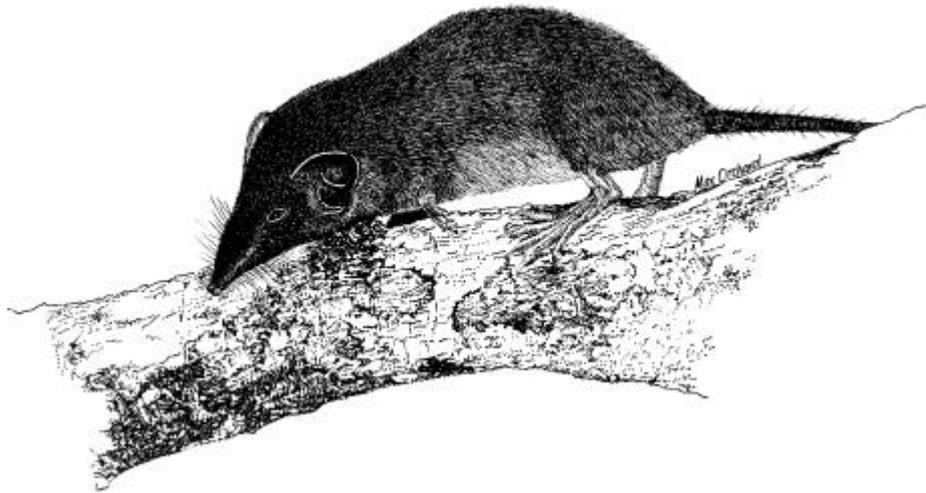


National Recovery Plan
for the
Christmas Island Shrew
Crocidura attenuata trichura



Martin Schulz



Natural Heritage Trust

Helping Communities Helping Australia

An Australian Government Initiative

Prepared by Martin Schultz, for the Australian Government Department of the Environment and Heritage.

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Assistant Secretary
Natural Resource Management Policy Branch
Department of the Environment and Heritage
GPO Box 787
CANBERRA ACT 2601

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This recovery plan sets out the actions necessary to stop the decline of, and support the recovery of, the listed threatened species. 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 the making of this plan does not necessarily indicate the commitment of individual stakeholders to undertaking any 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.

Copies available from: <http://www.deh.gov.au/biodiversity/threatened/recovery/list-common.html>

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SUMMARY

Current Status

The Christmas Island Shrew *Crocidura attenuata trichura* is the only member of the shrew family (Soricidae) recorded in an Australian territory. Currently this species is listed as Endangered under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). Due to current taxonomic uncertainty the phylogenetic relationship of the Christmas Island Shrew with closely related southeast Asian taxa requires resolution.

Distribution and Location

The species was widespread and abundant on Christmas Island at the time of settlement, occurring in rainforest on both the plateau and adjacent to the shoreline. It appeared to decline rapidly, with no subsequent records after 1908. The Christmas Island Shrew was thought to be extinct until an accidental finding of two single individuals in 1985. The species has not been recorded since these sightings, despite various subsequent targeted surveys, and therefore must be considered as extremely rare and possibly extinct. Habitat requirements critical to this species survival, including the provision of foraging, shelter and breeding resources are unknown.

Known and Potential Threats

Since the Christmas Island Shrew is so poorly known in terms of its conservation ecology, no known threats have been documented. However, the dramatic decline which occurred within 20 years of human settlement, suggests direct or indirect human threat. Current potential threatening processes include direct and indirect effects of the Yellow Crazy Ant *Anoplolepis gracilipes*, crazy ant control measures, habitat loss, disease, habitat alteration, predation and small population size.

Recovery Plan Objectives

The Recovery Plan is to follow two stages:

Stage 1: Prior to location of extant populations.

- To clarify the taxonomic status from existing museum specimens.
- To assess the current status and distribution through further targeted surveys.
- To develop a wildlife management program for habitat outside Christmas Island National Park
- To control the abundance and spread of the crazy ant.
- To implement a community awareness program that may assist in the location of previously unknown populations.

Stage 2: Subsequent to the location of extant populations.

- To establish captive breeding populations from any wild populations located, pending mitigation of the threat from the crazy ant and other potential predators and competitors.
- To effectively protect and manage wild populations.
- To identify habitat critical to survival, including shelter, breeding and foraging habitat.
- To determine and mitigate threatening processes affecting populations.

Biodiversity Benefits

Protection and maintenance of plateau and terrace rainforests will benefit other endemic rainforest-dependent species.

Estimated Cost

Stage 1 – Prior to location of extant populations

Recovery Action	Year of Implementation					Total
	1	2	3	4	5	
Action 1: Investigate the taxonomic	10,000	-	-	-	-	10,000
Action 2: Investigate current status and distribution#	58,000	58,000	58,000	58,000	58,000	290,000
Action 3: Development of wildlife management program outside CI National Park	*	*	*	*	*	-
Action 4: Control abundance and spread of the crazy ant	*	*	*	*	*	-
Action 5: Implement community awareness program	4,000	*	*	*	*	4,000
TOTAL COST	72,000	58,000	58,000	58,000	58,000	304,000

= The cost of Action 2 is dependent on the number of years taken to locate extant populations and fully determine its distribution; * = Costs covered by Parks Australia North core duties.

