National Recovery Plan

for the

Christmas Island Pipistrelle

Pipistrellus murrayi

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Natural Heritage Trust

Helping Communities Helping Australia

An Australian Government Initiative

Prepared by Martin Schulz and Linda F. Lumsden, for the Australian Government Department of the Environment and Heritage.
Published by the Commonwealth of Australia.
Made under the *Environment Protection and Biodiversity Conservation Act 1999*: August 2004

ISBN 0 642 55012 3

Disclaimer: This recovery plan sets out the actions necessary to stop the decline of, and support the recovery of, the listed threatened species or ecological community. The Australian Government is committed to acting in accordance with the plan and to implementing the plan as it applies to Commonwealth areas.

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

This plan should be cited as follows: Schulz, M. and Lumsden, L.F. 2004. National Recovery Plan for the Christmas Island Pipistrelle *Pipistrellus murrayi*. Commonwealth of Australia, Canberra.

Cover photograph: Christmas Island Pipistrelle by Lindy Lumsden.

SUMMARY

Current Status
The Christmas Island Pipistrelle *Pipistrellus murrayi* is an endemic bat species that is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999.* Due to taxonomic uncertainty the phylogenetic relationship of the Christmas Island Pipistrelle with closely related Southeast Asia and northern Australia taxa requires resolution.

Currently there are no estimates of the population size of the species.

Distribution and Habitat
This bat was formerly widespread and common in primary and secondary rainforest on Christmas Island. In the 1990s, however, targeted surveys indicated that a marked reduction in abundance and a westward range contraction had occurred since the initial survey for the species in 1984.

Few roosts have been documented. All have been situated in primary rainforest in a variety of situations, including under exfoliating bark on trunks, under dead fronds, beneath a Strangler Fig against the trunk of a canopy tree and in a tree hollow. No maternity roosts have been found as yet.

The Christmas Island Pipistrelle is an insectivorous bat that preys on a range of flying insects. It is an edge specialist favouring vegetation ecotones, tracks and other small gaps within primary rainforest. Commuting or foraging individuals also range into adjacent habitats, including secondary regrowth, minefield rehabilitation sites and formerly the Settlement area.

Known and Potential Threats
An unidentified threatening process(es) has resulted in, or contributed to, a recent population decline and a westward range contraction of the Christmas Island Pipistrelle. There are likely to be direct and indirect effects resulting from the spread of supercolonies of the Yellow Crazy Ant *Anoplolepis gracilipes*. A range of predators may be impacting on the conservation of the species: introduced species (e.g. Common Wolf Snake *Lycodon aulicus capucinus*, Feral Cat *Felis catus* and Black Rat *Rattus rattus*); and a naturalised predator, the Nankeen Kestrel *Falco cenchroides*. Habitat loss and alteration, altered prey availability, vehicle-related mortality, climatic conditions (e.g. cyclones, drought and associated wildfires), disease and decreasing population size may also be potential threats to this species.

Recovery Plan Objectives
The overall objectives of this recovery plan are to:

- determine the threatening processes responsible for the decline in the species,
- maximise the opportunity for the viability of the species in the wild, and
- clarify its taxonomic status.

Specific objectives for the five years of this recovery plan are:

- To assess current population and distribution trends of the Christmas Island Pipistrelle.
- To determine the roosting requirements of the Christmas Island Pipistrelle, including seasonal and distributional differences.
- To assess the potential for the Common Wolf Snake to prey on bats in roosts and if it is considered that they impact on pipistrelles, devise management actions to reduce predation.

- To assess the impact of the Nankeen Kestrel and if found to predate on pipistrelles, devise management actions to reduce impact.
- To identify primary foraging site characteristics in the dry and wet seasons, especially away from ecotones and roadways, within extensive tracts of primary rainforest.
- To examine dietary specialisation as a contributing factor in the species' decline.
- To clarify the taxonomic status of the Christmas Island Pipistrelle.
- To continue active management for the control of Yellow Crazy Ant supercolonies.
- To increase protection of known and potential habitat outside the Christmas Island National Park.
- To assess the potential impact on the Christmas Island Pipistrelle of phosphate stockpile removal within and abutting the Christmas Island National Park.
- To establish guidelines to reduce vehicle-related mortality along roads passing through important foraging areas.
- To review the conservation status of the species.

Biodiversity Benefits
Protection and maintenance of primary rainforest and secondary regrowth, and the control of introduced predators will benefit other endemic rainforest-dependent species.

Cost of Recovery Plan
The cost to implement this recovery plan is $276,000, plus additional funds to ameliorate key threatening processes when identified.

Conservation Status
Recent evidence suggests the Christmas Island Pipistrelle is experiencing an ongoing population decline. As a result a recommended action within the plan is to re-evaluate the conservation status of the species since it potentially meets criteria for Critically Endangered.

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INTRODUCTION

The Christmas Island Pipistrelle *Pipistrellus murrayi* is a small (weight 3-4.5 g) insectivorous bat that is considered by most authorities to be endemic to Christmas Island. Until recently it was considered widespread and common across the island (Tidemann 1985). Surveys in 1994 and 1998, indicated that this species had declined and contracted westwards in range. For example, the species was formerly commonly observed flying about the Settlement. The 1994 and 1998 surveys did not detect the species in this area (Lumsden & Cherry 1997, Lumsden *et al*. 1999). This decline is reflected in the species being listed in 'The Action Plan for Australian Bats' as Endangered following IUCN criteria (Duncan *et al*. 1999), and as Endangered under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). The threatening processes causing the decline of this species are unknown. The primary objectives of this Recovery Plan are to: a) determine the threatening processes responsible for the decline in the species, b) maximise the opportunity for the viability of the species in the wild; and c) clarify its taxonomic status.

Most of the information presented in this Recovery Plan on the distribution, abundance and ecology of the Christmas Island Pipistrelle is the result of three studies: Tidemann (1985), Lumsden & Cherry (1997), Lumsden *et al*. (1999). In recent years additional surveys have been undertaken on the pipistrelle as part of environmental impact statements (M. Bamford and G. Richards, pers. comm.). At the time of writing this Plan, one report (Bamford & Bamford 2002) was available for inclusion. The other studies have not yet been released into the public domain, and hence unfortunately could not be incorporated into the plan.

PART A: SPECIES INFORMATION AND GENERAL REQUIREMENTS

Species

Christmas Island Pipistrelle *Pipistrellus murrayi*. This species has sometimes also been called Murray's Pipistrelle or Murray's Pipistrelle Bat.

Conservation Status

Currently this species is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

There are no estimates of the population size of the Christmas Island Pipistrelle, however recent data indicates a marked decline, and the plan therefore recommends re-evaluating the conservation status since the species potentially meets criteria for Critically Endangered.

Taxonomy

There are differing opinions regarding the taxonomic status of the Christmas Island Pipistrelle and taxonomic clarification is required. The most accepted view is that this species represents an endemic taxon on Christmas Island, hence its listing under the EPBC Act. Andrews (1900) separated *P. murrayi* from related species using the following characteristics: "This species is considerably smaller than *P. abramus* and the Common Pipistrelle (*P. pipistrellus*). It is larger and much darker in colour than *P. pachypus*, and in point of size comes very near to *P. tenuis*, which, however, is distinguished from it by its much blacker tint and the complete absence of the rufous tinge which is noticeable to a greater or lesser extent in all the specimens of the present species. In *P. tenuis* also the outer incisor is stouter than the outer cusp of the inner. *P. indicus* is brighter-coloured and somewhat larger." In a revision of Australo-Papuan *Pipistrellus* Kitchener *et al*. (1986) considered *P. murrayi* a distinct species. A systematic review of the Vespertilioninae based on baculum by Hill & Harrison (1987) listed *P. murrayi* as a separate taxon.

Koopman (1973, 1993), however, listed *P. murrayi* as conspecific with *P. tenuis* based on a lack of distinction from other island forms of *Pipistrellus* in the Indo-Australian area, although no data were provided. *Pipistrellus tenuis* is a widespread species within southern and southeast Asia, with Java representing the nearest locality to Christmas Island (Corbet & Hill 1992). Some recent literature, such as the global Microchiropteran Bat Action Plan (Hutson *et al*. 2001), has followed this taxonomical approach.

The Australian Bat Action Plan (Duncan *et al*. 1999) followed the taxonomy of Kitchener *et al*. (1986) rather than that of Koopman (1993) and listed *P. murrayi* as a species endemic to Christmas Island.

Objects of the Act

Objects of the EPBC Act have been taken into consideration in the development of the Christmas Island Pipistrelle Recovery Plan, particularly:

a) to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance;
b) to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources;
c) to promote the conservation of biodiversity; and
d) to promote a co-operative approach to the protection and management of the environment involving governments, the community, landholders and indigenous peoples.

Objects e) to g) are not applicable due to the absence of indigenous people and the species not being listed under international fauna agreements.

Affected Interests

Public authorities, private companies and other organisations with affected interests include:

Australian Government, including:

- Department of the Environment and Heritage (including Parks Australia North; Land, Water and Coasts Division; Christmas Island Rainforest Rehabilitation Program; Approvals and Legislation Division),
- Department of Transport and Regional Services,
- Department of Finance and Administration,

Shire of Christmas Island,
Indian Ocean Territories,
CI Phosphates Pty Ltd (Phosphate Resources Ltd),
Asia Pacific Space Centre,
Telstra Corporation Ltd,
Union of Christmas Island Workers,
Christmas Island Tourist Association,
Island Care Inc., and
Crazy Ant Steering Committee.

Role and Interests of Indigenous People

Not applicable. People first settled Christmas Island in 1888. Prior to this time there were no indigenous peoples, as defined by the EPBC Act, inhabiting the island (Commonwealth of Australia 2002).

Benefits to Other Species

Threatening processes identified and management actions proposed for the Christmas Island Pipistrelle are similar to those for other threatened endemic species/subspecies of terrestrial vertebrates that are restricted to rainforest vegetation communities on the island (e.g. Cogger & Sadlier 1999, Duncan *et al*. 1999, Garnett & Crowley 2000, Davis *et al*. 2002, Hill 2002 a, and b, Schulz 2002). Management actions affording protection to plateau and terrace rainforest, considered to be the habitat critical to the survival of the Christmas Island Pipistrelle, will also provide protection for other rainforest-dependent species/subspecies listed under the EPBC Act, the ‘The Action Plan for Australian Birds’ (Garnett & Crowley 2000) and ‘The Action Plan for Australian Bats’ (Duncan *et al*. 1999) (Table 1). Any control of introduced predators undertaken as part of this plan may also benefit other species, e.g. threatened reptiles.

Table 1. Threatened endemic vertebrate fauna inhabiting Christmas Island primary rainforest.

Species	Listing
Mammals:	
Christmas Island Shrew *Crocidura attenuata trichura*	E[1]
Christmas Island Flying-fox *Pteropus melanotus natalis**	DD[3,*]
Christmas Island Pipistrelle *Pipistrellus murrayi*	E[1], E[3]
Birds:	
Abbott’s Booby *Papasula abbotti*	E[1], CE[2]
White-tailed Tropicbird (Christmas Island subspecies) *Phaethon lepturus fulvus*	CE[2]
Christmas Island Frigatebird *Fregata andrewsi*	V[1]
Christmas Island Goshawk *Accipiter fasciatus natalis*	E[1], CE[2]
Christmas Island Imperial-Pigeon *Ducula whartoni*	CE[2]

Christmas Island Emerald Dove *Chalcophaps indica natalis*	CE[2]
Christmas Island Hawk-Owl *Ninox natalis*	V[1], CE[2]
Christmas Island Glossy Swiftlet *Collocalia esculenta natalis*	CE[2]
Christmas Island Thrush *Turdus poliocephalus erythropleurus*	CE[2]
Christmas Island White-eye *Zosterops natalis*	CE[2]
Reptiles:	
Pink Blind Snake *Ramphotyphlops exocoeti*	V[1]
Christmas Island Gecko *Lepidodactylus listeri*	V[1]

CE = Critically Endangered; E = Endangered; V = Vulnerable; DD = Data deficient; [1] = Listed under the EPBC Act (as at August 2003); [2] = Listed in the 'Action Plan for Australian Birds' (Garnett & Crowley 2000); [3] = Listed in the 'Action Plan for Australian Bats' (Duncan *et al*. 1999); and * = Anecdotal evidence suggests this species has declined in recent years.

The ecological research and population monitoring for the Christmas Island Pipistrelle, outlined as some of the primary actions in this Recovery Plan, may provide valuable incidental information on the current distribution, status and roost locations of the poorly known Christmas Island Flying-fox *Pteropus melanotus natalis* (listed as Data Deficient in Duncan *et al*. 1999). Nocturnal surveys and ecological research of the Christmas Island Pipistrelle throughout the island and particularly in inaccessible regions may provide valuable information on other threatened nocturnal species such as the Christmas Island Hawk-Owl *Ninox natalis*, the little known Christmas Island Gecko *Lepidodactylus listeri*, and enigmatic rainforest species such as the Christmas Island Shrew *Crocidura attenuata trichura* and the Christmas Island Blind Snake *Ramphotyphlops exocoeti*.

Social and Economic Impacts

The Christmas Island Pipistrelle was formerly distributed throughout the island, including around the Settlement (Tidemann 1985). However, recent surveys (e.g. Lumsden & Cherry 1997, Lumsden *et al*. 1999) have indicated that the species predominantly occurs in primary plateau and terrace rainforest, adjacent areas of secondary rainforest regrowth and rehabilitation areas. No bats were recorded within the vicinity of the Settlement. Any proposed development or land management actions impacting upon primary and secondary rainforest (plateau and terrace) and adjacent habitats need to take this species into consideration. As with other threatened endemic rainforest fauna, the social and economic impacts resulting from management actions required to ameliorate impact on the Christmas Island Pipistrelle from future developments and the reinforcement of existing controls on primary rainforest clearance, may provide restrictions and additional costs to development proposals on the island.

The fauna on Christmas Island is unique and has the potential for attracting low impact ecotourism. A viewing and ultrasonic listening stopover point on one of the main roads in an area of high bat activity could be incorporated into tours highlighting the endemic wildlife of the island. The creation of endemic fauna and flora ecotourism may provide additional employment to the islanders, particularly if such tourism were strategically advertised within Australia and overseas. Rainforest rehabilitation, which provides employment for some islanders creates foraging habitat and in the years to come may provide roosting habitat for this species.

PART B: DISTRIBUTION AND LOCATION

Distribution

Current Known National Distribution

Endemic to Christmas Island. Wood Jones (1910) reported that small bats “which are said to be the *Pipistrellus murrayi* from Christmas Island” had been sighted on Cocos and Keeling Islands as “waifs and strays” although they had never become established residents there. There have been no subsequent records and no specimens were collected to substantiate this report. Therefore it is considered that the Christmas Island Pipistrelle is confined to Christmas Island (Lumsden & Tidemann 1999).

Historical Distribution

Little information was recorded in the early literature about the historical distribution of this species. Lister (1888) observed a small bat on the island but no specimens were collected. Andrews (1900) did not comment on its distribution or abundance when he described the species. However, he stated that “all species of mammals are extremely common” which may be inferred to include the Christmas Island Pipistrelle. In the following seventy years there were only passing references to the species. For example, Gibson-Hill (1947) commented “both bats, of which Mr Tweedie took examples in 1932 were flourishing during the period of my stay on the island”. In 1976, Bell (1976) recorded that “both bats are in good numbers”.

Due to the lack of information no historical distribution map could be prepared. It is likely that the species was widespread throughout the entire island. Due to the size of the island and the former continuous primary rainforest cover, it is likely that the species comprised a single population with no distinct geographical barriers to prevent genetic mixing between different locations on the island.

Extent and Geographic Location(s) of Populations

<u>Background</u>

There have been a number of studies in the last two decades that have examined the distribution, abundance and status of the Christmas Island Pipistrelle. In 1984, Tidemann (1985) undertook the first targeted study, with a small amount of follow up work in 1988. In 1994, Lumsden & Cherry (1997) conducted a preliminary re-assessment of the status of the species. This study was followed by a comprehensive investigation of the distribution, abundance and ecology in 1998 (Lumsden *et al*. 1999). Since then several consultancies for environmental impact assessments have incorporated investigations of the pipistrelle (M. Bamford and G. Richards, pers. comm.). However, only one of these studies (Bamford & Bamford 2002) could be incorporated into the Plan, as the others have not yet been released into the public domain (as at November 2003). Lumsden *et al*. (1999) recommended that a monitoring program be undertaken by Parks Australia North (PAN) staff on Christmas Island. However, since this recommended monitoring program was not adopted the data from the 1998 study is the most recent comprehensive data available. Consequently, it is used to represent the ‘current’ situation, however, there is an urgent need to reassess the situation given recent changes.

A number of techniques were used to determine the distribution and abundance of the Christmas Island Pipistrelle in 1998:

1. Ultrasonic bat detectors (which record the high frequency echolocation calls produced by bats) were set at 84 sites located throughout the island (Figure 1). These sites were primarily situated along tracks, since roads and tracks are used extensively by insectivorous bats as

foraging habitat. The pipistrelle was recorded at 41 of the 84 sites sampled (49%). In the western section of the island the species was recorded at most of the sites sampled (90% of the 31 sites), while less than half the sites in the southern section recorded bats (44% of the 16 sites), and few of the sites in the north-eastern section recorded bats (16% of the 37 sites). In addition to providing distributional data, detectors also provide relative levels of activity. Most of the sites with high (defined as > 1 pass per minute) or moderate (1 pass per 1-10 minutes) levels of activity were located in the western section of the island (Figure 1). In contrast, all sites in the southern and north-eastern sections had only low levels of activity (i.e. < 1 pass per 10 minutes), with the exception of a single site in the centre of the island (classified as within the southern section, Figure 1).

