that contribute to collisions or that some species are more collision prone than others.

Habitat loss and alteration are key threats to bats in Tasmania. Native forests have been converted to both eucalypt and pine plantations and agricultural land continues to be converted to eucalypt and pine plantations. Studies to investigate the value of plantation forests as habitat for bat roosting and foraging would be useful. An investigation of whether there are changes in bat utilisation in areas where native forests have been converted to plantation could provide an assessment of the impact of these changes in land use at a landscape scale. It would also be useful to undertake similar research in rural Tasmania to gain an understanding of the value of 'pasture trees' for bats (i.e. how important are single trees or small clumps of trees in a pasture landscape for bats).

Finally, more systematic surveys of bat distribution are required across Tasmania to improve the knowledge of the distribution of bats in Tasmania. Key areas are for surveys are south-west Tasmania, the Bass Strait islands and modified landscapes.

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