Stage 2 - Alternative costs if extant populations found in Year 1

Recovery Action	Year of Implementation					Total
	1	2	3	4	5	
Action 2: Investigate current status and distribution#	58,000	-	-	-	-	58,000
Action 6: Establish captive population¥	50,000	30,000	30,000	30,000	30,000	170,000
Action 7: Manage located populations	10,000	10,000	10,000	10,000	10,000	50,000
Action 8: Identify and describe habitat critical	29,000	29,000	-	-	-	58,000
Action 9: Identify threatening processes	15,000	15,000	-	-	-	30,000
TOTAL COST	162,000	84,000	40,000	40,000	40,000	366,000

= Depending on the year of location of extant populations; ¥ = This cost is assuming no reintroduction of captive shrews into the wild.

INTRODUCTION

The Christmas Island Shrew *Crocidura attenuata trichura* is the only member of the shrew family (Soricidae) recorded in Australia. The genus of white-toothed shrews *Crocidura*, with 158 recognised species, is the most speciose of all mammalian genera (Wolsan & Hutterer 1998, Nowak 1999). The taxonomy and distribution of many members of the genera is confusing and inconclusive (Nowak 1999, Jiang & Hoffmann 2001). All members of the genus are small, with a head and body length of 40–180mm and tail length of 40–110mm and a distinctly pointed muzzle.

The Christmas Island Shrew varies from light or reddish-brown to dark slate grey in colouration, with a weight range between 4.5 and 6.0g (Meek 2000; J. Tranter, Dept Environment and Heritage, pers. comm.). It is similar in appearance and occupies a corresponding niche to small Australian carnivorous marsupials (Dasyuridae), such as planigales *Planigale* sp. and dunnarts *Sminthopsis* sp. (Eisenberg 1981).

This little animal was once extremely common all over the island and its distinctive shrill squeaks could be heard all around as one stood quietly in the rainforest (Lister 1888, Andrews 1900). By 1908 it was considered to be probably extinct with no specimen either seen or heard during a visit by Andrews (1909). It was rediscovered in 1985, with two specimens located accidentally over a period of less than one month in rainforest on the western side of the island (Meek 2000; J. Tranter, DEH, pers. comm.). Following inquiries by Meek (1998), it was reported that two specimens were encountered in 1958 during rainforest clearing operations for phosphate mining near South Point. However, since 1985, no further individuals have been recorded despite various targeted surveys across the island using a variety of techniques (e.g. Meek 2000), fauna surveys as a component of environmental assessment reports for development proposals, and during the course of field studies on other rainforest fauna. Given there are only two confirmed records over the past century, the Christmas Island shrew has to be considered as extremely rare or possibly extinct.

The most important short-term objective of the Recovery Plan is to initiate targeted field surveys to determine the current distribution and status of the Christmas Island Shrew.

PART A: SPECIES INFORMATION AND GENERAL REQUIREMENTS

Species

Christmas Island Shrew *Crocidura attenuata trichura*

Conservation Status

Currently listed Endangered under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act).

Taxonomy

The taxonomic status of the Christmas Island Shrew is unclear.

It was originally regarded as “a local variety” of the southeast Asian White-toothed Shrew *Crocidura fuliginosa* (Dobson 1888 cited in Thomas 1888), which is widespread in southeast Asia, including Indonesia (Jenkins 1982, Corbet & Hill 1992). This was because the type specimen collected by Dobson (1888) (cited in Andrews 1900) had a tail of 80mm, 10mm longer than the head and body length of 70mm, and thickly covered with fine hairs. However, in the ten specimens collected by Andrews (1900) the tail (range: 63–75mm) was typically shorter (in one individual by 10mm) than the head and body length (range: 65–82 mm) and in only two specimens was it slightly longer. Based on the morphological characteristics, Jenkins (1976) described it as a subspecies of the Gray or Long-tailed Shrew *C. attenuata*. The Gray Shrew occurs from the Himalayas southwards and eastwards through Thailand, Burma and China to Malaysia and Indonesia (Jenkins 1982, Corbet & Hill 1992). Corbet & Hill (1992) have since questioned the validity of the Christmas Island Shrew being considered conspecific with *C. attenuata* based on morphological characteristics.

Objects of the Act

Objects of the EPBC Act have been considered in developing this 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, land-holders and indigenous peoples.

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

International Obligations

The Christmas Island Shrew is not listed under international fauna agreements.

Affected Interests

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

Commonwealth Government, including:

- Dept of the Environment and Heritage DEH (including Parks Australia North, Natural Heritage Division, CI Rainforest Rehabilitation Program, Approvals and Legislation Division),
- Dept of Immigration, Multicultural and Indigenous Affairs (DIMIA)
- Dept of Transport and Regional Services (DOTARS),

Christmas Island National Park Advisory Committee,
Shire of Christmas Island,

CI Phosphates Pty Ltd (Phosphate Resources Ltd) (CIP),
 Union of Christmas Island Workers,
 Christmas Island Tourist Association,
 Department of Environmental Protection,
 Asia Pacific Space Centre,
 Telstra Corporation Ltd,
 Monash University, and
 Australian zoos.

Role and interests of indigenous people

Not applicable. Christmas Island was first settled in 1888; prior to this time there were no indigenous peoples inhabiting the island (Commonwealth of Australia 2002).