2. Driving searches: additional distributional data was collected by driving roads at night searching for bats using the following techniques:

a) Extensive driving was undertaken at night while checking detector and trap sites (approximately 2,500 km over the 6 week study). Every individual seen in the headlights was recorded. Virtually all accessible roads were driven at night. A number of tracks in the western and southern sections of the island were not sampled due to extensive treefalls.

b) Driving detection: an additional 242 km of driving was undertaken with a bat detector aimed out the window of a slowly-moving vehicle, so that bats could be recorded by sound as well as sight. Most of the major roads on the island were sampled using this technique (Lumsden *et al*. 1999).

Figure 2 indicates all roads sampled (both driving techniques combined) and the locations where bats were recorded. These results support the stationary detector site data (Figure 1), with the majority of records from the western section of the island, despite extensive driving in all three island sections.

3. Harp traps were set at 16 sites to capture individuals for the purpose of collecting morphometric and demographic data.

<u>Known Distribution</u>

The known distribution of the Christmas Island Pipistrelle (as at 1998) is shown in Figure 3, with all records combined, incorporating stationary detector sites, the driving searches, harp trapping and a limited number of roost sites that were located by tracking radio-tagged individuals.

While no pipistrelles were recorded from most of the north-eastern section of the island, it is possible that low densities of individuals occur in parts of this area. For example, in October 2001, Bamford & Bamford (2002) observed a single bat on two consecutive nights (possibly the same individual), foraging in the proposed southern extension to the airport runway. No other individuals were observed in this area or along the roads between this location and the Settlement.

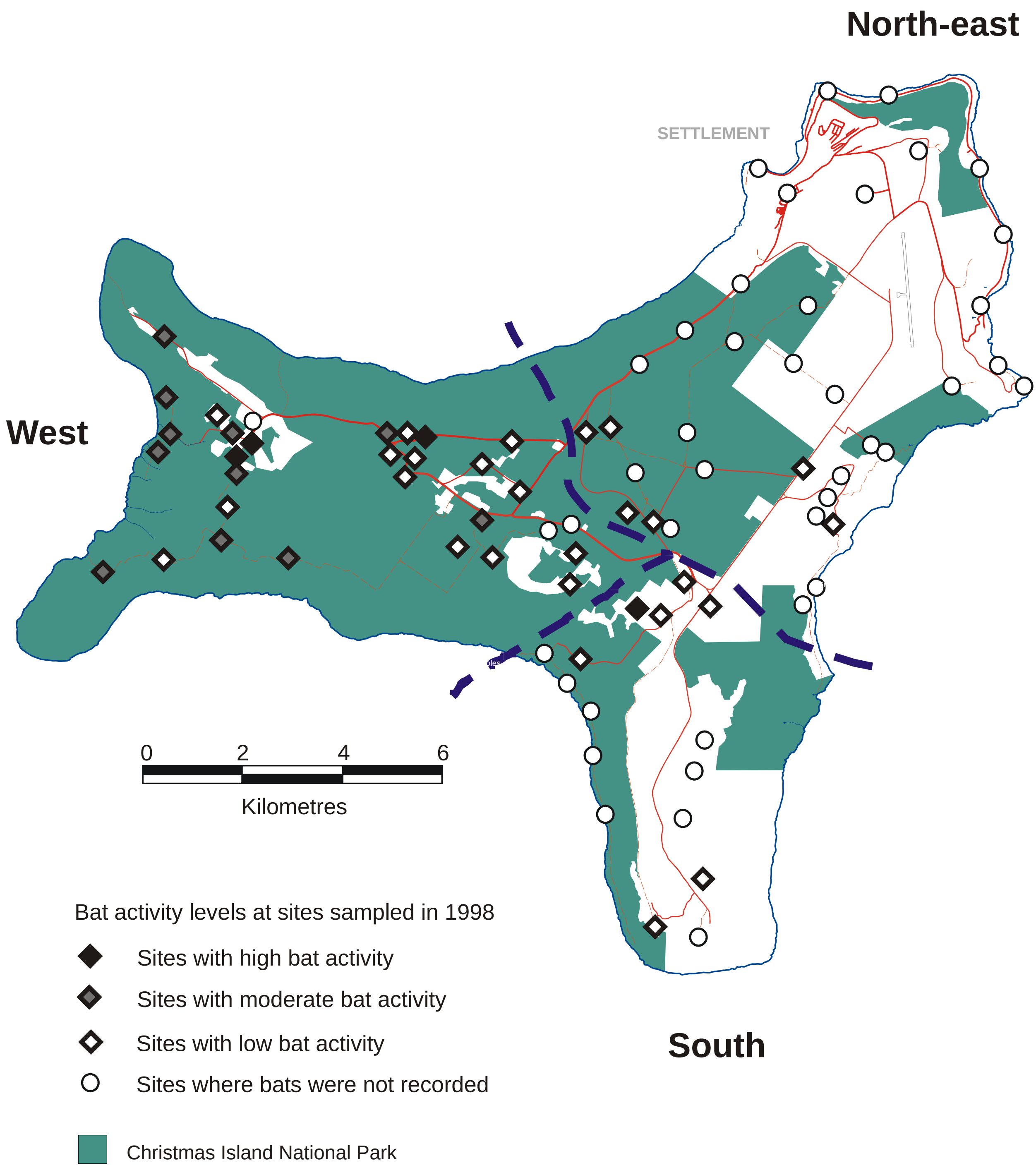
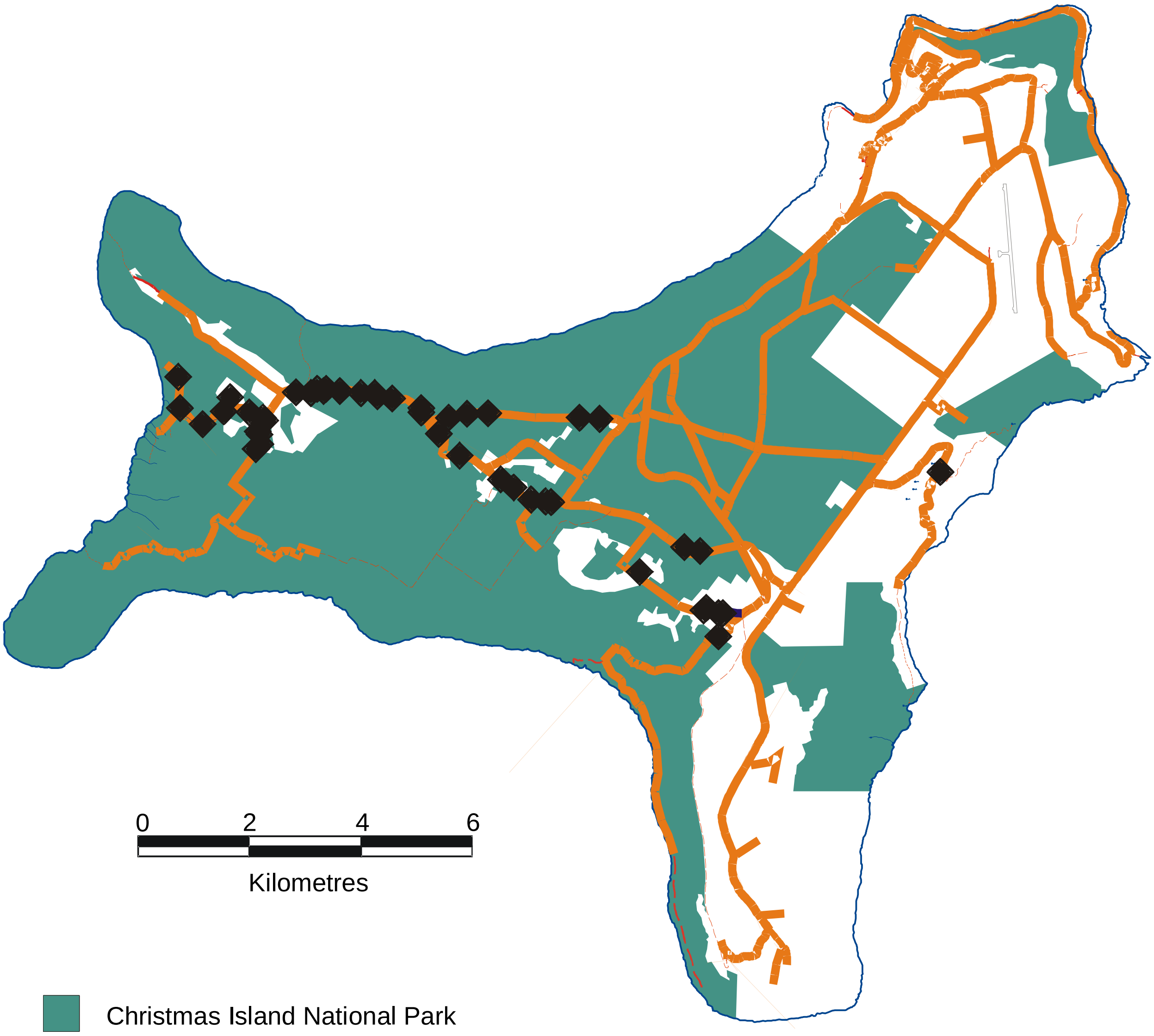


Figure 1. *Relative levels of activity of the Christmas Island Pipistrelle at the 84 stationary detector sites sampled in 1998 (adapted from Lumsden* et al. *1999).* The sections of the island referred to in the text are indicated. Refer text for explanation of activity levels.



Christmas Island National Park

Roads and tracks

Roads driven at night searching for pipistrelles

Pipistrelle sightings

Figure 2. *Roads driven at night searching for the Christmas Island Pipistrelle and the locations where pipistrelles were seen during the 1998 study (adapted from Lumsden* et al. *1999).* Approximately 2,500 km were driven at night during this study, 242 km of which incorporated the use of a bat detector aimed out of the vehicle window, in addition to visual observations.

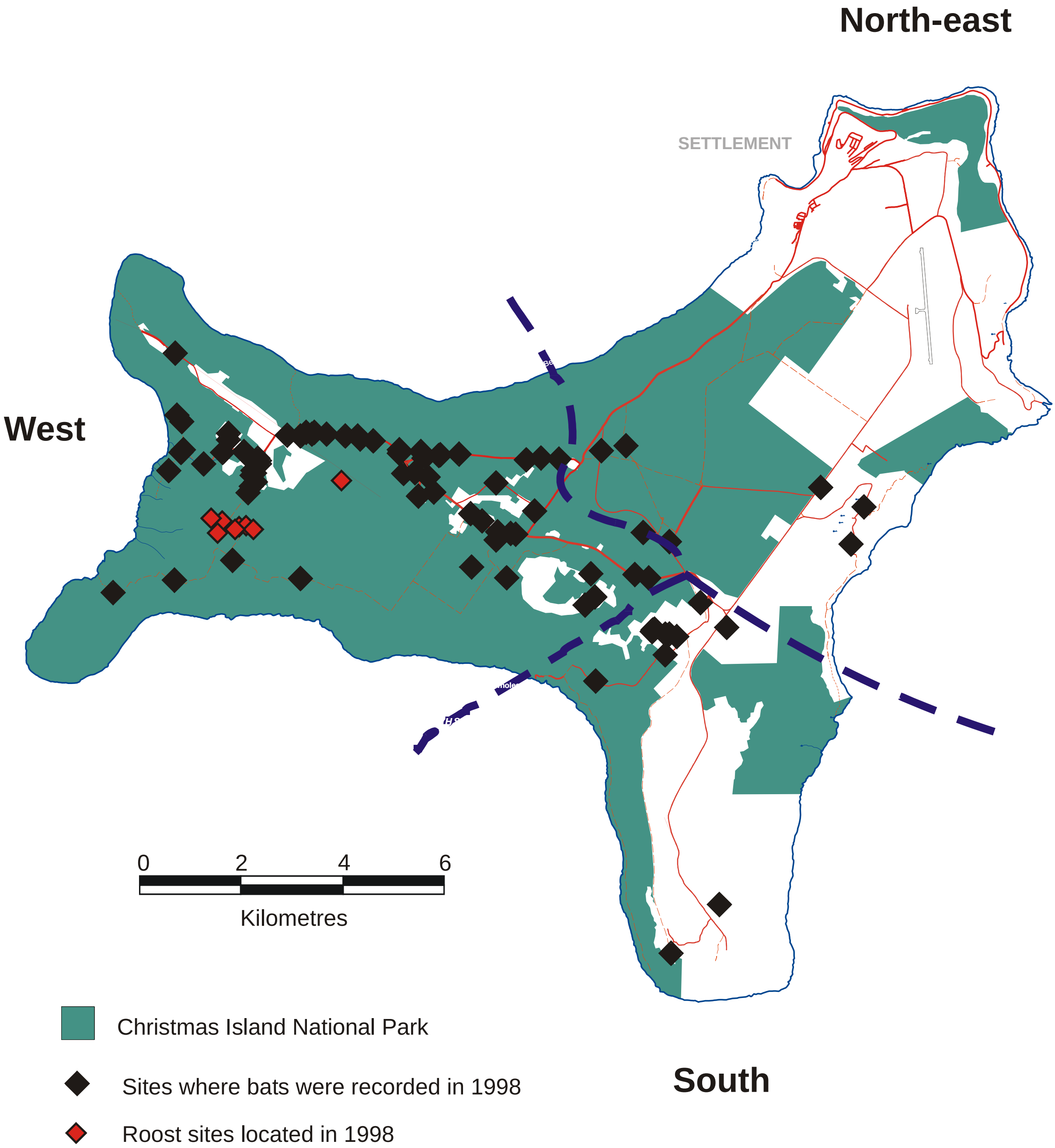


Figure 3. *Known distribution of the Christmas Island Pipistrelle on Christmas Island in 1998 and the sections of the island referred to in the text (adapted from Lumsden* et al. *1999).* Records shown in black are from stationary detector sites, driving searches and harp trapping. Roosts sites located during the 1998 study are shown in red.

Evidence for Decline in the Distribution and Abundance

The Christmas Island Pipistrelle appears to have undergone a significant population decline and range contraction since the mid-1980s when Tidemann (1985) found the species to be common and widely distributed over the island. Population decline in a species is determined by repeatable techniques, demonstrating range contraction and/or loss in numbers. Tree-dwelling insectivorous bats have a unique set of characteristics that make it difficult to document population decline:

- The Christmas Island Pipistrelle does not roost in caves or other situations where individuals can be readily observed and population trends assessed. Instead the species roosts in small numbers in cryptic locations and regularly shifts between a number of roost sites.
- The species is nocturnal making it more difficult and time consuming to obtain distributional and abundance data than for other groups (e.g. insectivorous forest-dwelling birds).
- It is not possible to obtain density measures, such as is routinely undertaken for forest birds using standardised census sampling techniques. Instead relative abundance is assessed in terms of the number of bat detector passes over a period of time. This approach provides useful comparative data on the relative amount of bat activity. However, it cannot be used to represent the number of individuals present in an area since the technique does not distinguish between a small number of individuals making regular passes and a larger number of individuals making single passes.
- In many bird census techniques the behaviour of individual birds is recorded e.g. feeding, resting and flying. However, using any sampling technique to detect tree-dwelling bats (e.g. ultrasonic detector, visual observations or trapping) it is difficult to attribute how individuals are utilising a particular site. An exception is that with ultrasonic detectors actual prey capture can be identified by characteristic feeding buzzes. However, for individuals not emitting feeding buzzes it cannot be ascertained if they are utilising a sampling area searching for food, are in transit between roosting and foraging sites or are present in the area for some other reason.
- Little is known of temporal usage of sites by tree-dwelling bats.

A complicating factor is the rapid change in technology that makes it difficult to compare current to past tree-dwelling bat studies (compared, for example, to forest-dwelling birds where essentially over the last couple of decades techniques to determine distribution and abundance has remained unchanged):

- *Ultrasonic Detectors*: The primary technique used in recent studies to assess the distribution and relative abundance of the pipistrelle was ultrasonic bat detectors. Detector technology has advanced considerably in recent years, from basic units that required constant monitoring to advanced units using timers and storage facilities that allow remote detection throughout the night.
- *Trapping*: Harp traps started being used in Australia in the late 1970s. Current designs of harp traps are more efficient than the earlier designs. Some species of tree-dwelling bats were rarely recorded prior to the widespread use of harp traps.
- *Transmitters*: The only reliable method to detect the roosts of most tree-dwelling bats is by radio-tracking. It is only in recent years that transmitters have become sufficiently lightweight to use on small bats. The technology of batteries have also resulted in units now lasting for considerably longer providing the opportunity for increased likelihood of roost detection and better understanding of roost usage patterns.

Given these constraints, the evidence for a decline and range contraction in the Christmas Island Pipistrelle is as follows (taken from Lumsden *et al*. 1999):

1. Comparison of studies undertaken in 1984 and 1998

There appears to have been a dramatic change in the distribution and abundance of the Christmas Island Pipistrelle since the mid-1980s when Tidemann (1985) undertook the original ecological study of the species. However, quantifying these changes are difficult as different techniques were used in that study, compared to the more recent studies (Lumsden & Cherry 1997, Lumsden *et al*. 1999).