Benefits to other species/ecological communities

Threats identified and management actions proposed for the Christmas Island Shrew are similar to those for other threatened endemic species that are restricted to rainforest vegetation communities on the island. Actions affording protection to plateau and terrace rainforest will also provide protection for other rainforest-dependent species (Table 1).

The targeted survey for the Christmas Island Shrew may provide additional information on the current distribution, status and habitat of the poorly known Christmas Island Gecko *Lepidodactylus listeri* and Christmas Island Blind Snake *Ramphotyphlops exocoeti*. During the course of targeted field surveys for the shrew, incidental records of these poorly known reptiles should be entered into an ‘Incidental Flora and Fauna Database’ to be established by Parks Australia North (PAN) on Christmas Island. The database should also include records of exotic species because of their potential threats as predators and competitors to native fauna.

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

Species	Listing
Christmas Island Pipistrelle <i>Pipistrellus murrayi</i>	E ¹ , E ³
Christmas Island Flying-fox <i>Pteropus melanotus natalis</i> *	DD ^{3,*}
Abbott’s Booby <i>Papasula abbotti</i> (listed <i>Sula abbotti</i> on EPBC Act)	E ¹ , CE ²
White-tailed Tropicbird (Christmas Island subspecies) <i>Phaethon lepturus fulvus</i>	CE ²
Christmas Island Frigatebird <i>Fregata andrewsi</i>	V ¹
Christmas Island Goshawk <i>Accipiter fasciatus natalis</i>	E ¹ , CE ²
Christmas Island Imperial-Pigeon <i>Ducula whartoni</i>	CE ²
Emerald Dove (Christmas Island subspecies) <i>Chalcophaps indica natalis</i>	CE ²
Christmas Island Hawk-Owl <i>Ninox natalis</i>	V ¹ , CE ²
Glossy Swiftlet (Christmas Island subspecies) <i>Collocalia esculenta natalis</i>	CE ²
Island Thrush (Christmas Island subspecies) <i>Turdus poliocephalus erythropleurus</i>	CE ²
Christmas Island White-eye <i>Zosterops natalis</i>	CE ²
Christmas Island Blind Snake <i>Ramphotyphlops exocoeti</i>	V ¹
Christmas Island Gecko <i>Lepidodactylus listeri</i>	V ¹

CE = Critically Endangered; E = Endangered; V = Vulnerable; DD = Data deficient; ¹ = Listed under EPBC Act; ² = ‘Action Plan for Australian Birds’ (Garnett & Crowley 2000); ³ = ‘Action Plan for Australian Bats’ (Duncan *et al.* 1999); and * = Recent evidence suggests the species has undergone significant declines in total population numbers and its status is in urgent need of review (CIP pers. comm.).

Social and economic impacts

Until it is determined whether the Christmas Island Shrew is extant, it is difficult to comment on the social and economic impacts resulting from management actions. The last confirmed

records are from plateau and terrace rainforest, suggesting any development proposals and threatening processes affecting these habitats must include consideration of this species until further information is available. Similar to other endemic rainforest fauna that is threatened, the potential presence of the species could impact on economic activity or development. This arises from the listing under the EPBC Act, which invokes a range of protective provisions and offences where a population is to be affected. The magnitude of this potential impact is unknown, as it will vary with the location, size and extent of an affected population (once discovered), and the nature and extent of the activity, proposed or current.

Most fauna species on Christmas Island are endemic and some have the potential for attracting low impact ecotourism. The Christmas Island Shrew, although a cryptic component of the endemic fauna, provides an interesting 'story' as the only extant endemic mammal (excluding bats) on the island and the only Australian shrew. Such a 'story' may provide added appeal to tourists with a strong natural history background contemplating visiting the island. Rainforest rehabilitation, which provides employment for some islanders, may create potential habitat for the species in years to come.

PART B: DISTRIBUTION AND LOCATION

Distribution

Current Known (or Likely) National Distribution: Endemic to Christmas Island (closely related species occur in Java and other parts of southeast Asia)

Historical Distribution: Widespread on Christmas Island at settlement, occurring in forest on both the plateau and adjacent to the shoreline and being described as 'very abundant' or 'extremely common' (Lister 1888, Andrews 1900).

Extent and Geographic Location(s) of Populations: Currently unknown, but, on the basis of available information (Figure 1), is considered extremely rare or possibly extinct on Christmas Island.

The Christmas Island Shrew was thought to be extinct until the accidental separate finding of two individuals in 1985:

- One was found running from a bird's nest fern that had recently fallen on to a track approximately 200m southwest of the shrine, in an area locally known as LB4 on the central plateau (approximate location: 10°28'S, 105°35'E) (J. Tranter, DEH, pers. comm.). This animal was kept in captivity for some twelve months.
- The second was found on a walking track 30 to 40m north of the stream at No. 1 Dale (approx.: 10°28'S, 105°33'E) on the west coast in the late afternoon during fine weather (P. Goh, Dept of Foreign Affairs and Trade, pers. comm.). This individual died shortly afterwards while being held in captivity (J. Tranter, DEH, pers. comm.).

Information indicating the unconfirmed capture of two other shrews in 1958 when South Point (approx.: 10°33'S, 105°39'E) was being cleared for mining was provided by D. Powell (pers. comm. 1997 cited in Meek 1998).

Recently reported, unconfirmed sightings, following publicity regarding the species, were at:

- the junction of the Pink House and Murray Roads (10°29'S, 105°38'E) (Coates, K. pers. comm. 1996 cited in Meek 1998),
- the Christmas Island Resort Pool (10°27'S, 105°42'E) (Rochford, M. pers. comm. 1997 cited in Meek 1998), and
- Martin Point (10°27'S, 105°33'E) (Blackford, P. pers. comm. 1997 cited in Meek 1998).

These sightings were investigated immediately by trained staff but are unlikely to have been Christmas Island shrew (P. Meek pers. comm.)

No confirmed sightings have been made since 1985, despite:

- Systematic surveys for the shrew during 1997-98 using a variety of techniques (Meek 2000).
- Recent surveys using a variety of techniques during environmental impact assessments on proposed developments (e.g. Asia Pacific Space Centre) (G. Richards, Greg Richards and Associates, pers. comm.).
- Earlier surveys (e.g. Tidemann 1988: 2036 trapnights with pitfall, Elliott and snapback traps in 1988; N. Dunlop: 1500 pitfall trapnights in 1985/1986; and H. Yorkston: 120 pitfall trap nights in 1987).
- Extensive nocturnal studies of the Christmas Island Hawk-Owl *Ninox natalis* (Hill & Lill 1998a, b), Christmas Island Pipistrelle *Pipistrellus murrayi* (Lumsden & Cherry 1997, Lumsden *et al.* 1999) and reptiles (Cogger & Sadlier 1981, 2001) throughout primary rainforest.
- Studies of gut contents and/or faecal material of potential predators, including the Feral Cat *Felis catus* (Tidemann *et al.* 1994, data in the CIP-commissioned 2002 fauna survey), Christmas Island Hawk-Owl (Hill & Lill 1998b) and the Wolf Snake *Lycodon capucinus* (Rumpff 1992, Cogger & Sadlier 2001).

Habitat

At the time of settlement, the Christmas Island Shrew was widespread in rainforest extending from the shoreline to the plateau (Lister 1888, Andrews 1900). It was not recorded whether the shrew occurred within other forest communities, for example scrubby forest in exposed situations on shallow soils, coastal fringe vegetation dominated by pandanus *Pandanus christmatensis* and the Cabbage Tree *Scaevola taccada*, and in perennially wet areas. The importance to the species of karst terrain (including caves, overhangs, rock crevices, sinkholes, and inland cliffs rising out of the terrace rainforest) is unknown.

The most recent records were of single individuals from tall plateau rainforest in deep soils (J. Tranter, DEH, pers. comm.) and terrace rainforest with shallow soils (P. Goh, DFAT, pers. comm.). The majority of primary plateau and terrace rainforest, including the locations for the two 1985 sightings, is now protected within the Christmas Island National Park. It is unknown whether the shrew may occur in secondary regrowth. There appear to have been no records from around human habitation on the island.

The Christmas Island Shrew was recorded to shelter in holes in rocks and roots of trees, and foraged predominantly on small beetles (Andrews 1900). Other *Crocidura* species either dig their own burrows in loose soil or leaf mould frequently under fallen trees and rocks or use those of other animals (Nowak 1999). An important component of habitat occupied by some *Crocidura* shrews is the presence of a high degree of ground cover with associated deep leaf litter and slightly moister soil (Dickman 1995). These preferences are linked to increased prey availability and predator avoidance, but may also facilitate burrow construction (Dickman 1988, 1995). It is not known whether the Christmas Island Shrew favours these microhabitats within the rainforest.

Habitat critical to the survival of the species

Until further information is obtained, by applying the precautionary principle to the EPBC Act criteria, all areas of primary plateau and terrace rainforest on the island should be considered as potential habitat critical to survival (Figure 1). If the shrew is found to be extant, identifying habitat requirements critical to survival is recommended.

Important populations

None known, as the species has not been recorded since 1985. Should any individuals be located, they would be regarded as constituting a component of an important population.