Tidemann (1985) provided a map showing all the locations where the pipistrelle was recorded during his study (reproduced in Figure 4). These records were mainly from sightings while driving along roads, with some additional locations from harp trap captures. For the purpose of comparison, Figure 4 shows all sightings of pipistrelles recorded while driving during the 1998 study (this does not include the 242 km of driving detection as this technique was not used by Tidemann), combined with harp trap captures. Although the distribution and intensity of sampling may not be identical, this comparison provides an indication of distributional trends. The exact routes driven during the 1984 study are not known, however it is likely that the majority of the accessible tracks were driven at night, as was the case in 1998 (refer to Figure 2). By comparing the two maps in Figure 4 it is apparent that the species has contracted westwards and that there were less recorded sightings in 1998 in contrast to 1984. In 1984 pipistrelles were observed in the Settlement area on several occasions, and in areas in the north-east section where they now appear to be absent or in very low numbers. Extensive amounts of driving were conducted in the central plateau area during 1998 and no pipistrelles were seen. In contrast, the apparent disappearance from the Circuit Track, east of Winifred Beach Track, in the southern part of the western section, is probably due to a sampling artefact, as it was sampled frequently during 1984, but was largely inaccessible in 1998 due to numerous treefalls, with only limited sampling undertaken along the western section of this track (see Figure 2).

2. Comparison of studies undertaken in 1994 and 1998

The studies in 1994 (Lumsden & Cherry 1997) and 1998 (Lumsden *et al*. 1999) employed identical sampling methods at stationary detector sites using Anabat detectors. It is therefore possible to directly compare results from these two studies to investigate changes in population status. In both studies pipistrelles were recorded at less than 50% of the sites sampled (Figure 5). The westward contraction appeared to be already well advanced in 1994, with most records concentrated in the western end of the island and pipistrelles recorded at only one site in the north-eastern section. No pipistrelles were recorded at this site in 1998.

To assess changes in relative activity levels at individual sites, 22 of the 27 sites sampled using detectors in 1994 were resampled in 1998. This revealed an overall mean reduction in the amount of bat activity of 33% from 1994 to 1998 (Lumsden *et al*. 1999). The main area of difference between the two years was in the centre of the island, where four sites revealed a decrease in the category of activity level, from either high to moderate, or moderate to low (Figure 5). This area was on the edge of the distribution of the pipistrelle in 1998, and therefore may have been reflecting the westward contraction of the species at that time.

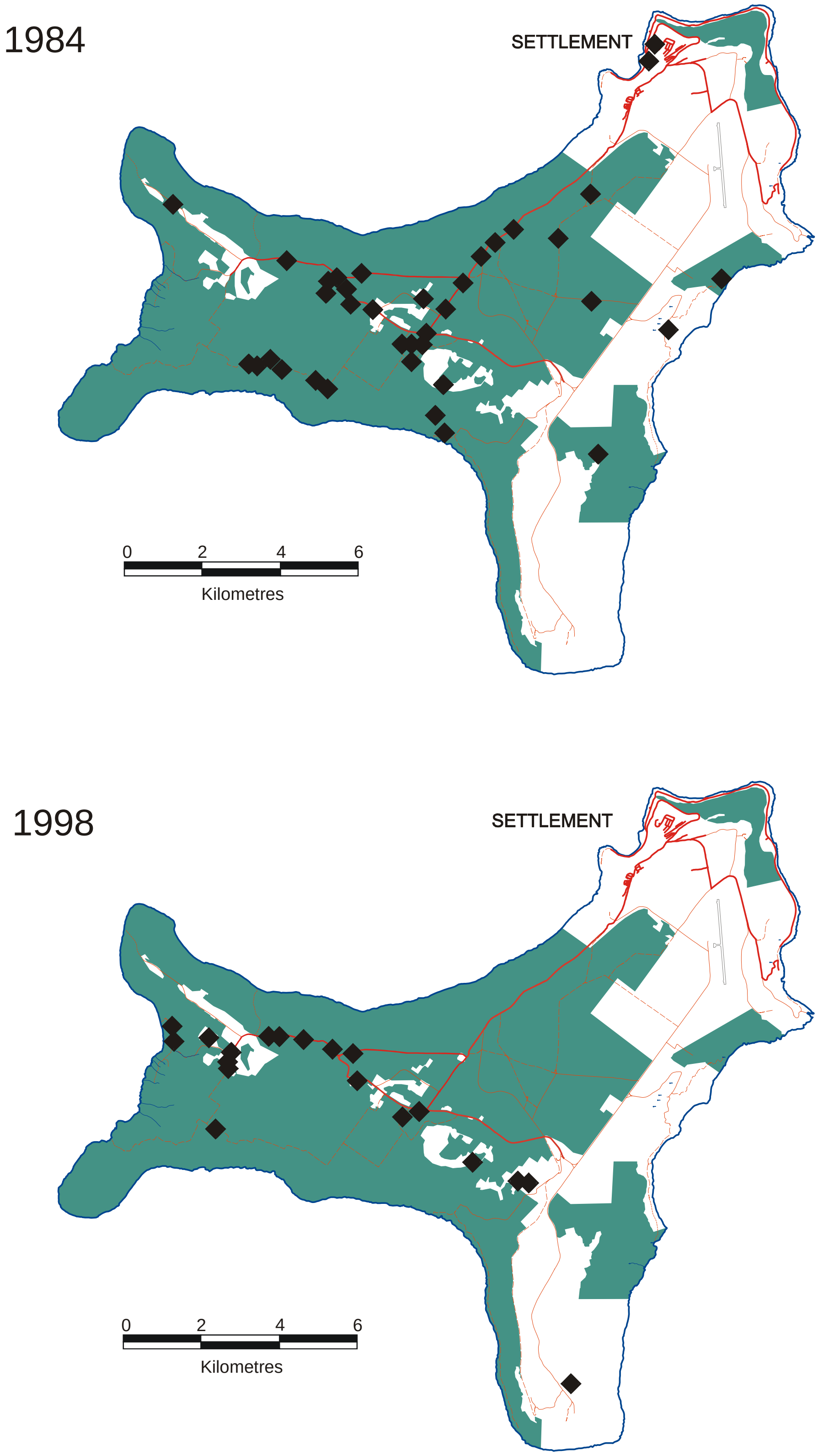


Figure 4. *Range contraction of the Christmas Island Pipistrelle on Christmas Island, between studies in undertaken in 1984 (Tidemann 1985) and 1998 (Lumsden* et al. *1999).* So that the data are comparable, only the bats observed while driving and the trapping records are included from the 1998 survey which were the techniques used in 1984 (refer text for more detail).

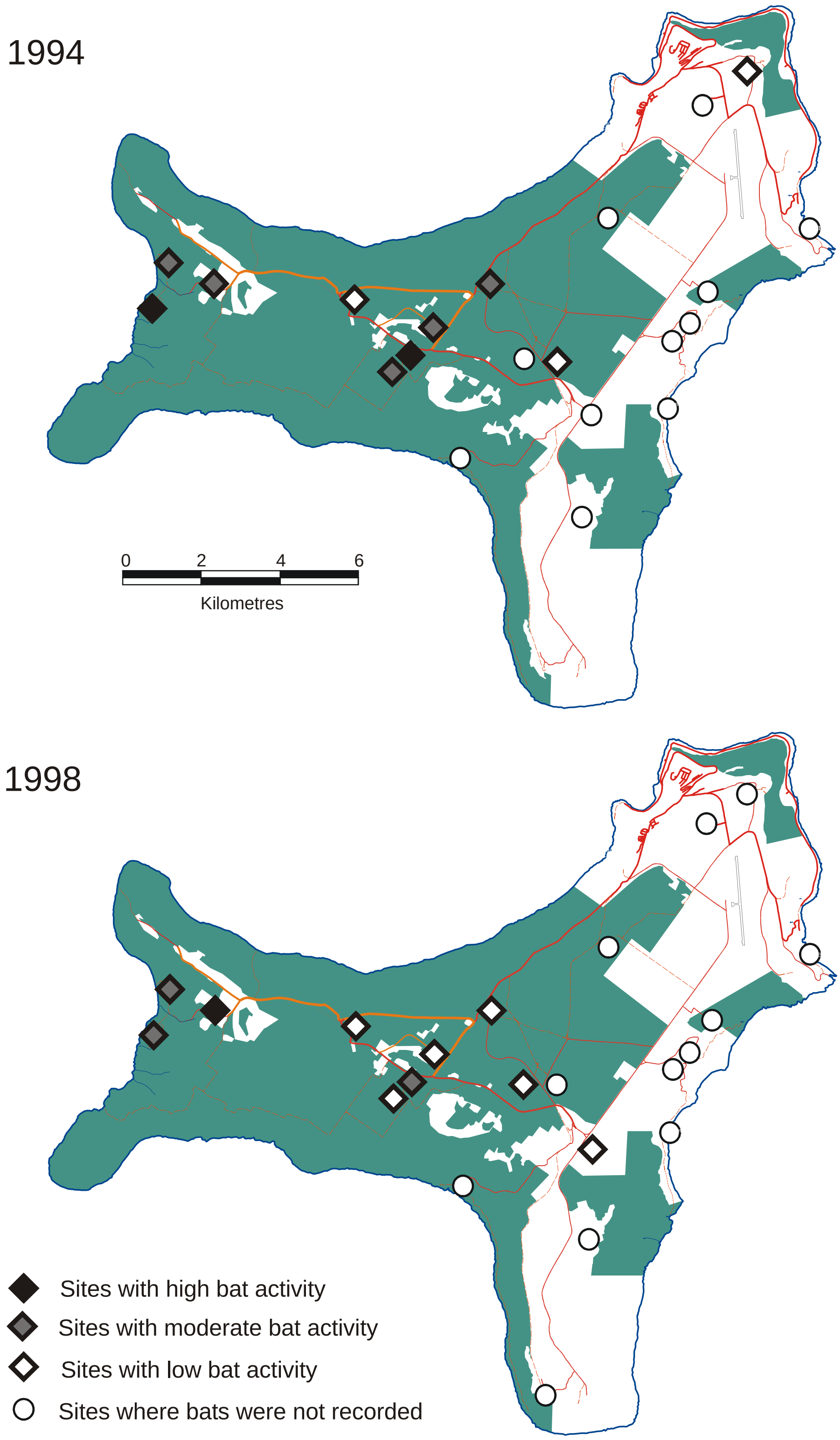


Figure 5. *Comparison of activity levels of the Christmas Island Pipistrelle at 22 sites sampled using bat detectors in both 1994 and 1998 (from Lumsden* et al. *1999).* Refer text for explanation of activity levels.

3. Anecdotal evidence

Anecdotal evidence also suggests a decline in the Christmas Island Pipistrelle. For example, the species was regularly seen in the grounds of the Parks Australia North (PAN) office at Drumsite in the Settlement until the mid-1990s, but not seen subsequently (M. Orchard, PAN, pers. comm., cited in Lumsden *et al*. 1999). Pipistrelles were regularly seen foraging in the clearing at the Christmas Island Research and Education Station in the centre of the island in the 1980s (H. Rumpff, PAN, pers. comm., cited in Lumsden *et al*. 1999), but in 1994 and 1998 were only occasionally recorded. In 1993 and 1994, R. Hill (pers. comm., cited in Lumsden *et al*. 1999) recorded very few visual observations in primary rainforest while conducting ecological studies on the Christmas Island Hawk-Owl *Ninox natalis*.

Habitat Critical to the Survival of the Species

The Christmas Island Pipistrelle has been recorded in a range of habitats on the island, including plateau and terrace rainforest, secondary rainforest regrowth (of all ages), mine regeneration areas and formerly around the Settlement area (Tidemann 1985, Lumsden & Cherry 1997, Lumsden & Tidemann 1999, Lumsden *et al*. 1999). However, when identifying habitat critical to the survival of the species, it is important to identify components of vegetation types critical to different life cycle requirements:

1. Foraging Habitat

The foraging habitat is the best-understood requirement in terms of identification of habitats critical to survival. Bats that are seen or heard in flight at night may be using an area as a foraging location, or for commuting between a roost site and foraging area (which can also be considered as habitat critical to survival). To identify sites that are specifically being used as foraging areas, the recordings made using ultrasonic detectors are examined for characteristic feeding buzzes.

The Christmas Island Pipistrelle is an edge specialist where it forages on a variety of flying insects, in particular moths and beetles (Lumsden & Cherry 1997, Lumsden *et al*. 1999). Evidence suggests it favours vegetation ecotones, tracks and other small gaps within primary rainforest. Tidemann (1985) recorded it foraging on the ecotone of primary rainforest and rehabilitation areas or secondary regrowth, and along tracks and drill lines within primary rainforest. Individuals were also encountered foraging over the High School and inside the open-air Christmas Island Club. In October 2001 Bamford & Bamford (2002) observed an individual foraging along the ecotone of secondary forest and a fernfield in an old mine site, near the southern end of the airport runway. Lumsden *et al*. (1999) found the highest levels of foraging activity occurred in areas of primary rainforest (feeding buzzes were recorded at 73% of the 15 sites where bats were recorded), secondary rainforest regrowth (50% of the eight sites where bats were recorded), and the ecotone of primary rainforest and secondary rainforest regrowth (43% of seven sites where bats were recorded). An example of a site where high levels of bat activity were recorded is shown in Figure 6. Low levels of foraging activity were recorded in rehabilitation areas (25% out of the four sites with bats). No foraging activity was recorded at mined sites (n = 6 sites) and no bat activity was recorded around the Settlement (n = 5 sites) or along the coastline (n = 3 sites).

Within primary rainforest, Lumsden & Cherry (1997) suggested that the main foraging activity was concentrated along edges within small clearings, such as tracks, regenerating drill lines and clearings caused by treefalls. Lumsden *et al*. (1999) tested this at 16 paired sites where bat activity levels were sampled on tracks and in the adjacent rainforest, and found higher foraging activity levels along tracks compared to adjacent rainforest away from distinct edges.

Three environmental variables influenced the observed patterns of foraging distribution (from Lumsden *et al*. 1999):
a. areas with high levels of flying insect availability.
b. ‘section of the island’, with 86% of sites utilised for foraging in the far west, compared to 26% of sites in the remainder of the island.
c. proximity to free water, which may be a reflection of the majority of bats recorded in the western section of the island, such as in the vicinity of The Dales.

Within foraging areas, bats have been recorded feeding from just above the ground level (approximately 0.1 m) to 20 m above primary rainforest canopy (Tidemann 1985, Lumsden & Cherry 1997, Lumsden *et al*. 1999).

Information on foraging habitat has primarily been collected in the dry season. It is currently not known whether foraging habitat preferences alter during the wet season.

Figure 6. *Site of high bat activity: secondary rainforest regrowth at the start of Winifred Beach Track along the edge of the Christmas Island National Park.* The bat detector used to assess activity levels is shown on the left side of the track. (Photo: Lindy Lumsden).

2. Diurnal Roosting Habitat
All roosts of the Christmas Island Pipistrelle have been located within primary plateau rainforest. The species is also likely to roost in similar situations in terrace rainforest. It is not known whether secondary rainforest regrowth currently provides roosting habitat for this species, however, it is likely to provide potential roosting habitat in the future. No roosts have been found in caves, rock overhangs or buildings (Lumsden *et al*. 1999, Lumsden & Tidemann 1999).

Tidemann (1985) located a single radio-tagged individual roosting in a mass of epiphytic vegetation on a canopy tree *Syzygium nervosum*, approximately 15m above the ground. Lumsden *et al*. (1999) tracked seven radio-tagged bats and found them roosting singly or in clusters of up to 47 individuals, in a variety of situations in primary plateau rainforest within the Christmas Island National Park (see Figure 3):

1. Under exfoliating bark of dead canopy trees, predominantly *Tristiropsis acutangula*, 6 to 20 m above the ground (n = 7) (Figure 7).
2. Under flaking fibrous matter on the trunk of live Arenga Palms *Arenga listeri*, 15 m above the ground (n = 1).
3. Under dead fronds of live *A. listeri* (n = 1) or Pandan *Pandanus* sp. (n = 1), 15 and 5 m above ground respectively (Figure 8).
4. Under a Strangler Fig against the trunk of a canopy tree 5 m above the ground (n = 1) (Figure 9).
5. In the hollow of a *Syzygium nervosum* 26 m above the ground level (n = 1) (Figure 10).

Available information suggests that roost fidelity is variable with some individuals shifting between roosts daily while others utilised the same site for at least seven consecutive days. As with many other small insectivorous bats, this species displayed roost area fidelity, shifting roost site regularly between a number of nearby roosts (distance between consecutive roosts: 14 to 186 m, n = 9).

All information on roost site selection has been collected in the dry season. It is currently not known whether roost selection dynamics alter during the wet season.

3. Maternity Roosts

The Christmas Island Pipistrelle is likely to form maternity roosts (where females give birth to their young) during the wet season. All individuals examined by Tidemann (1985) appeared to be in reproductive synchrony, and he concluded that birthing was likely to occur towards the end of December with lactation expected to last for about four weeks into mid or late January. Insectivorous bats often utilise a variety of situations as non-breeding roosts but are highly specific in selecting maternity roosts in the breeding season (Kunz & Lumsden 2003). In tree-roosting bats, these maternity roosts frequently occur in specific types of trees, which are present in low numbers in the landscape (e.g. Lumsden *et al*. 2002). There is no information currently available on maternity roost characteristics selected by the Christmas Island Pipistrelle. These roosts are likely to be situated within primary rainforest, possibly in tree hollows.

Figure 7. *Roost site under exfoliating bark of a dead* Tristiropsis acutangula *in primary rainforest* (Photo: Lindy Lumsden).

Figure 8. *Roost site under the dead fronds of a Pandan in primary rainforest* (Photo: Lindy Lumsden).

Figure 9. *A strangler fig against the trunk of a rainforest canopy tree in primary rainforest providing roosting habitat* (Photo: Lindy Lumsden).

Figure 10. *A hollow high on the main trunk of this* Syzygium nervosum *was used as a roost site by 45 individuals* (Photo: Lindy Lumsden).

4. Commuting Habitat

No information is currently available on the habitat favoured by this species as commuting routes between roost and foraging areas. Limited radio-tracking data suggests individuals can travel distances greater than what may be expected for such a small species. For example, a radio-tagged male was caught at a foraging site only 20 minutes after it had departed a roost, covering a straight-line distance of 2 km during this time (Lumsden *et al*. 1999).

It is not known if this species will cross extensive areas of open modified landscapes, such as mined areas, to reach isolated or disjunct patches of primary and/or secondary rainforest.

Little information is available on the relative importance of various habitat types for roosting, foraging, commuting and maternity sites during all seasons of the year. Until such information is available, habitat critical to survival of the Christmas Island Pipistrelle, based on the requirements established by Regulation 7.09 of the EPBC Act, is defined as:

1) All areas of primary rainforest, since this habitat is known to support foraging, roosting and commuting habitat; and

2) All areas of secondary rainforest regrowth (of all ages), since this habitat is known to provide important foraging habitat, provides commuting habitat, may currently provide roosting habitat, and is likely to support roosting and maternity sites in the future.

The majority of recent records of this species are from the western section of the island and therefore this area is the most critical for the immediate conservation of the species. However, due to the species' rarity, it is important that all areas on the island that fit the criteria for habitat critical to the survival of the species be identified as such in this plan. Habitat critical to the survival situated in the south and north-east sections may provide refuge for relict populations due to the unknown impacts of the Yellow Crazy Ant in areas of important foraging and roosting habitat in the western section of the island. Furthermore, habitat critical to the survival in the south and north-east sections of the island support areas of vegetation that, with appropriate management, will present opportunities for bat re-colonisation to ensure the long-term future of the species. This approach follows Regulation 7.09 (1f) of the EPBC Act, which states that habitat critical to the survival of the species includes areas necessary to ensure the long-term future of the species through reintroduction or re-colonisation.

Mapping of Habitat Critical to the Survival of the Species

The map of habitat critical to the survival of the species (Figure 11) is based on the habitat identified above.

The vegetation map of the island is based on vegetation communities, and no maps are available to distinguish areas of primary and secondary rainforest. Therefore to map habitat critical for the survival of the Christmas Island Pipistrelle the following vegetation communities have been incorporated (which will include areas of both primary growth and secondary regrowth of each community): Tall Closed Forest, Deep Soil Phase; Closed Forest Freshwater Seepage; Closed Forest Scree/Pinnacle Phase; and Closed Forest, Shallow Soil Phase.

Important Populations

Prior to human settlement, it is considered highly likely that the species would have occurred as a single population across the island. This is due to the island's small size, the continuous primary rainforest cover, and the absence of any distinct geographical/vegetation barriers to prevent genetic mixing between different locations on the island. Since the pipistrelle is endemic to Christmas Island and is currently listed as endangered, it is considered that all remaining components of this population, and all areas identified as habitat critical to the survival, are important for the long-term conservation of the species. Small colonies situated in the south and north-east sections of the island may form important relicts due to the unknown impacts of the Yellow Crazy Ant in areas of high pipistrelle foraging activity and important roosting habitat in the western section of the island.

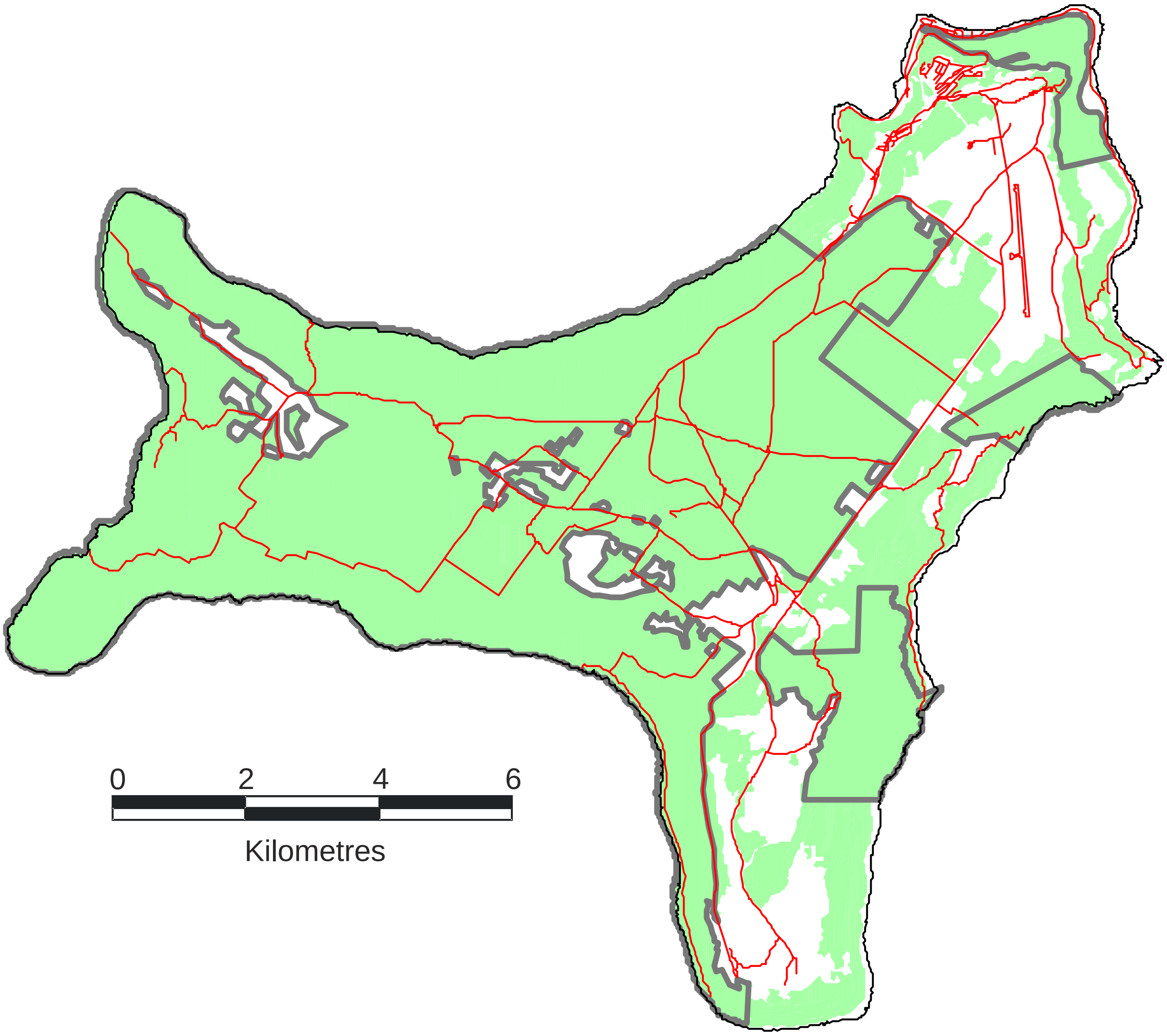


Figure 11. *Habitat critical to the survival of the Christmas Island Pipistrelle based on closed forest and tall closed forest vegetation communities, including both primary forest and secondary rainforest regrowth.* The shaded area shows the habitat critical to the survival of the pipistrelle, and thick grey line indicates the outline of the Christmas Island National Park.

PART C: KNOWN AND POTENTIAL THREATS

Identification of Threats

It is currently not known what has caused the recent decline of Christmas Island Pipistrelle. However, factors that may be influential and hence warrant investigation are listed below. It is likely that the decline of the species is the result of a combination of factors, and as the information available on species' biology and conservation ecology is limited, it is possible that other hitherto unidentified threatening processes may be of additional importance.

Known Threats:

<u>Habitat Loss</u>

The Christmas Island Pipistrelle is a rainforest-dependent species that requires primary rainforest for roosting sites. The extensive clearfelling of primary rainforest for phosphate mining has reduced the roosting habitat available for the species compared to that available at the time of settlement. While opening up parts of the rainforest may have increased the area available as foraging habitat, roosting habitat is generally more restricted and limiting than foraging habitat for insectivorous bats. Hence it is expected that a population decline was experienced by the species in the years of intensive clearing for phosphate mining.

Habitat loss is not considered to be the cause of the recent decline in distribution and abundance as clearing of primary rainforest had not occurred during most of the time between the study of Tidemann (1985) and Lumsden *et al.* (1999) (clearing of primary rainforest ceased in 1987). However any additional loss of habitat may compound the other factors that are impacting on the species and are likely to be more influential now that the species has been reduced to lower population size and is in decline.

The proposed removal of phosphate stockpiles within the Christmas Island National Park may adversely affect foraging and commuting habitat, and possibly roosting habitat. Proposals currently under consideration to clear primary rainforest on vacant crown land may provide additional pressure on remaining Christmas Island Pipistrelle populations and/or reduce suitable habitat available for the long-term recovery of the species. These proposals include phosphate mining at sites in the eastern section of the island, and activities associated with developments such as the siting of a mobile phone tower on Limestone Hill, South Point; the Christmas Island airport upgrade; and Linkwater Road re-alignment north of the Christmas Island Resort area. Small numbers of pipistrelles have been sighted recently at Limestone Hill and in the proposed southern extension of the airport (Bamford & Bamford 2002; M. Bamford, pers. comm.).

Potential Threats:

<u>Yellow Crazy Ant *Anoplolepis gracilipes*</u>

The Yellow Crazy Ant is a tramp species that has been recognised as among the top 100 of the "world's worst" invaders by the IUCN and the Global Invasive Species Database (O'Dowd 2002). It is currently under nomination for listing as a key threatening process under the EPBC Act and has been recognised as a key threat to biodiversity on Christmas Island (Commonwealth of Australia 2002). Due to its generalised biology it can be readily translocated in packaging material, timber, plants and soil, and continues to spread around the globe (O'Dowd 2002). It was accidentally introduced to the island some time between 1915 and 1934 (O'Dowd *et al*. 1999). These ants form multi-queened supercolonies, and dramatic increases in supercolony formation began in the mid to late 1990s at several widespread locations. The effect of the supercolonies is that the Yellow Crazy Ant may become the numerically dominant consumer on both the forest floor and in the canopy (O'Dowd *et al*.

1999, O’Dowd *et al*. 2003). Supercolonies range in size from several hectares to several hundred hectares, and at the height of their infestation occupied 25% of the total rainforest area on Christmas Island.

It is currently not known what impact the Yellow Crazy Ant has on the Christmas Island Pipistrelle. However, evidence indicates that the continuing spread of the ant would have deleterious consequences for the long-term viability of the species. The Yellow Crazy Ant has been recorded preying on mammals elsewhere, such as newborn pigs, dogs, cats, rabbits and rats (e.g. Lewis *et al*. 1976, Haines *et al*. 1994). The Christmas Island Pipistrelle is known to be attacked and killed by the ant: one individual captured in a harp trap set on the Martin Point Track died as a result of Yellow Crazy Ant attack in 1998 (Lumsden *et al*. 1999). Bats contacted by Yellow Crazy Ants that are not killed directly are likely to suffer reduced fitness due to exposure from sprayed formic acid leading to blindness and physiological stress (O’Dowd *et al*. 1999).

The 1998 study of the Christmas Island Pipistrelle by Lumsden *et al*. (1999) was undertaken at the time that supercolonies were beginning to form on the island and the potential problem they may cause was just starting to be recognised. Some of the locations that indicated a reduction in Christmas Island Pipistrelle abundance between 1994 and 1998 were in areas where supercolonies had started to form (e.g. Field 22S and The Dales; Lumsden & Cherry 1997, Lumsden *et al*. 1999). However, in the 1998 study, foraging and commuting activity was recorded in some areas that supported Yellow Crazy Ant supercolonies (e.g. Martin Point Track where the supercolony formed in 1997). Many sites that revealed a reduction in pipistrelle activity levels between 1994 and 1998 were in areas unaffected by Yellow Crazy Ant supercolonies. Therefore it cannot be concluded that the observed activity reductions in some sites were as a result of the Yellow Crazy Ant. However, since that time 14 of the 15 sites with high or moderate levels of pipistrelle activity were invaded by, or were within the bat’s foraging range of, ant supercolonies (Appendix One).

All the roosts located in 1998 were in areas that were devoid of supercolonies at the time. The majority of roosts were situated under exfoliating bark, strangler figs or in hollows on the main trunks of rainforest canopy trees (e.g. Figures 7-10). These roost locations are directly in the path of foraging columns of ants travelling from nests on the ground to the canopy where they forage (O’Dowd *et al*. 1999). Consequently, such roost sites are likely to be readily accessed and investigated by Yellow Crazy Ants. In supercolonies the density of ants has been recorded at about five ants per 100 cm^2 of tree bole at breast height (D. O’Dowd, pers. comm.). Some roost sites may also be potentially usurped by ants nesting in canopy or mid-strata tree hollows. It is likely that in areas infested by Yellow Crazy Ant, the Christmas Island Pipistrelle would be forced to select alternative roosts, where available. Such roosts may not provide appropriate structural characteristics to afford shelter from adverse weather conditions or predators, or provide the appropriate thermal microclimate. No maternity sites have been located but these roosts may be situated in the hollows of rainforest canopy trees. Similarly, these sites would also be susceptible to infestation and potential predation. Given the small size of the pipistrelle (adults weigh 3-4.5 g, with new-born young likely to weigh approximately 1 g) maternity sites located within supercolony areas, and in particular the non-volant young, must be considered at risk.

The Yellow Crazy Ant has a generalist diet foraging on seeds, a variety of leaf litter and arboreal invertebrates, crustacea including land crabs, reptiles, birds and mammals, throughout the day and night (e.g. O’Dowd *et al*. 1999, O’Dowd 2002). The maintenance of Yellow Crazy Ant supercolonies results in intense localised predation pressures resulting in the alteration of invertebrate diversity and abundance throughout all strata of the rainforest.

For example, in affected areas compared to forests with no Yellow Crazy Ant supercolonies, Davis *et al*. (2002) recorded lower densities of litter-dwelling invertebrates, and G. Richards (pers. comm.) observed markedly less stridulating katydids in the rainforest canopy. Such predation pressures on invertebrates are likely to influence prey availability of the Christmas Island Pipistrelle, and require investigation. Reduction in flying insect numbers may result in reduced breeding success and a reduction in bat population size.

Yellow Crazy Ant infestations also lead to tree dieback with some rainforest canopy tree species more affected than others (e.g. *Inocarpus fagifer*), thereby potentially resulting in the alteration of the species composition of the primary rainforest (O'Dowd *et al*. 2001, 2003). Additionally, alteration in various invertebrate and seed-dispersing terrestrial bird populations may influence floristic composition of affected rainforest areas (Davis *et al*. 2002). Changes in rainforest species composition may have long-term effects on the Christmas Island Pipistrelle in terms of the availability of suitable roosts and maternity sites. For example, some canopy trees are more prone to hollow and exfoliating bark formation than others.

The Yellow Crazy Ant has the potential to alter the whole ecology of the island due to its generalised foraging and nesting habits in both disturbed and undisturbed habitats. For example, an estimated 15 to 20 million Red Crabs *Gecarcoidea natalis* have been killed since 1989, resulting in dramatically altered plant community dynamics (O'Dowd & Lake 1989, 1990, 1991; Green *et al*. 1997). The Red Crab has been described as a keystone species influencing the ecology of the rainforest on Christmas Island at a landscape level (Lake & O'Dowd 1991). The removal of the Red Crab results in increased seedling production, increased forest leaf litter accumulation, and an increase in understorey growth thereby altering the structure of the rainforest. Alteration in forest structure may significantly influence within-rainforest foraging habitat. The increased density of the understorey layer may exclude access to potential roosts in the lower forest strata. Evidence indicates that the Christmas Island Pipistrelle forages in canopy breaks including those along ecotones and caused by treefalls, and less frequently within the canopy in open situations with little mid-storey (Lumsden *et al*. 1999). A denser mid-canopy structure would restrict within-canopy foraging.

A priority conservation management objective of the Crazy Ant Steering Committee and Parks Australia North was to control Yellow Crazy Ant supercolonies using ant baits. An aerial baiting program has resulted in the destruction of supercolonies at all sites baited (Green 2002; Kemp 2003; M. Jeffery, Parks Australia North, pers. comm.). Follow-up ground surveys and baiting are at present being conducted in areas that previously did not support supercolonies and were therefore not targeted by aerial baiting. The impact of anticide baiting on the Christmas Island Pipistrelle, both directly through contact with the bait and indirectly through flow-on impacts on prey species, is unknown (e.g. Green 2002).