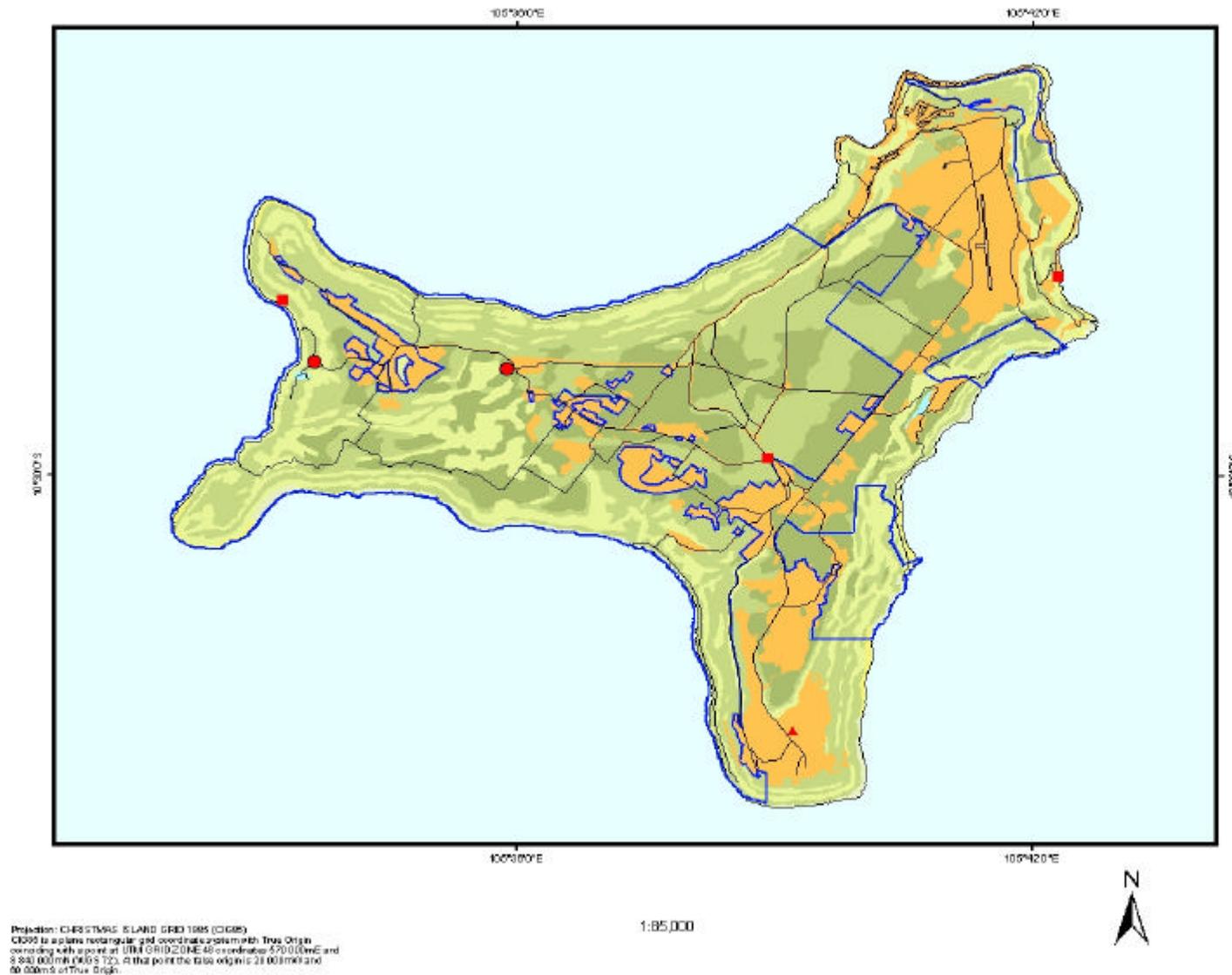


Figure 1
Distribution of
Crocidura attenuata trichura
Christmas Island Shrew

Legend

- 1995 Record
- Unconfirmed
- ▲ Unconfirmed - 1958
- Roads
- National Park
- Vegetation**
- Cleared, natural and planted revegetation
- Rainforest, freshwater seepage
- Rainforest, screepinnade phase
- Rainforest, shallow soil phase
- Heath, shrubland, low rainforest
- Open forest, and vine woodland
- Tall rainforest, deep soil phase

Source: Shrew locality data collated by M Schulz. Vegetation, roads and park boundary sourced from Christmas Island Geographic Information System, 2004.

Caution: Data used in this map have been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything contained herein.

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 For further information contact: Jeff Tranter
 Ph. 02742480 jett.tranter@e.gov.au

Projection: CHRISTMAS ISLAND GRID 1985 (CGRS)
 CGRS is a plane rectangular grid coordinate system with True Origin coinciding with a point at UTM GRID ZONE 49 coordinates 570000mE and 8 881 000mS (60 S T2). At that point the false origin is 21 000mE and 60 000mS of True Origin.

1:85,000

PART C: KNOWN AND POTENTIAL THREATS

Identification of threats

Known Threats: Not known.

Potential Threats:

Disease

The Christmas Island Shrew was considered to be probably extinct by 1908 (Andrews 1909), suggesting exposure to threats other than broadscale habitat destruction. About this time (1901 to 1904), the endemic Maclear's Rat *Rattus macleari* became extinct, proposed to be the result of the introduction of trypanosome-infected Black rat *Rattus rattus* (Pickering and Norris 1996). Isolated island species that have evolved in the absence of diseases common to continental faunas are more susceptible due to loss of population heterogeneity (Caughley and Sinclair 1994). Introduction of a new disease is the most likely cause of the initial decline.

Yellow Crazy Ant *Anoplolepis gracilipes*

This ant was accidentally introduced to the island between 1915 and 1934. Crazy ants form multi-queened supercolonies, and dramatic increases in supercolony formation began in the mid to late 1990s at several widespread locations, including The Dales area. Prior to aerial baiting in September 2002, supercolonies infested over 2500ha of rainforest.

Crazy ants have the potential to alter the whole ecology of the island. For example, the Red Crab *Gecaroidea natalis* population has declined by at least 30% due to ant attack, resulting in dramatically altered plant community dynamics (Garnett & Crowley 2000; M. Jeffery, PAN, pers. comm.). Additionally, the ants farm scale insects, causing damage to trees resulting in dieback and canopy thinning (Garnett & Crowley 2000; M. Jeffery, PAN, pers. comm.). Flow on effects could include spread of the introduced Black Rat into areas formerly occupied by the crabs, alteration in both ground- and tree-dwelling invertebrate diversity and abundance, changes in ground layer vegetation structure, invasion of weeds and introduced Giant African Land Snail *Achatina fulica* in die-back affected forest, and alteration in leaf litter depth affecting soil moisture. The direct effects on the shrew are unknown, but it is likely that breeding, shelter and foraging sites would be severely effected. It is also likely the ants kill young animals in the nest, and possibly adults in severely affected areas (as recorded for a Christmas Island Pipistrelle in a harp trap in The Dales area by Lumsden *et al.* 1999).