<u>Predation</u>
Except for one death due to Yellow Crazy Ants (see above), no instances of predation have been recorded. However the likelihood of observing the predation of a small, cryptic nocturnal bat is extremely low, and predation is probably occurring but going unrecorded. The Christmas Island Pipistrelle may be exposed to predation pressures from three categories of predators:

1. Introduced Predators:

a) Common Wolf Snake *Lycodon aulicus capucinus*: This species is a recent coloniser from Southeast Asia that was first recorded in the Settlement area in 1987 (Smith 1988). It forages predominantly on lizards and occasionally small mammals on the ground or in the lower forest strata (Deoras 1978, Daniel 1989, Murthy 1990). The Common Wolf Snake is usually associated with human habitation and on Christmas Island is established around the Settlement area (Rumpff 1992, Fritts 1993) (Figure 12). Until 1998, the only record elsewhere on the island was of a population around the buildings at Grants Well in the centre of the island. In 1998 the location of a number of individuals further west indicated a range expansion for this species: a population was found at the Christmas Island Research and Education Station, 1.3 km south of Grants Well, and one snake was found active at night on the EW Baseline at the junction of the eastern arm of the Circuit Track (Cogger & Sadlier 1999, Lumsden *et al*. 1999) (Figure 12). This westward range extension appears to be continuing with a specimen located on 20 May 2003 at Field 22S, another 2.3 km further south-west (M. Jeffery, pers. comm.) (Figure 12). Although the Common Wolf Snake has been recorded on the edge of primary rainforest in the central parts of the island it is not known whether it is confined to the edges or is spread throughout rainforest tracts. The Common Wolf Snake is capable of climbing trees (Auffenberg 1980) and may predate on roosting bats, particularly those sheltering under exfoliating bark and Strangler Figs on the lower trunks of rainforest trees. Non-volant young left in maternity roosts at night while the adults are away foraging may be particularly exposed to predation by this snake.

Lumsden *et al*. (1999) considered this snake to be a likely factor in the observed decline and westward range contraction of the Christmas Island Pipistrelle. In 1984 when Tidemann (1985) recorded the pipistrelle to be widespread and common, including in the Settlement area, the snake was not yet introduced to the island. However, by the early 1990s, extremely high densities (up to 500 individuals per ha) were recorded (Rumpff 1992). In 1994 no pipistrelles were observed in the Settlement, although low levels of activity were recorded at a single site nearby (see Figure 5). No pipistrelles were recorded anywhere in the far north-eastern section of the island in 1998, and anecdotal evidence suggested they disappeared from the Drumsite area of the Settlement several years before (Lumsden *et al*. 1999). The expansion of the Common Wolf Snake into the central region of the island may account for the decline of the bat in that region (for example the marked decline in bat activity around the Christmas Island Research and Education Station) and the general westward contraction in distribution. No bats were recorded at the detector sites immediately adjacent to the three Common Wolf Snake locations in the centre of the island (Figure 12).

Introduced snakes have had devastating impacts on island fauna elsewhere (e.g. Savidge 1987, Fritts & Rodda 1998, Loope *et al*. 2001). For example, the Brown Tree Snake *Boiga irregularis* has caused the extinction of 75% of the native forest bird species and half the native lizards on Guam within 40 years of introduction (Loope *et al*. 2001), and reduced the Mariana Fruit Bat *Pteropus mariannus* population to only 100 adults, with no recruitment for a decade (Fritts & Rodda 1998). Of all the introduced predators on Christmas Island, the Common Wolf Snake is the only species for which the timing of the introduction was immediately prior to the decline of the pipistrelle and whose distribution mirrors that of the pipistrelle (Figure 12). Having evolved in the absence of arboreal predators, the Christmas Island Pipistrelle is likely to be naive to the risk of climbing snakes and would not have developed strategies to avoid such predation. The Common Wolf Snake has had serious detrimental impacts when introduced to other islands. For example, on Reunion Island it has been attributed with causing a decline in endemic mice and the near extinction of a species of gecko (Cheke 1987). Weighing less than 5 g the Christmas Island Pipistrelle is smaller than some of the other vertebrate species that the Common Wolf Snake has been recorded preying upon.

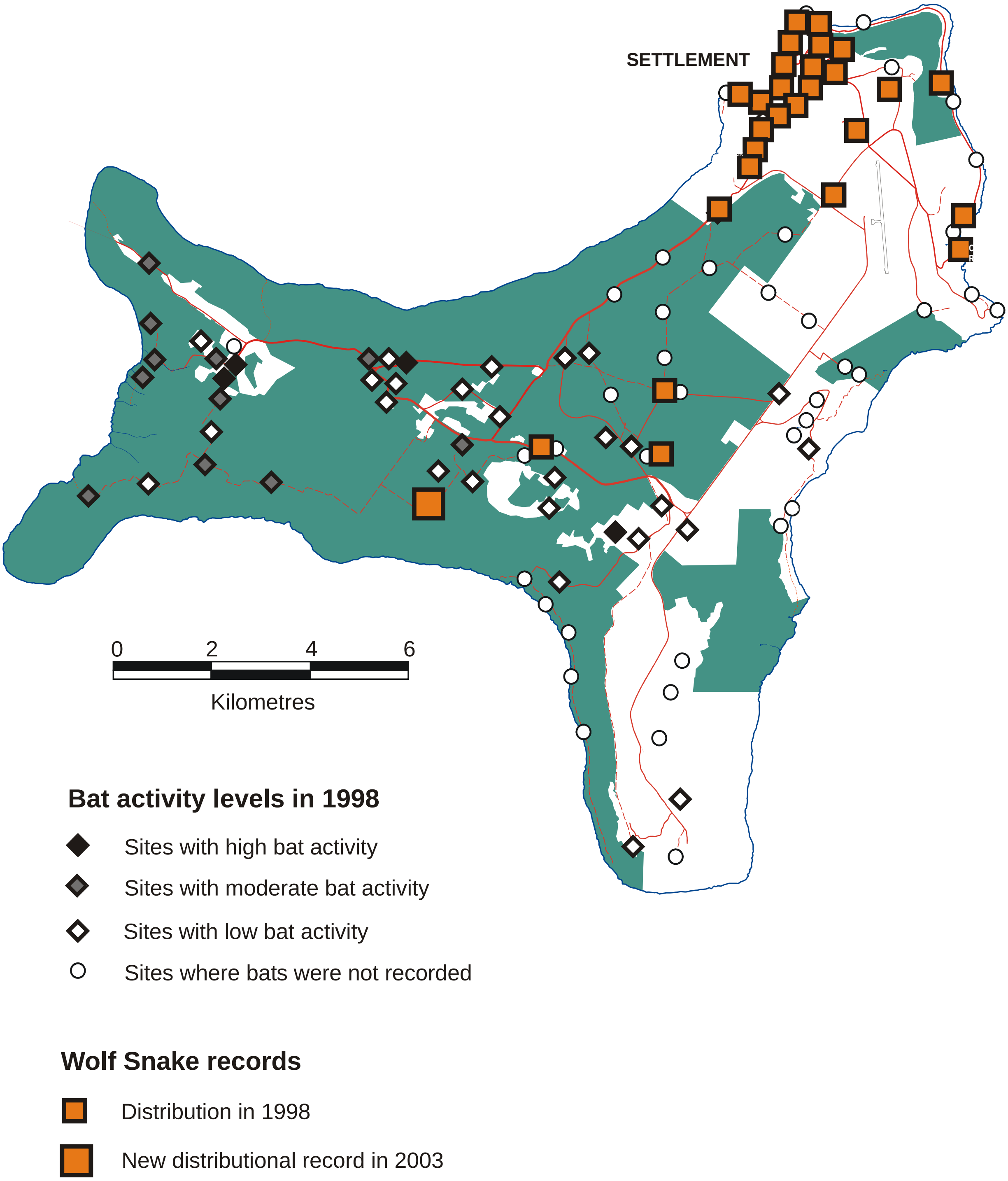


Figure 12. *The distribution of the Common Wolf Snake up until 1998, in comparison with activity levels of the Christmas Island Pipistrelle at 84 detector sites sampled in 1998 (from Lumsden* et al. *1999).* A record of the Wolf Snake from 2003 indicates a continued westward expansion (M. Jeffery, pers. comm.).

b) Feral Cat *Felis catus*: This introduced predator became established soon after settlement, and is now common and widespread on the island. It is considered to pose a severe threat to native animals on Christmas Island (Commonwealth of Australia 2002). Although dietary studies have not revealed the Christmas Island Pipistrelle as a prey species (Tidemann *et al*. 1994), it is possible that occasional individuals are captured given their low roosting and foraging habits.

c) Black Rat *Rattus rattus*: This exotic species has been attributed with the extinction of bats on islands elsewhere in the world (e.g. Daniel & Williams 1984), and is thought to be a severe threat to native animals on Christmas Island (Commonwealth of Australia 2002). The Black Rat was introduced when the island was first settled, and is now common and widespread throughout the island, and occurs both in areas occupied and not occupied by the pipistrelle. However, it is possible that the Black Rat may be a contributing factor in the decline of the pipistrelle. Potential changes in the distribution and abundance of this opportunistic rat, in response to altered food resources as a result of the impacts of the Yellow Crazy Ant supercolonies on rainforest structure, may need to be considered.

2. Naturalised Predators
Nankeen Kestrel *Falco cenchroides*: On mainland Australia, the Nankeen Kestrel preys primarily on terrestrial vertebrates, with bats occasionally recorded as a dietary item (Lewis 1987, Marchant & Higgins 1993). This raptor expanded its range and significantly increased in abundance on the island in the 1980s (H. Rumpff, cited in Lumsden *et al*. 1999). Although a bird of grasslands and other open habitats on mainland Australia, on Christmas Island this species is also widespread in areas of secondary rainforest regrowth. It is absent from extensive tracts of primary rainforest (such as in the west of the island). However, it is present along the edges and tracks through some areas of primary rainforest, using these openings as foraging locations. In 1984, Tidemann (1985) recorded the pipistrelle hawking insects along roads and ecotones during the late afternoon, several hours before dusk. Foraging by bats during daylight hours on islands elsewhere in the world has been attributed to a lack of avian predators (Speakman 1995). No daytime foraging of the Christmas Island Pipistrelle was observed in 1994 by Lumsden & Cherry (1997) or 1998 by Lumsden *et al*. (1999) suggesting a temporal shift in foraging behaviour. Such a change in behaviour may be the result of predation pressure, with emergence shifting to dusk when predation risk is lower.

The Nankeen Kestrel was widespread across the island (in 1998), both in areas that the pipistrelle had disappeared from and in areas where it was still relatively common (Lumsden *et al*. 1999). Therefore, it is unlikely that predation by this species is the primary cause of the decline, however, the possibility that it is a compounding factor cannot be ruled out, and requires investigation.

3. Endemic Predators
The Christmas Island Pipistrelle has not been recorded as a prey item of the Christmas Island Goshawk *Accipiter fasciatus natalis* or Christmas Island Hawk-Owl *Ninox natalis* (Hill 2002a, b; Hill & Lill 1998). However, it is possible that both species may opportunistically prey on this bat. The relationship between the pipistrelle and these potential natural predators is not likely to have altered recently, and hence they are not considered to be the cause of the recent decline.

<u>Prey Availability</u>
Unknown factors may be altering the densities of prey available to the Christmas Island Pipistrelle. Preliminary dietary studies have indicated a range of flying invertebrates are taken as prey items. Further investigations, however, are required to determine if the species is an opportunistic feeder or shows dietary specialisation, and if this varies throughout the year. As

discussed above, Yellow Crazy Ant supercolonies appear to have resulted in the reduction of invertebrate diversity and abundance. Alteration to flying insect numbers may result in reduced breeding success of the pipistrelle, leading to a reduction in population size.

Habitat Alteration

In the 1960s drill lines were bulldozed across the island at 120 m intervals for phosphate mining exploration. This resulted in the clearing of 354 separate lines with a total length of 506 km (Lumsden *et al*. 1999). The Christmas Island Pipistrelle is an edge specialist targeting forest ecotones and gaps within the rainforest canopy. In 1984 Tidemann (1985) commonly observed bats flying along open drill lines. By the mid-1990s, the combination of storm damage and the regeneration of vegetation along many of the drill lines resulted in the loss of this temporary foraging niche. The loss of this habitat may have caused a local reduction in population numbers. It does not, however, account for the apparent abundance of this bat at first settlement (e.g. Andrews 1900) or the westward contraction in range of the pipistrelle.

Climatic Conditions

Cyclones have been documented to severely impact bats on islands (e.g. Craig *et al*. 1994, Gannon & Willig 1994, Rodriquez-Duran & Vazquez 2001). A severe storm in March 1988 damaged significant areas of primary rainforest. The impact of this natural event on the roosting, maternity and foraging areas of the pipistrelle is unknown.

The effects of drought as experienced in 1997 and early 1998 on the Christmas Island Pipistrelle are unknown. It is likely that such conditions restrict prey numbers and may influence the thermal properties of roosts resulting in a population decline. Although forest fires are uncommon on the island, during recent extended dry periods in 1994 and 1997, fires occurred in terrace rainforest. The effects of forest fire on the Christmas Island Pipistrelle is unknown, but may result in direct adverse impacts due to the loss of roost sites (particularly exfoliating bark on tree trunks), and indirectly by affecting invertebrate populations. There may be an increased potential for wildfires in primary rainforest as a result of falling debris from wayward or failed launches from the proposed Asia Pacific Space Centre.

Vehicle-related Mortality

The Christmas Island Pipistrelle commonly forages along roads from close to ground level to above canopy height within and along the ecotone of primary rainforest and secondary rainforest regrowth (Tidemann 1985, Lumsden & Cherry 1997, Lumsden *et al*. 1999). Small rainforest bat species are known to be the victims of roadkills elsewhere (Schulz 2000). Currently the incidence of vehicle-related mortality (e.g. from night haulage trucks associated with phosphate mining) is unknown. Although not considered a major cause of mortality, increased night-time traffic levels along roadways may result in an increase in vehicle-related mortality, especially in the western section of the island, due to the construction of the Immigration, Reception and Processing Centre and associated infrastructure. If population numbers were high, deaths due to vehicles would probably be inconsequential. However, as numbers decrease, any additional deaths have a greater impact.

Disease

Although there is no evidence for disease in the Christmas Island Pipistrelle population the possibility that the decline in the species is due to an epidemic resulting from an introduced pathogen cannot be ruled out. It is believed that the extinction of the two native species of rats on Christmas Island was due to an introduced pathogen carried by the Black Rat (Pickering & Norris 1996). There was no obvious external sign of ill health in the pipistrelles caught during the 1994 or 1998 studies. If disease was a factor it could be expected that animals on the edge of the distribution, where the decline was most evident, would have been in a poorer condition (as indicated by lower body weights) than individuals in the west of the island. However, there was no difference between the two areas in the body weight of individuals captured.

<u>Decreasing Population Size</u>
Current evidence suggests that the Christmas Island Pipistrelle is declining in both distribution and numbers. A small population size increases the risk of extinction through inbreeding depression and stochastic events (Caughley & Sinclair 1994).

Areas Under Threat
Potentially, all primary rainforest and secondary rainforest regrowth, which together provide key critical diurnal roost, maternity roost and foraging habitat, may be considered as areas under threat:

a) <u>Habitat Loss</u>: Loss of any area of primary rainforest, secondary rainforest regrowth and rehabilitation sites will result in the elimination of currently utilised habitat or areas of habitat required for the long-term recovery of the species.

b) <u>Yellow Crazy Ant</u>: Potentially all disturbed and undisturbed forest habitat may be under threat, depending on the success of control measures taken and maintained by the Crazy Ant Steering Committee and Parks Australia North. While most of the large supercolonies have now been controlled, numerous small supercolonies are developing in plateau areas (D. O'Dowd, pers. comm.), which if not controlled may impact on the pipistrelle in the future.

c) <u>Predators</u>: The identified suite of potential predators occurs throughout the island in a range of habitats occupied by the Christmas Island Pipistrelle as foraging or roosting habitat. The extent of areas occupied by the Common Wolf Snake away from the Christmas Island Research and Education Station, Grants Well and the Settlement area are poorly known. It is not known whether this snake ranges into primary rainforest away from roads and disturbed edges.

d) <u>Prey Availability</u>: Foraging occurs in a wide variety of habitats. However, it is not known which of these represent core foraging habitats and whether the species specialises on specific flying insects at various times of the year.

e) <u>Habitat Alteration</u>: The regrowth of the drill lines bulldozed in the 1960s is occurring in primary rainforest and secondary rainforest regrowth throughout the island.

f) <u>Roadkills</u>: Vehicle-related mortality is likely to occur on main thoroughfares between the Settlement and phosphate mining sites or developments in the south and west of the island. Increased mortality may occur as a result of the Immigration, Reception and Processing Centre, as sections of the road between this Centre and the Settlement pass through areas of high bat foraging activity (Figure 2).

g) <u>Climatic Conditions and Disease</u>: All areas of known and potential habitat may be affected by these threatening processes.

h) <u>Decreasing Population Size</u>: Since this declining species is restricted to Christmas Island all areas of habitat currently supporting pipistrelles may be affected by the risks associated with small population size.

Populations Under Threat
Since the cause of the decline and westward contraction of the Christmas Island Pipistrelle is still to be established, it must considered that the entire population is under threat. Christmas Island supports the only known location of the Christmas Island Pipistrelle. Therefore conservation of this population is essential to the survival of the species.

PART D: OBJECTIVES, CRITERIA AND ACTIONS

Recovery Objectives and Timelines

The overall objectives of this recovery plan are to:

- determine the threatening processes responsible for the decline in the species,
- maximise the opportunity for the viability of the species in the wild, and
- clarify its taxonomic status.
- evaluate the Christmas Island Pipistrelle's conservation status.

Specific objectives for the five years of this Recovery Plan are listed below. Note that these objectives are not listed in order of priority.

- *Objective 1*: To assess current population and distribution trends of the Christmas Island Pipistrelle.
- *Objective 2*: To determine the roosting requirements of the Christmas Island Pipistrelle, including seasonal and distributional differences.
- *Objective 3*: To assess the potential for the Common Wolf Snake to prey on bats in roosts and if it is considered that they impact on pipistrelles, devise management actions to reduce predation.
- *Objective 4*: To assess the impact of the Nankeen Kestrel and if found to predate on pipistrelles, devise management actions to reduce impact.
- *Objective 5*: To identify primary foraging site characteristics in the dry and wet seasons, especially away from ecotones and roadways, within extensive tracts of primary rainforest.
- *Objective 6*: To examine dietary specialisation as a contributing factor in the species' decline.
- *Objective 7*: To clarify the taxonomic status of the Christmas Island Pipistrelle.
- *Objective 8*: To continue active management for the control of Yellow Crazy Ant supercolonies.
- *Objective 9*: To increase protection of known and potential habitat outside the Christmas Island National Park.
- *Objective 10*: To assess the potential impact on the Christmas Island Pipistrelle of phosphate stockpile removal within and abutting the Christmas Island National Park.
- *Objective 11*: To establish guidelines to reduce vehicle-related mortality along roads passing through important foraging areas.
- *Objective 12*: To review the conservation status of the species.

Performance Criteria

Performance Criteria listed below match the corresponding Objectives and are to be achieved within the five-year duration of the plan:

- *Criterion 1*: The current status of the population and distribution trends in the species are determined.
- *Criterion 2*: Roosting requirements are characterised, including maternity and non-breeding roosts. Roosting requirements in the core of the species range are compared with those at the eastern limit of the range, and the impact of Yellow Crazy Ant supercolonies on roosting habitat is determined.
- *Criterion 3*: The impact of the Common Wolf Snake on roosting bats is determined and management actions established to reduce such impacts where they occur.
- *Criterion 4*: The impact of the Nankeen Kestrel on pipistrelles is determined and management actions established to reduce such impacts where they occur.
- *Criterion 5*: Primary foraging habitat is identified away from forest ecotones and roadways.
- *Criterion 6*: The diet of the species is determined in both the wet and dry season and compared to prey availability.
- *Criterion 7*: Taxonomic status of the Christmas Island Pipistrelle is resolved.
- *Criterion 8*: All supercolonies of the Yellow Crazy Ant are eliminated and ongoing management undertaken to ensure no subsequent re-infestation.
- *Criterion 9*: Protection of known or potential habitat is increased outside the Christmas Island National Park.
- *Criterion 10*: An assessment of the impacts on the Christmas Island Pipistrelle of proposed phosphate stockpile removal within and abutting the Christmas Island National Park has been conducted.
- *Criterion 11*: Guidelines have been established and implemented to reduce vehicle-related mortality.
- *Criterion 12*: The conservation status of the species has been reviewed.

Evaluation of Performance

The plan's performance is to be reviewed by an Island Recovery Team as proposed for avifauna by Garnett & Crowley (2000). This recovery team is to be established with the primary objective of developing and implementing island-wide conservation management and recovery plans, including for the Christmas Island Pipistrelle. The Recovery Team is to review and evaluate progress with respect to this Recovery Plan annually over the five-year period. This recovery team should comprise:

a. on-island representatives, including Parks Australia North staff, a Shire of Christmas Island representative, and other local members as deemed appropriate, and
b. off-island representatives, including, a scientific member of the Crazy Ant Steering Committee and one or two leading bat ecologists with first-hand knowledge of the island's ecology.

Actions

The EPBC Act requires that a Recovery Plan must provide for research and management actions necessary to halt the decline of, and support the recovery of, listed threatened species or ecological communities to maximise these species/communities chances of long-term survival. Therefore, some of the actions identified within this Plan are research actions that are essential to identify threatening processes and the cause of the decline and range contraction in the Christmas Island Pipistrelle.

Note: The identified actions have been divided into research and management actions and are not listed according to order of significance or impact.

A. Research and Monitoring Actions

Action 1: Assess population and distribution trends in the Christmas Island Pipistrelle and establish long-term monitoring programs (Obj. 1, 3, 4, 6, 8, 9, 10 and 11; Perf. Crit. 1, 3, 4, 6, 8, 9, 10 and 11)

Background Summary: Available evidence indicates that the species is in decline and its range is contracting westwards. As the last comprehensive study was undertaken in 1998, it is critical that a reassessment of the current status and distribution of the species is undertaken, and that changes in activity levels in areas that were formerly infested with the Yellow Crazy Ant supercolonies are investigated. A long-term monitoring program is required to assess the recovery of the species.

Threatening Process: Various, particularly threatening processes contributing to a decline and westward range contraction in the species.

Actions:

1a) Using the same methodology at the same sites sampled by Lumsden *et al*. (1999) investigate whether the continuing trend of westward range contraction is still occurring. Conduct sampling in May-June of Year 1 using the sampling technique outlined in Appendix One. Undertake repeat sampling using the same techniques in May-June of Year 5.

1b) Using comparable techniques to Lumsden *et al*. (1999), determine differences in activity levels at localities supporting high or moderate bat activity that have been or currently are infested with Yellow Crazy Ant supercolonies, as outlined in Appendix One. This monitoring study needs to be conducted in May-June for direct comparison with the pre- or early infestation results presented in Lumsden *et al.* (1999). It should include the same insect sampling techniques (Appendix One). Conduct repeat sampling using the same techniques in May-June of Year 5.

1c) Establish a Christmas Island Pipistrelle database to record casual night-time observations, daylight foraging observations, predation incidences, sightings away from ecotones and roads, and other information that would be valuable in the context of this Recovery Plan. Such a database could provide supplementary baseline information on critical components of the species' ecology.

1d) Establish an island-wide monitoring program to determine long-term population and distributional trends that can be undertaken by Parks Australia North personnel using an easily repeatable set of criteria as recommended in Appendix Two. As part of this action: i) purchase equipment required to undertake long-term monitoring (Appendix Two); ii) establish protocols for the analysis of each sampling session in consultation with experienced bat ecologists and iii) establish a database to ensure the accessibility of monitoring results in the advent of staff turnover.

Action 2: Determine roosting requirements, investigating seasonal and distributional differences (Obj. 2, 3, 9 and 10; Perf. Crit. 2, 3, 9 and 10)

Background Summary: Only limited information is available on roosting requirements of the Christmas Island Pipistrelle, and this is all from within the dry season. No information is available on roosting requirements during the birthing and lactation periods in the late dry and wet season. Many insectivorous bats that utilise a range of diurnal roosts outside the breeding season display more specific maternity roost site selection, as a function of thermal properties, and protection from predators and adverse conditions (e.g. Kunz & Lumsden 2003). Roosts used during this period, particularly maternity sites which may be a limiting factor, are critical to the long-term maintenance of the population. There is also no information on roosts used at the eastern limit of the species' range. The identification of roosts in this area and a comparison of roost selection between the core of the species' distribution and the eastern edge may assist in understanding the reasons behind the contraction in the distribution of the species. The loss of roost suitability may be an important contributing factor to its decline and range contraction. The provision of artificial predator-proofed roosts may assist in re-colonisation of forested areas in the east that were formerly inhabited.

Threatening Process: Yellow Crazy Ant, introduced predators and possibly as yet unidentified threatening processes.

Actions:

2a) In Year 1, determine the roosting requirements of males and females, during both the non-breeding and breeding (i.e. early wet) seasons. Compare roosts used with available roosting habitat to investigate roost site selection. Sample both in the core of the species distribution (i.e. in the western section) and along the eastern edge of its current range. In the east, target areas that supported bat activity in the 1998 survey (Appendix Three). Repeat this sampling in Year 5.

2b) Locate diurnal roosts in areas previously affected by Yellow Crazy Ant supercolonies and in unaffected areas, and compare these results with the roosts located by Lumsden *et al*. (1999) to identify potential shifts in roost structure usage. To be comparable sampling should be undertaken in May-June of Year 1, and should include the area sampled in 1998 (Appendix One). Conduct repeat sampling using the same techniques in May-June in Year 5.

2c) In sections of rainforest where roost sites are determined to be limiting, or no longer suitable, trial artificial roosts based on roost characteristics as determined by Action 2a. If required, these roosts must be erected in such a manner as to avoid access by Robber Crabs (due to known destructive interference with artificially erected structures), and the potential predators Yellow Crazy Ant, Black Rat and Common Wolf Snake.

Action 3: Determine the impact of the Common Wolf Snake on roosts, and if considered to impact on pipistrelles, develop management actions to reduce the predation risk (Obj. 2 and 3; Perf. Crit. 2 and 3)

Background Summary: The westward contraction in the distribution of the Christmas Island Pipistrelle corresponds with the westward expansion of the Common Wolf Snake. However, it is currently unknown whether this snake is able to access pipistrelle roosts within primary rainforest.

Threatening Process: Introduced predator.

Actions:

3a) Establish and maintain a database using the CIGIS for Common Wolf Snake records, with every sighting away from the Settlement, Grants Well, and the Christmas Island

Research and Education Station areas to be recorded. Such a database could provide important baseline information on the distribution of this species.

3b) Conduct a survey for the Common Wolf Snake in the central section of the island to document the range of this species outside known populations using spotlighting and active area search techniques. The survey is to include dry and wet season sampling periods and investigate areas away from roads and dwellings. Investigate the gut contents of all snakes encountered.

3c) Investigate the ability of the Common Wolf Snake to access simulated roosts under exfoliating bark and strangler figs on rainforest tree trunks in captivity.

3d) If, based on the investigations in 3b and 3c, it is considered that the Wolf Snake is impacting on bats within their roosts, devise and implement appropriate management actions.

Action 4: Determine the impact of the Nankeen Kestrel, and if found to prey on pipistrelles, develop management actions to reduce the impact (Obj. 4; Perf. Crit. 4).

Background Summary: The absence of daytime foraging in recent years corresponds to an increase in the population of the naturalised Nankeen Kestrel.

Threatening Process: Naturalised predators.

Actions:

4a) Establish and maintain a Nankeen Kestrel sightings database using the CIGIS with PAN staff (and members of the public) recording sightings of this species. Such a database will provide important baseline information for the location of nests (see Action 4b).

4b) Conduct dusk watches at sites of high bat activity, coupled with a dietary study of prey remains found at nests to determine predation rates by the Nankeen Kestrel. This action is to be concentrated within the current range of the pipistrelle. Dusk watches are to be undertaken in the dry and wet seasons.

4c) Evaluate the importance of Nankeen Kestrel control if this species is determined a key predator of the Christmas Island Pipistrelle.

Action 5: Identify primary foraging sites away from ecotones and roads (Obj. 1, 5, 6, 9 and 10; Perf. Crit. 1, 5, 6, 9 and 10)

Background Summary: Primary foraging habitats have been poorly described for the species in rainforest away from roads, ecotones and drill lines. Many of the drill lines bulldozed in the 1960s have become overgrown. Bats were commonly observed using drill lines in 1984 (Tidemann 1985). However, by 1998 many drill lines were ill-defined and provided little ‘edge’ for this edge specialist to target (Lumsden *et al*. 1999). The importance of open drill lines to the pipistrelle requires understanding in a landscape context. Therefore, it is important to characterise foraging habitat used by pipistrelles away from classic edges, such as roads and ecotones.

Threatening Process: Habitat alteration and habitat loss.

Actions:

5a) Identify and characterise foraging areas utilised by the Christmas Island Pipistrelle away from roads, ecotones and defined drill lines in primary rainforest. This investigation should include examining the importance of the crown of the rainforest canopy as a large ‘edge’ surface; the importance of emergents and natural openings, such as resulting from storm damage; and the importance of ‘within-canopy’ foraging. This action is to be undertaken in the dry and wet season sampling periods.

Action 6: Investigate dietary specialisation as a contributing factor to the current status of Christmas Island Pipistrelle (Obj. 5 and 6; Perf. Crit. 5 and 6)

Background Summary: The Christmas Island Pipistrelle forages on a variety of flying insects caught on the wing. However, it is not known whether the species is a specialist or generalist feeder. Changes in the primary rainforest ecosystem (e.g. through Yellow Crazy Ant supercolony infestation) may have altered the availability of prey items. If this resulted in prey being limited, it would impact on the status of the pipistrelle.

Threatening Process: Currently unknown, evidence suggests Yellow Crazy Ant supercolony infestation may have altered primary rainforest insect populations in terms of diversity and abundance.

Actions:

6a) Identify the diet of the pipistrelle in the dry and wet seasons, by analysing droppings collected from individuals caught in harp traps.

6b) Compare diet with prey availability at identified foraging areas (determined by feeding buzzes recorded using a bat detector) to identify the degree of dietary specialisation in the species.

Action 7: Clarify the taxonomic status of the Christmas Island Pipistrelle (Obj. 7; Perf. Crit. 7)

Background Summary: The taxonomic status of the Christmas Island Pipistrelle requires clarification.

Actions:

7a) A genetic study of the Christmas Island Pipistrelle and closely related species, using samples obtained from dry or ethanol preserved museum specimens. Such a study would require genetic material of the Christmas Island Pipistrelle, two Australian and two Southeast Asian *Pipistrellus* species, including *P. tenuis*. This investigation is recommended to be undertaken by, or in conjunction with, an experienced bat taxonomist.

B. Management Actions

Action 8: Continue active management for the control of Yellow Crazy Ant supercolonies (Obj. 8 and 9; Perf. Crit. 8 and 9)

Background Summary: The long-term viability of the Christmas Island Pipistrelle may be threatened by the presence and spread of Yellow Crazy Ant supercolonies. Parks Australia North in consultation with the Crazy Ant Steering Committee is undertaking surveys for the presence of Yellow Crazy Ant supercolonies in both infested and unaffected areas following a successful aerial baiting campaign. All supercolonies encountered will be eliminated through ground-baiting techniques where possible.

Threatening Process: Yellow Crazy Ant.

Actions:

8a) It is important that a program of ongoing monitoring and surveillance be established to detect future supercolony formation and undertake appropriate remedial actions.

8b) The known roosting areas in the far west of the island (especially the Winifred Beach Tk area, see Figure 3) should be intensively monitored on a regular basis so that any future outbreaks can be controlled immediately.

Action 9: Increased protection of known and potential habitat outside the National Park (Obj. 1, 2, 3, 4, 5, 8, 9, 10 and 11; Perf. Crit. 1, 2, 3, 4, 5, 8, 9, 10 and 11)

Background Summary: The Christmas Island Pipistrelle was formerly widespread and common throughout the island. Extensive loss of habitat through clearfelling for phosphate mining has resulted in a reduction of suitable habitat available, particularly for diurnal and maternity roosting purposes. Some areas identified as having high and moderate bat activity in 1998 occurred outside or along roads delineating the boundary of the Christmas Island National Park (Lumsden *et al*. 1999):

i. Off Dales Road, 0.3 km west of Winifred Beach Track turnoff (10^{o}28’30”, 105^{o}34’16”) (Site 7),
ii. Winifred Beach Track, 0.1 km south of Dales Road (10^{o}28’40”, 105^{o}34’25”) (Site 21),
iii. ML 106 area, on track heading west, 0.6 km from Blowholes Road (10^{o}30’24”, 105^{o}38’35”) (Site 34).

Threatening Process: Habitat loss.

Actions:

9a) The protection of known pipistrelle foraging areas outside the Park should be a priority, for example an important foraging area is located at the start of the Winifred Beach Track (see above, from Lumsden *et al*. 1999; see Figure 6).

9b) In accordance with the requirements of the EPBC Act development proposals likely to have a significant impact on the Christmas Island Pipistrelle must be referred to the Commonwealth Environment Minister to determine whether approval is required under the Act. This includes actions likely to adversely affect habitat critical to the survival of the species, therefore determining whether an action is likely to have a significant impact needs to include consideration of suitable roosting and foraging habitat. All areas of primary rainforest and advanced secondary rainforest regrowth (e.g. > 30 years old) require a detailed appraisal of the vegetation to determine its potential to provide roosting sites. This is to be based on the current knowledge of roosting habitat as outlined in Lumsden *et al.* (1999), or further information as it comes to hand. Areas supporting primary rainforest, or secondary rainforest regrowth of any age, need to be appraised for foraging habitat, by sampling with bat detectors, using the technique outlined in Appendix One.

Action 10: Assess the impact of phosphate stockpile removal on the Christmas Island Pipistrelle (Obj. 9 and 10; Perf. Crit. 9 and 10)

Background Summary: The proposed removal of phosphate stockpiles within and abutting the Christmas Island National Park may adversely affect foraging, roosting and commuting habitat.

Threatening Process: Habitat loss.

Actions:

10a) Areas proposed for phosphate stockpile removal, other than those previously approved under the *Environment Protection (Impact of Proposals) Act 1974*, to be reviewed in terms of impact to the Christmas Island Pipistrelle. Any stockpiles considered to be important to Christmas Island Pipistrelles, for example, those containing known roost areas, or important foraging or commuting areas are to be protected from phosphate extraction.

Action 11: Guidelines to reduce vehicle-related mortality (Obj. 1 and 11; Perf. Crit. 1 and 11)

Background Summary: The Christmas Island Pipistrelle commonly uses roadways passing through primary rainforest and secondary rainforest regrowth for foraging and commuting purposes. This species is particularly susceptible to vehicle-related mortality due to it commonly flying close to ground level.

Threatening Process: Vehicle-related mortality.

Actions:

11a) Establish guidelines in consultation with the relevant affected interests to reduce the risk of night-time vehicle-related mortality on roadways traversing areas of known high and moderate bat activity.

11b) Upgrading of roads and construction of infrastructure along the route between the Immigration Reception and Processing Centre and the Settlement should involve minimal rainforest clearance and night-time speed restrictions should be placed along sections supporting known populations of foraging and commuting bats. The Christmas Island Shire and the Australian Federal Police should form part of consultations for any proposed changes to traffic conditions or speed limits.