A priority conservation management objective of PAN is to control crazy ant supercolonies by aerial baiting. The impact of this on the shrew, both through contact with baits and flow on impacts on prey species, is unknown. In September 2002 all known supercolonies were baited. Results indicate this was successful in controlling supercolonies over 2500ha of Christmas Island. Crazy ants are still present in low densities and PAN staff will continue to monitor any new supercolony formation and treat by hand baiting over the next few years.

Habitat Loss

Although the dramatic decline of the shrews occurred before extensive clearing and prior to the network of bulldozed drill lines, these factors could have contributed to the population not recovering from the initial decline. The unconfirmed 1958 reports were the result of habitat clearance for phosphate mining (Meek 2000). This suggests that, similar to many of the island's endemic avifauna, remaining shrew populations would have been adversely affected by the destruction of about a third of the rainforest for phosphate mining. They may also have been affected by the drill lines resulting in increased predation risk and localised alteration in microhabitat characteristics, such as the loss of ground cover.

New proposals to clear primary rainforest on vacant crown land may apply additional pressure on any remaining shrew populations. 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; road re-alignment and new port facilities north of the former Christmas Island Resort area.

Habitat Alteration

Alteration of the rainforest habitat due to the extinction of Maclear's Rat and Bulldog Rat *R. nativitatis* and theorised alteration in crab populations (particularly Red Crab), may have resulted in an adverse change in microhabitats within rainforest critical to the maintenance of shrew populations (Meek 2000).

Predation

No instances of predation have been recorded. However, it is likely that introduced predators (e.g. Feral Cat, Black Rat and Wolf Snake), the naturalised Nankeen Kestrel *Falco cenchroides*, and endemic predators, such as the Christmas Island Goshawk *Accipiter fasciatus natalis* and Christmas Island Hawk-Owl *Ninox natalis*, may opportunistically predate on the Christmas Island Shrew.

Small Population Size

Current evidence strongly suggests that the Christmas Island Shrew occurs in very low densities, compared to early observations made of the species. A small population size increases the risk of extinction through inbreeding depression and stochastic events (Caughley & Sinclair 1994). The network of wide mining haulage roads may have further isolated populations due to a possible reluctance of individuals to cross wide open spaces due to elevated predation risk.

Other Potential Threats

The two individuals recorded in 1985 were both located on park roads or walking tracks within rainforest in the western section of the island. There is a possibility some shrews may be road killed, and such a threat is likely to increase with a substantial growth in vehicular traffic associated with developments, such as the Asia Pacific Space Centre and the Immigration, Reception and Processing Centre.

Although forest fires are uncommon on the island, during recent extended dry periods in 1994 and 1997, fires occurred in terrace forest. The effects of forest fire on the Christmas Island Shrew is unknown, but may result in adverse impacts due to the loss of ground cover and leaf litter, and by affecting invertebrate populations.

Areas under threat

Unknown, since this species has not been recorded since 1985.

Populations under threat

Targeted surveys undertaken by Meek (2000) and various consultants using a variety of techniques have failed to locate this species, suggesting it is extremely rare and possibly extinct. Any population located must be considered to be under extreme threat.

PART D: OBJECTIVES, CRITERIA AND ACTIONS

Recovery objectives and timelines

The overall objectives of this recovery plan are to:

- clarify the taxonomic status of the Christmas Island Shrew,
- clarify the current status and distribution, and
- maximise the opportunity for the viability of this species in the wild.

Proposed measures for habitat protection and control or eradication of the crazy ant should assist the survival of any extant populations.

Specific objectives for the five years of this Recovery Plan are:

- *Objective 1:* To clarify the taxonomic status from existing museum specimens.
- *Objective 2:* To assess the current status and distribution through targeted surveys.
- *Objective 3:* To control the abundance and spread of the crazy ant
- *Objective 4:* To establish captive breeding populations from any extant populations, pending mitigation of all potential threats.
- *Objective 5:* To effectively protect and manage any extant populations
- *Objective 6:* To identify habitat critical to survival, including shelter, breeding and foraging habitat.
- *Objective 7:* To determine threatening processes affecting the species.
- *Objective 8:* To develop and implement a community awareness program to assist in the location of previously undetected populations.

Performance Criteria

Performance Criteria listed below match the corresponding Objectives:

- *Criterion 1:* Taxonomic status of the Christmas Island Shrew resolved.
- *Criterion 2:* Current conservation status and distribution determined.
- *Criterion 3:* Abundance and spread of crazy ant is less than at 2002 levels, with all high-density supercolonies reduced by 99% of their original densities.
- *Criterion 4:* Captive breeding populations established with the aim of reintroduction once potential threat control has been achieved.
- *Criterion 5:* Any identified extant populations protected and population numbers increase.
- *Criterion 6:* Habitat critical to survival investigated and determined.
- *Criterion 7:* Threatening processes determined, and actions taken to control them.
- *Criterion 8:* Increased knowledge of the shrew amongst island residents, an enhanced ability amongst islanders to identify the species from other small mammals and guidelines on what to do if a shrew is found.