Action 12: Review the conservation status of the species (Obj. 12; Perf. Crit. 12)

Background Summary: Recent evidence has indicated a continued decline in the species since the fieldwork of Lumsden *et al.* (1999). A summary of this information is provided in Appendix 4.

Actions:

12a) Determine whether recent information provides justification to elevate the conservation status of the Christmas Island Pipistrelle to Critically Endangered as defined under the EPBC Act. Specific issues to be considered include: i. it has undergone a very severe reduction in numbers, ii. its geographic distribution is very restricted indicating that it is precarious for the survival of the species, and iii. evidence suggests that the numbers will continue to decline at a very high rate.

PART E. MANAGMENT PRACTICES

Many of the Objectives and Actions outlined in Part D are designed to identify currently undetermined threatening processes that are resulting in the decline and westward contraction of the Christmas Island Pipistrelle. Until these processes have been identified the following interim management initiatives and prescriptions are proposed. Activities that may have a significant impact on the Christmas Island Pipistrelle and would therefore trigger the requirement for environmental assessment and approval under the EPBC Act are indicated below (EPBC trigger). Note that this listing is not in order of priority.

Protecting Important Populations or Occurrences

- Eradicate all known Yellow Crazy Ant supercolonies.
- Conduct active ground searching for Yellow Crazy Ant supercolonies both in previously infested and unaffected areas, including away from tracks. All supercolonies located to be baited.
- No removal of rainforest within the Christmas Island National Park (EPBC trigger).
- Removal of phosphate from within the Christmas Island National Park to be assessed in terms of impact on the Christmas Island Pipistrelle as outlined in Christmas Island National Park Management Plan (Commonwealth of Australia 2002; page 93) (EPBC trigger).
- In accordance with the EPBC Act any action which is likely to have a significant impact on the Christmas Island Pipistrelle through removal of primary rainforest or secondary rainforest regrowth on vacant crown land or leasehold land must be referred to the Commonwealth Environment Minister to determine whether approval is required under the EPBC Act. Determining whether an action is likely to have a significant impact needs to include consideration of suitable roosting and foraging habitat. All areas of primary rainforest and advanced secondary rainforest regrowth (e.g. > 30 years old) require a detailed appraisal of the vegetation to determine its potential to provide roosting sites. This is to be based on the current knowledge of roosting habitat as outlined in Lumsden *et al.* (1999), or further information as it comes to hand. Areas supporting primary rainforest, or secondary rainforest regrowth of any age, need to be assessed for foraging habitat, by sampling with bat detectors, using the technique outlined in Appendix One.
- Conduct monitoring for the pipistrelle using the methodology as described in Appendix Two.
- Identify sections of roadways with regular night-time traffic frequently used by bats using a hand-held bat detector.
- Determine whether areas with extensive bat activity (as recorded during driving transects by Lumsden *et al*. 1999) have frequent night-time traffic, and establish a set of interim guidelines to minimise the risk of vehicle-related mortality.
- All new roadworks and associated structures to be constructed in a manner to minimise the loss of primary and secondary rainforest habitat (EPBC trigger).

Protecting and Restoring Habitat

In addition to the measures taken above, the following extra actions are also required to protect and restore habitat:

- Development of new roads and tracks in primary rainforest shall require an environmental impact assessment (EPBC trigger).
- Adoption of strategy to avoid wildfires within primary rainforest and secondary rainforest regrowth.

Managing and Reducing Known and Potential Threatening Processes

In addition to the measures taken above, to manage and reduce known/potential threatening processes the following extra actions are required:

- Encourage members of the public to record sightings of the Common Wolf Snake away from the Settlement.
- Collect the gut contents of any road-killed or captured specimens of the Common Wolf Snake for future analysis. Record date and location details.
- Document any observations (including by members of the general public) of Common Wolf Snakes active in the shrub and lower canopy layer of primary rainforest and secondary regrowth. Such observations could provide important baseline data for Action 3.
- Collect any observations (including from the general public) on prey taken by the Nankeen Kestrel.
- Identify the location of Nankeen Kestrel nests. Collect boluses (regurgitated pellets) and prey fragments from around these nests. Preserve all these collected samples for subsequent analysis. Record date and location details.
- Implement the recommendation from the Christmas Island National Park Management Plan (Commonwealth of Australia 2002) to establish an integrated program of 'eradication where possible, or control (to an acceptable level) of introduced or feral animals', especially the Feral Cat and Black Rat. The most important area to target for the Christmas Island Pipistrelle is the western section of the island, from Jacks Hill to the west coast, since this supports all the pipistrelle roosts that have been located in recent years (refer Figure 3).
- Continuation of PAN liaison with Department of Transport and Regional Services, Australian Quarantine and Inspection Service and West Australian Quarantine and Inspection Service to ensure tight quarantine controls to prevent the accidental introduction of new environmental weeds, diseases and exotic pests on the island. Special attention should be given to guarding against the introduction of exotic snakes, such as the Brown Tree Snake that has had a devastating impact on the fauna of other oceanic islands.

PART F: DURATION AND COSTS

Resource Allocation

The most critical conservation problems facing the Christmas Island Pipistrelle are from unidentified threatening process(es) resulting in decline and range contraction, and from habitat loss. Actions taken to remedy these problems are likely to have positive benefits on a range of endemic rainforest fauna and flora species. Some of the actions outlined in this Plan are identified in the Christmas Island National Park Plan of Management (Commonwealth of Australia 2002), the strategic nature conservation document for the island, as broader actions necessary for the maintenance of fauna biodiversity on the island. Similarly, in this Plan some of the actions recommended correspond with those identified in other recovery (e.g. Abbott's Booby and Christmas Island Hawk-Owl) and action plans (e.g. Garnett & Crowley 2000). Consequently, opportunities exist for sharing resources and a co-ordinated strategy to implement Recovery Plans for all threatened Christmas Island fauna requires investigation.

Action 8 is supporting the ongoing management for the control of the Yellow Crazy Ant supercolonies as outlined in draft Yellow Crazy Ant Action Plan and the Christmas Island National Park Management Plan. Therefore, this action requires no additional funding from the Christmas Island Pipistrelle Recovery Plan. However, it is essential that adequate funding be provided for this work from other sources, with the current Plan used to assist in the procurement of the necessary funding.

A number of Actions are ongoing (e.g. Action 10) and may be considered as core duties of Parks Australia North.

The majority of funding outlined in the Duration and Costs section is aimed at identifying the threatening processes resulting in the decline and range contraction of the Christmas Island Pipistrelle. Research into this bat and reasons for its decline and westward range contraction have been identified as of high priority in the Christmas Island National Park Management Plan (Commonwealth of Australia 2002). This research, particularly that proposed for the Common Wolf Snake, may also identify threatening processes that are responsible for the decline and range contraction of the Blue-tailed Skink *Cryptoblepharus egeriae*, Forest Skink *Emoia nativitatis* and Christmas Island Gecko *Lepidactylus listeri*.

A large number of actions identified in this Recovery Plan are aimed at identifying currently unknown threatening processes. Many of these actions can be investigated simultaneously in the same field sampling periods, thereby representing a considerable saving in costs. Actions that can be conducted concurrently are denoted by the symbols A, B and C in the Duration and Costs Section. These funding estimates have incorporated Parks Australia North providing vehicles and accommodation to the researchers while on the island.

Effective management of the Christmas Island Pipistrelle will be ongoing and encompass both management practices covered as core Parks Australia North duties, and specialist actions that will only be identified following the outcome of actions identified in this Recovery Plan. Costs associated with the management of currently unidentified threatening processes have not been included in this Plan, and can only be determined once the threatening processes have been identified.

Duration and Costs

Actions that can be conducted concurrently are denoted by the symbols A (dry season sampling), B (wet season sampling) and C (Wolf Snake investigation), with the costing for A and B provided at the end of the table.

Recovery Action	**Year of Implementation**					**Total**
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
***Action 1*: Assess population and distribution trends.**						
1a Investigate westward range contraction	A	-	-	-	A	**A**
1b Impact of YCA on activity levels	A	-	-	-	A	**A**
1c Establish & maintain pipistrelle database	PAN	PAN	PAN	PAN	PAN	
1d Establish and conduct monitoring program	5,000+ PAN	1,000+ PAN	1,000+ PAN	1,000+ PAN	1,000+ PAN	**9,000**
***Action 2*: Determine roosting requirements.**						
2a Determine seasonal and distributional roosting requirements	A+B*	-	-	-	A+B*	**A+B**
2b Impact of YCA on roost requirements	A	-	-	-	A	**A**
2c Trial artificial roosts	Dependent of findings of Action 2 & 3					
***Action 3*: Determine the impact of the CWS on roosts, and if found to impact on pipistrelles, develop appropriate management actions.**						
3a Establish & maintain CWS database	PAN	PAN	PAN	PAN	PAN	
3b Conduct survey for CWS in central section of island	26,000 (=C*)	-	-	-	-	**C**
3c Assess climbing ability of CWS and the potential risk to roosting pipistrelles	C*	-	-	-	-	**C**
3d Devise & implement appropriate management actions	C*	Dependent of findings of Actions 3b & 3c				**C**
***Action 4*: Determine the impact of the Nankeen Kestrel, and if found to prey on pipistrelles, develop management actions to reduce impact.**						
4a Establish & maintain Nankeen Kestrel database	PAN	PAN	PAN	PAN	PAN	
4b Assess Nankeen Kestrel as a predator	5,000 +A+B	-	-	-	-	**5,000+ A+B**
4c Potential Nankeen Kestrel control	Dependent on findings of Action 4b					
***Action 5*: Identify primary foraging sites away from ecotones and roads.**						
5a Identify foraging areas away from artificial edges	A+B*	-	-	-	A+B*	**A+B**
***Action 6*: Investigate dietary specialisation.**						
6a Investigate diet in the wet and dry seasons	10,000+ A+B	-	-	-	-	**10,000+ A+B**
6b Investigate degree of dietary specialisation	10,000+ A+B	-	-	-	-	**10,000+ A+B**
***Action 7*: Clarify the taxonomic status.**						
7a Resolve taxonomic uncertainty	8,000	-	-	-	-	**8,000**

Recovery Action	Year of Implementation Year 1	Year 2	Year 3	Year 4	Year 5	Total
***Action 8*: Continue active management for the control of YCA supercolonies.** **8a** Ongoing monitoring and remedial actions as required **8b** Roost areas intensively monitored on a regular basis	To be sourced from other budgets by the Yellow Crazy Ant Steering Committee and PAN PAN					
***Action 9*:** Increased protection of known and potential habitat outside the National Park. **9a** Protect known important foraging areas **9b** Potential impact of future development proposals	Component of PAN core duties Component of PAN core duties					
***Action 10*:** Assess impact of phosphate stockpile removal on the species. **10a** Impacts of phosphate stockpile removal	Component of PAN core duties					
***Action 11*:** Guidelines to reduce vehicle-related mortality **11a** Establish guidelines to reduce mortality risk **11b** Minimise impact of night-time traffic between IRPC and the Settlement	Component of PAN core duties in consultation with the CRA and relevant affected interests (eg. AFP, CIS) Component of PAN core duties in consultation with the CRA, DIMIA, DoFA, CIS and AFP					
***Action 12*:** Review the conservation status **12a** Review the conservation status	To be assessed under EPBC Act					
A. Dry season component	56,500	-	-	-	56,500	**113,000**
B. Wet season component	47,500	-	-	-	47,500	**95,000**
Additional Funding (as outlined above)	64,000	1,000	1,000	1,000	1,000	**68,000**
TOTAL COST	168,000 plus additional funds dependent on identification of key threatening process	1,000	1,000	1,000	105,000	**276,000**

YCA = Yellow Crazy Ant; CWS = Common Wolf Snake; IRPC = Immigration Reception and Processing Centre; CRA = Central Road Authority; AFP = Australian Federal Police; CIS = Christmas island Shire; DIMIA = Department of Immigration and Multicultural and Indigenous Affairs; DoFA = Department of Finance and Administration, * = some wet season sampling may extend into the following year (i.e. sampling undertaken in December – January).

ACKNOWLEDGEMENTS

Special thanks to the following people who assisted with the preparation of this recovery plan: Terry Reardon provided advice on the process required to resolve the taxonomic uncertainty surrounding this species. Mick Jeffery provided useful contact details and valuable comments on current management issues on Christmas Island, including information on the impact of the Yellow Crazy Ant and the current status of the ant with respect to active management strategies being conducted by the Crazy Ant Steering Committee. Alistair Graham provided lively discussion on various issues included in this plan. Greg Richards and David James provided recent information of the species that was presented in Appendix 4. David Titley provided information on the Anabat II detector, Zcaim and future developments of the recommended ultrasonic detection system for monitoring the species on the island. Karen Jung supplied GIS data. Carol Harris helped track down obscure library references. Mike Bamford, Graeme Gillespie, Alistair Graham, Judy Hagan, Mick Jeffery, Dennis O'Dowd, Greg Richards, Chris Tidemann and Susan Wright provided useful comments on earlier drafts of the Recovery Plan. Special thanks to Susan Wright for her advice during the development of this plan and assistance in deciphering the EPBC Act.

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APPENDIX ONE: RESURVEY OF KNOWN PIPISTRELLE SITES AFFECTED BY YELLOW CRAZY ANT SUPERCOLONIES

It is recommended that sites known to contain important foraging and roosting areas in 1998, that were subsequently infested with Yellow Crazy Ant supercolonies, be resurveyed to investigate the impact of this introduced species on the pipistrelle.

A. Sites

Sites of high or moderate Christmas Island Pipistrelle activity and roost areas (from Lumsden *et al*. 1999) that were subsequently infested with Yellow Crazy Ant supercolonies, and those that were located nearby (i.e. within foraging range).

Site #	Location	Lat./Long.	Flying*/ Roost	Activity Level
Sites within subsequently infested areas				
14	Circuit Track, 0.15 km E of Winifred Beach Track	10°29'38" 105°34'09"	Flying	Moderate
16	Winifred Beach carpark	10°30'00" 105°32'58"	Flying	Moderate
26	0.1 km S of Martin Point carpark	10°28'10" 105°33'35"	Flying	Moderate
27	Creek below Hughs Dale waterfall, where walking track crosses creek	10°28'45" 105°33'28"	Flying	Moderate
28	At start of walking track to Hughs Dale waterfall, 20 m from the road.	10°28'32" 105°33'38"	Flying	Moderate
45	Road to Dales, 0.4 km W of intersection below LB4	10°28'32" 105°35'53"	Flying	Moderate
76	Circuit Track, 1.5 km E of Winifred Beach Tk	10°29'50" 105°34'52"	Flying	Moderate
R1	Winifred Beach Track, Sydney Dale area	10°29'10" 105°34'06"	Roost	
R4	Winifred Beach Track, Sydney Dale area	10°29'23" 105°34'03"	Roost	
R8	Winifred Beach Track, Sydney Dale area	10°29'18" 105°33'53"	Roost	
R9	Winifred Beach Track, Sydney Dale area	10°29'15" 105°33'56"	Roost	
R10	Winifred Beach Track, Sydney Dale area	10°29'18" 105°33'52"	Roost	
Sites within foraging range of subsequently ant infested areas				
7	Off Dales Road, 0.3 km W of Winifred Beach Track turnoff	10°28'30" 105°34'16"	Flying	Moderate
8	0.1 km down track to rehab area 22S, at gate	10°29'26" 105°36'57"	Flying	Moderate
13	Winifred Beach Track, 0.75 km S of Dales Road	10°28'58" 105°34'21"	Flying	Moderate
21	Winifred Beach Track, 0.1 km S of Dales Road	10°28'40" 105°34'25"	Flying	High
22	Winifred Beach Track, 0.3 km S of Dales Road	10°28'46" 105°34'22"	Flying	High
44	Road to Dales, 0.5 km E of intersection below LB4	10°28'36" 105°36'15"	Flying	High
70	Toms Ridge, 3.0 km NW of Dales Road	10°27'32" 105°33'36"	Flying	Moderate
R2	Winifred Beach Track, Sydney Dale area	10°29'12" 105°34'09"	Roost	
R7	Winifred Beach Track, Sydney Dale area	10°29'13" 105°34'10"	Roost	
R6	Winifred Beach Track, Sydney Dale area	10°29'17" 105°34'18"	Roost	
R11	Winifred Beach Track, Sydney Dale area	10°29'14" 105°34'19"	Roost	
R12	Winifred Beach Track, Sydney Dale area	10°29'17" 105°34'14"	Roost	

* = Foraging or Commuting.

B. Sampling Period and Climatic Conditions

For comparative purposes a resurvey of these sites needs to be conducted between 10 May and 20 June. Nights with rain periods are to be avoided due to possible suppression of bat activity and to the resultant reduced sensitivity of the bat detector microphone.

C. Sampling Techniques

These techniques are identical to those used by Lumsden *et al*. (1999), except where indicated, so that results can be compared with the 1998 study.

Bat Sampling: In the 1998 study, bat calls were recorded on Anabat II bat detectors linked to tape recorders via delay switches. There have been significant advances in recent years in bat detector technology and it is recommended for future work on the Christmas Island Pipistrelle that Anabat detectors are used in conjunction with the new Anabat CF Storage Zcaim (Titley Electronics, Ballina, NSW). This system downloads calls directly to a memory card and avoids the previous problem of cassette tapes filling up with high frequency insect noise. All-night recordings are now possible, and units should be set to record from before dusk until after dawn. This will provide more detailed information of activity levels throughout the night and will also document any daytime flying activity. The number of bat passes between 1830 and 2100 hrs (Christmas Island Standard Time) will be used for comparison with the 1998 and 1994 studies. The detector and CF Zcaim are to be housed in a waterproof box with only the microphone exposed (e.g. refer to Plate 6 in Lumsden *et al.* 1999). To protect the units from Robber Crabs *Birgus latro* these units need to be placed above the ground, for example on folding chairs. The chair arms are used to position the box at an angle of 45^o (Plate 7 in Lumsden *et al*. 1999). A waterproof cover extending out from the top of the box protects the microphone from rain. The sensitivity dial on the detectors are set at seven, and on this setting bats can be detected at a range of 15 to 20 m. The majority of sites are sampled for a single night, although repeat sampling is required if rain occurs during the sampling period.

Data analysis: Since the pipistrelle is the only bat on the island that echolocates, all bat echolocation calls recorded on the Anabat detector/CF Zcaim can be assigned to this species. However, insects on Christmas Island produce high frequency noise that sounds very similar to bat calls and is recorded by the detector. If recordings are made onto cassette tapes the calls should be examined using Anabat software to distinguish them. However, if a CF Zcaim is used, as recommended, insect noise is largely eliminated (G. Richards, pers. comm). Each time a bat flies past the detector, the CF Zcaim saves a computer file, with a unique date and time stamp. Where there is continuous activity, a file is automatically saved every 16 seconds. Feeding buzzes are identified by the rapid increase in pulse rate of the echolocation call. These buzzes indicate foraging activity as distinct from commuting bats, and are counted separately for each recording session.

To compare with earlier studies, activity levels are assessed by the number of passes over a 150-minute time period, commencing 45 minutes after sunset (i.e. 1830 to 2100 hrs). Activity levels are defined as high (>1 pass per minute, i.e. >150 passes in 150 min.), moderate (1 bat pass per 1 to 10 minutes, i.e. 15 to 150 passes in 150 min.) and low (<1 bat pass per 10 min., i.e. <15 passes in 150 min.).

Insect Sampling: Insect availability is to be measured using a light trap at each detector site. The light trap consists of a 20 litre plastic bucket with a cone fitted inside (Plate 9 in Lumsden *et al.* 1999). Attached to the cone is a fluorescent light with two tubes, a black light and a standard light. The cone projects the light upwards to sample the airspace in which the bats forage. At the base of the cone is a jar containing 70% alcohol, into which the attracted insects fall. The light is powered by a 12 V battery and a timer activates the unit to turn on at dusk and off at dawn. To keep out of reach of Robber Crabs the light trap is hung on a rope tied between two trees, or placed on a folding chair.

Captured insects are to be dried at 80^{o}C for three hours and weighed to give a dry weight of available prey. Only insects <15 mm in total body length are included so that the assessment is based on prey items within the likely size range taken by the pipistrelle.

The number of insect calls recorded on the bat detectors could be used as an additional measure of insect activity (G. Richards, pers. comm.), although only a component of the insect fauna would be recorded in this way.

APPENDIX TWO: PIPISTRELLE MONITORING PROTOCOL

This monitoring strategy has been adapted from Lumsden et al. (1999):

The most appropriate way to monitor the pipistrelle population is to employ similar techniques to those used in the 1998 survey (refer to Appendix One for stationary sampling methods), so that results can be compared. It is recommended that two strategies be used to investigate aspects of the Christmas Island Pipistrelle status: 1) decline in activity levels at known sites, and 2) contraction in distribution.

1). Vehicle-based Driving Detection

This strategy will provide distributional information, which currently is of importance given the westward range contraction of the species. The methodology for this strategy is outlined below.

<u>Advantages</u>:

- Provides information on distributional change.
- Much quicker and easier in providing useful information.

<u>Disadvantages</u>:

- Provides limited information on abundance levels at particular sites.

<u>Vehicle-based Driving Detection Methodology</u>

- Drive a **standardised** route encompassing all regions of the island and passing through sites of low, moderate and high bat activity (Figure 13). This route is to be driven at a speed of $\leq$40 kph with two people, a driver and a bat detector operator. The latter person will hold the detector out of the passenger window, at a constant angle, pointing forward in the direction the vehicle is travelling.
- Route: Start at the Parks Australia North office in the Settlement, down Murray Road, past Central Area Workshop along the road to The Dales, down Winifred Beach Track to the Circuit Track, U-turn, back to the road to The Dales, turn right, continue east to LB4, turn right, continue to Coconut Corner, along EW Baseline to NS Baseline, past the Airport, down the upper road to the Casino, back along the coast through the Settlement to the Parks Office (Figure 13).
- The censuses are only to be conducted in suitable weather conditions: no rain, wind speed <10 kph, and less than three quarter moon phase.
- They are to be conducted within a standardised 2.5 hour time period, commencing no earlier than 45 minutes after sunset and finishing no later than 3 hours 15 minutes after sunset. It is likely to take approximately 2.0 to 2.5 hours to complete the circuit; therefore it should commence as soon as possible following 45 minutes after official sunset.
- <u>Equipment</u>: See below.
- <u>Recording Technique</u>: Two potential methods depending on equipment availability and the ability of a GPS to provide continual accurate locational information (NB: this may be a problem due to rainforest canopy cover, the typically high vertical extent of the cloud and continuous cloud cover):

  a) The detector operator would record the output of the detector continually on to cassette tapes for the entire driving route. The operator would give the speedometer reading and location at all road junctions on to the tape, using the voice activation function on the detector. Whenever a sound thought to be a bat call was heard, the speedometer would also be recorded by the operator onto the cassette tape. It is important that the bat detector operator is familiar with the sound of pipistrelle calls heard over the external microphone of the Anabat detector. A familiarisation session should be run for any new operator prior to a monitoring sampling session. Where possible, the same bat detector operator should be used. It is recommended that the resulting tapes are sent for analysis to someone experienced in distinguishing between bat and insect sounds. Hence this sampling strategy would also require the small cost of analysing the recordings.

b) The Anabat detector would be connected to the Anabat CF Storage Zcaim, with a compatible GPS also hooked up to provide locational information to be continually downloaded. With a limited amount of training, the files produced using this technique could be analysed on the island, as insect noise is largely excluded using this technique (G. Richards, pers. comm.).

2). Stationary Site Detection

This strategy will provide information on changes in abundance levels at known sites, which is important to monitor given the apparent decrease in abundance at some localities.

A selection of sites with varying activity levels from the 1998 survey (Lumsden *et al*. 1999) would be sampled. Use of the stationary detector method should have the advantage that the equipment can be set up and left all night and then retrieved the following day, minimising labour costs. Deployment of two or more units per sample night would reduce the number of sampling nights required. The following 10 sites are recommended for sampling.

Site #	Location	Lat./Long.	Activity level
4	Pipeline track NW of Jedda Cave, 0.4 km NW of Powerline Track	10°28'27" 105°38'16"	Low
8	0.1 km down track to rehab area 22S, at gate	10°29'26" 105°36'57"	Moderate
14	Circuit Track, 0.15 km E of Winifred Beach Track	10°29'38" 105°34'09"	Moderate
16	Winifred Beach carpark	10°30'00" 105°32'58"	Moderate
19	Track in front of Research Station	10°29'28" 105°38'46"	Low
21	Winifred Beach Track, 0.1 km S of Dales Road	10°28'40" 105°34'25"	High
28	At start of walking track to Hughs Dale waterfall, 20 m from the road.	10°28'32" 105°33'38"	Moderate
34	ML 106 area, on track heading W, 0.6 km from Blowholes Road.	10°30'24" 105°38'35"	High
44	Road to Dales, 0.5 km E of intersection below LB4	10°28'36" 105°36'15"	High
70	Toms Ridge, 3.0 km NW of Dales Road	10°27'32" 105°33'36"	Moderate

<u>Equipment and Technique</u>: As for Appendix One.

<u>Analysis</u>: Electronic files could be analysed on the island if someone was appropriately trained, or could be sent off-island to someone experienced in distinguishing between bat and insect sounds.

Advantages:
- Provide information on abundance levels at a number of known sites.

Disadvantages:
- A number of sites would need to be sampled to show patterns and as only one detector unit is currently available on the island only one site could be sampled a night (although see recommendations below). This limitation would mean that multiple nights would have to be devoted to pipistrelle monitoring within each time period.
- Provides information on distributional change with a large amount of effort (i.e. sampling nights).

Monitoring Equipment Recommended

Note: The Parks Australia North Anabat detector was found to be faulty in 1998 and needs to be returned to Titley Electronics for repairs, before the monitoring program commences. It appeared to be a problem with the speaker affecting the volume of the calls. Since there is considerable vehicle noise when undertaking vehicle detection, it is necessary to have the volume level working correctly. In addition new equipment would need to be purchased as outlined below.

- 2 Anabat II Detectors (one as a backup, Supplier: Titley Electronics) (for both monitoring strategies)
- 2 Cassette players and blank cassettes (Vehicle-based driving detection only)
- 2 Anabat CF Storage Zcaim, 2 128MB Compact Flash Memory Cards (for data storage) and Anabat software (Supplier: Titley Electronics) (definitely Stationary Sampling, preferably Vehicle-based driving detection)
- 1 USB Reader/Writer or a Parallel Reader/Writer (to download information from CF Zcaim to computer).
- Associated cables (connecting tape recorder to detector, CF Zcaim to detector; Supplier: Titley Electronics) (for both monitoring strategies)
- Garmin Etrex GPS (or similar common brand water-resistant hand-held GPS) (for both monitoring strategies).
- 2 Waterproof tool box (Stationary Sampling)
- 2 Folding Chairs (Stationary Sampling)
- Waterproof cover (Stationary Sampling) (Lumsden *et al*. 1999 used a laminated manilla folder attached to the lid of the tool box with Velcro, Plate 6 and 7).

Timing

To detect changes in status at particular sites (Stationary Sites) or distributional changes (Vehicle-based Driving Detection) it will require a minimum of two years of sampling but is recommended to be conducted on a yearly basis for the full five-year life of this Plan.

It is recommended that the:
- Stationary Sampling be undertaken one time per year per site in May-June to coincide with the 1998 survey, and
- Vehicle-based Detection Sampling be undertaken on two nights at four monthly intervals, with one sample period to coincide with the timing of the 1998 survey (May-June).

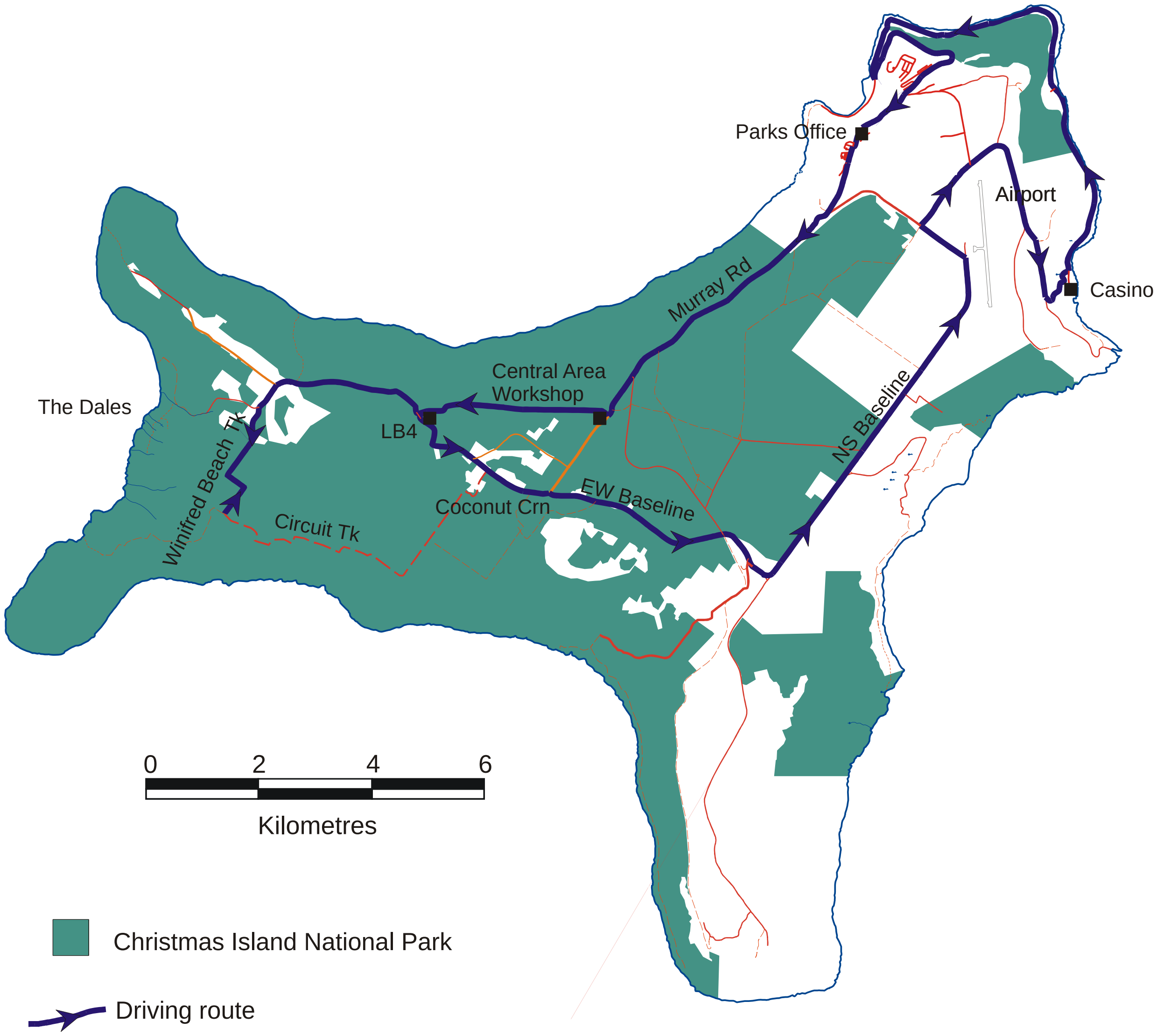

Figure 13. *The route to be used for the monitoring program using Vehicle-based Driving Detection, commencing and finishing at the Park's office (from Lumsden* et al. *1999).*

APPENDIX THREE: KNOWN BAT SITES ON THE EASTERN EDGE OF THE CHRISTMAS ISLAND PIPISTRELLE'S RANGE

To determine threatening processes influencing the decline and westward contraction in the range of the Christmas Island Pipistrelle, roost sites need to be located along the eastern limit of the known range (Action 2). The following sites in the centre of the island where bat activity was recorded in 1998 (from Lumsden *et al*. 1999) should be targeted for this work.

Site #	Location	Lat./Long.	Activity level
4	Pipeline track NW of Jedda Cave, 0.4 km NW of Powerline Track	10°28'27" 105°38'16"	Low
18	NS Baseline, 0.2 km NE of Grants Well Track	10°28'52" 105°40'19"	Low
19	Track in front of Research Station	10°29'28" 105°38'46"	Low
32	Behind shrine near junction of EW Baseline and Blowholes Road	10°30'05" 105°39'04"	Low
33	Minefield ML 106, 50 m W of Blowholes Road on mining road	10°30'27" 105°38'50"	Low
34	ML 106 area, on tk heading W, 0.6 km from Blowholes Road.	10°30'24" 105°38'35"	High
42	Track from Research Station to Murray Road, 0.2 km S of Murray Road	10°28'28" 105°38'03"	Low
52	Jane Up, NW of Research Station	10°29'21" 105°38'32"	Low
53	0.1 km SE along track off junction of EW Baseline and South Point Road	10°30'18" 105°39'23"	Low
60	Road to Greta Beach, 0.4 km N of top carpark	10°29'27" 105°40'41"	Low

APPENDIX FOUR: SUMMARY OF RECENT INFORMATION INDICATING FURTHER RANGE AND POPULATION DECLINE

This Appendix provides a summary of recent information indicating a continuing decline and range contraction in the species.

A. Greg Richards, Bat Consultant (pers. comm.)

For more detailed information refer to the fauna survey as part of the EIS of the Mine Lease Applications & National Park Reference Areas conducted in August 2002 for Phosphate Resources Limited by EWL Sciences Pty Ltd.

Evidence indicating a significant reduction in abundance using ultrasonic data as an index of abundance. Using similar methodology to Lumsden *et al*. (1999) the Christmas Island Pipistrelle data collected by G. Richards indicated:

1. the species was recorded in less sites than in 1998;
2. the species had undergone a further westward range contraction on the island;
3. there were a decreased number of bat passes at most sites; and
4. the species was only recorded foraging in four localities.

B. David James, PAN (pers. comm.)

The following information was provided by David James: In February and March 2004 searches for the Christmas Island Pipistrelle were undertaken using Anabat detectors and harp traps. Using the detector driving technique outlined in Lumsden *et al*. (1999) and detailed in Appendix 2, twelve hours of driving at 20 kph over five nights were undertaken on roads and tracks from the South West Baseline to Winifred Beach, approximately 250km total. There was only one site that Pipistrelles were recorded at in any numbers – at the start of the Winifred Beach Track, which was the area with the highest levels of activity in the 1998 surveys. In the 12 hours of sampling, bats were detected at only three other locations, and each time by only a single animal. No bats were recorded at many of the sites where they were regularly recorded in 1998. Harp traps have been set in a number of locations on the island, but the only site that bats have been trapped is the site on Winifred Beach Track.

The level of recording by David James appears to be considerably lower than during the 1998 study.

Summary:
This recent evidence indicates that a review of the conservation status is required. The species appears to have markedly declined since 1998 and there may be few localities where viable populations remain on the island.