Evaluation of performance

The plan's performance to be reviewed by an Island Recovery Team as proposed for avifauna by Garnett & Crowley (2000). This recovery team to be established with the primary objective of developing and implementing island-wide conservation management and recovery plans, including for the Christmas Island Shrew. The Recovery Team 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 PAN staff, a Shire of Christmas Island representative, and other local members as deemed appropriate), and
- b. off-island representatives (including two or more members of the scientific community with first-hand knowledge of the island's ecology and endemic fauna).

In addition to annual review, implementation of the plan should be reviewed at the end of 5 years (as required under the EPBC Act). If the Christmas Island Shrew is not found during the life of this plan (see Action 2), the conservation status listing should also be reviewed, and if appropriate, the species nominated for listing as Extinct.

Actions

The Actions are to follow two distinct stages:

STAGE 1 – PRIOR TO LOCATION OF EXTANT POPULATIONS

This stage incorporates actions to be undertaken prior to the location of extant populations of the Christmas Island Shrew.

Action 1: Investigate the taxonomic status of the shrew (Obj. 1; Perf. Crit. 1).

Genetic studies, using (dry or ethanol preserved) museum specimens can determine the phylogenetic relationship with closely related shrews in Java and other parts of southeast Asia. This can be achieved by analysing molecular sequence data, such as mitochondrial cytochrome *b* gene or the control region of D-loop. Taxonomic investigations of *Crocidura* shrews have been conducted indicating the potential availability of primers of closely related species, for example *C. attenuata* (Ruedi & Vogel 1995, Motokawa *et al.* 1997, Motokawa *et al.* 2000) and *C. fuliginosa* (Ruedi *et al.* 1990, Ruedi & Vogel 1995, Ruedi *et al.* 1998, Querouil *et al.* 2001). This could be done in various institutions, such as the Evolutionary Biology Unit, South Australian Museum or the Centre for Environmental Adaptation and Stress Research, University of Melbourne. Although this action will determine the taxonomic status, even if genetic studies show that the Christmas Island Shrew is not a distinct species or subspecies (from those found in Asia), it still represents a unique element of Australian fauna which meets criteria for threatened listing under the EPBC Act, and therefore requires a recovery plan outlining recovery actions.

Action 2: Investigate current status and distribution (Obj. 2; Perf. Crit. 2).

Before any remedial work to aid recovery, it must be determined if the shrew is extant. Once 're-discovered', information on current status and distribution is essential to manage recovery. Targeted surveys of potential habitat in rainforest throughout the island, by suitably qualified and experienced personnel, should be conducted twice annually over the five-year period, or until populations have been located, and the status and distribution determined. Appendix 1 details the suggested targeted survey approach. If after 5 years, the community awareness program, feral animal control actions and practices, and habitat protection measures have been implemented, and no shrew is found, nomination for listing as Extinct under the EPBC Act should be considered.

Action 3: Develop wildlife management program for potential habitat outside the Christmas Island National Park (Obj. 3, 5 & 6; Perf. Crit. 3, 4, 5 & 6).

The majority of primary rainforest outside the National Park is publicly owned, by the Commonwealth. To achieve protection of threatened species, including any remaining extant populations of the shrew, outside the national park, it is essential that a considered approach be adopted through developing a comprehensive wildlife management program. Such an approach will assist PAN in negotiations over development proposals, allow for the input of relevant decision-makers and landholders, and facilitate greater certainty for environmentally sensitive developments. The plan should also allow for adaptive management as better information becomes available on the Christmas Island Shrew and other threatened species, in particular whether the shrew is extant, and if so what habitat is critical for survival.

Action 4: Control abundance and spread of crazy ant (Obj. 3, 5 & 7; Perf. Crit. 3, 5 & 7). In September 2002 an aerial baiting program was undertaken, with all known supercolonies treated with insecticide. Results so far indicate that the program was successful in controlling supercolonies over 2500 ha of Christmas Island. Crazy ants are still present in low densities on Christmas Island. PAN staff will continue to monitor any new supercolony formation and treat by hand baiting over the next few years.

Action 5: Implement community awareness program (Obj. 2, 5 & 8; Perf. Crit. 2, 5 & 8). All confirmed records over the past century (ie. 2) have been accidental, rather than targeted. Given the species' rarity and the difficulty using traditional capture techniques, due to the various crab species, it is likely that future records will also be accidental. To enhance the profile of the shrew amongst islanders and interest groups, a community based awareness program is required. This should be based on a information brochure, to encourage reporting and assist distinguishing the shrew from other small mammals, such as the house mouse *Mus musculus* and immature black rat. The program should improve on publicity used previously to enhance the profile of the shrew, and include instructions on what to do if one is seen/found. It should also clearly explain what conservation actions will occur (and why) if shrews are found. Additionally, PAN staff should conduct information sessions with school groups, field staff from various organisations (e.g. Shire of Christmas Island, CI Phosphates Pty Ltd and Asia Pacific Space Centre), and other interest groups.

This community awareness program must be coupled with confirmation of reported sightings by qualified PAN staff. On confirmation, an assessment of the site's attributes, and a survey within similar habitat in the vicinity should be undertaken by suitably qualified and experienced personnel to identify the extent of the population. It would be valuable for PAN to establish a database for sightings, and devise procedures or protocols for assessing any reported sighting, and the handling of any individuals located.

STAGE 2 – SUBSEQUENT TO LOCATION OF EXTANT POPULATIONS

Action 6: Establish captive breeding population (Obj. 3, 4, 5 & 7; Perf. Crit. 3, 4, 5 & 7). When an extant population is located, it is important that a captive breeding population be established to assist in the continuing survival of the species, with the view to reintroduction once crazy ants and other potential threats are controlled. Evidence from the LB4 individual captured in 1985 indicates that the species copes well in captivity, although food provision was time consuming (J. Tranter, DEH, pers. comm.). It is preferable that captive animals be held on Christmas Island to avoid transportation stress, and exposure to new diseases and different climatic conditions. Such a captive population must also be protected from direct or indirect (e.g. through food provided) exposure to ant bait, and from potential predators common around the Settlement, such as the wolf snake, black rat and cat. Alternatively, captive breeding populations could be established in recognised zoos on mainland Australia where appropriate quarantine, disease-management and climatic conditions can be provided. The feasibility of establishing the captive populations in the same holding facility as proposed for some endemic Christmas Island bird species (Garnett & Crowley 2000) should be investigated if the shrew is 'rediscovered'.

Action 7: Effective management of populations (Obj. 4, 5, 6 & 7; Perf. Crit. 4, 5, 6 & 7). The location of any site supporting extant populations must be identified as habitat critical for the species. Steps must be taken to protect the area to ensure continuing survival and aid in population increase. Based on the limited information available recommended protection of the area in which a population is found needs to include no further habitat loss within at least

1km of the outer limits of the population detected; no new roading through the identified area; predator control (including the feral cat and black rat), as well as control and monitoring of the crazy ant. Further actions could include removal of individuals into a captive population (see Action 5). Where a population is located outside the National Park, appropriate management strategies are to be devised and implemented with the relevant interest groups, landowners or managers. Research relevant to the protection of any extant population is a high priority, and must include identifying habitat critical to survival and threatening processes.

Action 8: Identify and describe habitat critical (Obj. 3, 5, 6 & 7; Perf. Crit. 3, 5, 6 & 7).

When plentiful, the Christmas Island Shrew was recorded in rainforest extending from the shoreline to the plateau. However, in terms of identifying components of this vegetation comprising critical foraging, breeding and sheltering habitat, little information is available. For any populations of shrews located, an important action is to identify critical microhabitat within the rainforest used for foraging, shelter and breeding purposes. Additionally, it will be important to assess usage of regrowth areas, sites infested by crazy ants and weeds, and the importance of edge effect. Such an action will assist in the identification and protection of other areas of potential habitat critical to survival, and aid in targeted surveys to locate additional populations.

Action 9: Identify threatening processes (Obj. 3, 4, 5, 6 & 7; Perf. Crit. 3, 4, 5, 6 & 7).

The threatening processes affecting the viability of Christmas Island Shrew populations have not been identified, although disease, habitat loss and habitat alteration are suspected to have been important factors in their decline. It is also likely that the spread of the crazy ant will have a deleterious effect on remaining populations. However, it is important with any extant populations, to assess components of the site that may assist in the identification of threatening processes. Confirmation of threatening processes is critical for long-term effective management of the species. Management practices must then be determined to reduce the impact of identified threats on located populations of the shrew.

Management Practices

It is difficult to identify specific management practices to avoid adverse impacts on the Christmas Island shrew due to the lack of information on the species. Many of the Actions outlined above are designed to determine specific management practices. Until these have been determined, the broad interim management practices below should be adopted to minimise potential further declines:

- No removal of primary plateau rainforest within Christmas Island National Park;
- Implementation of the Invasive Ants on Christmas Island Action Plan;
- Continuation of liaison with AQIS and WAQIS to ensure tight quarantine controls to prevent the accidental introduction of new diseases and exotic pests;
- Feral Cat and Black Rat control programs within primary plateau and terrace rainforest;
- Maintenance of existing habitat quality of primary rainforest through strategies to minimise spread of exotic weeds following the Weed Management Strategy (Hart 1998); and
- Adoption of strategy to avoid wildfires within potential shrew habitat.

Removal of any primary plateau and terrace rainforest could result in a significant impact on the Christmas Island shrew and should be referred to the Commonwealth Environment Minister under the EPBC Act. Removal of primary plateau and terrace rainforest on vacant crown land or leasehold land should not occur without intensive targeted surveys for the Christmas Island Shrew (see Appendix 1).

PART E: DURATION AND COSTS

Stage 1 – Costs of actions prior to location of extant populations

Recovery Action	Year of Implementation					Total
	1	2	3	4	5	
Action 1: Investigate the taxonomic status	10000	-	-	-	-	10000
Action 2: Investigate current status and distribution#	58000	58000	58000	58000	58000	290000
Action 3: Develop wildlife management program	*	*	*	*	*	-
Action 4: Control abundance and spread of the crazy ant	*	*	*	*	*	-
Action 5: Implement community awareness program	4000	*	*	*	*	4000
TOTAL COST	72000	58000	58000	58000	58000	304000

= The cost of Action 2 is dependent on the number of years taken to locate extant populations and fully determine its distribution; * = Costs covered by Parks Australia North core duties.

Stage 2 - Alternative costs if extant populations found in Year 1

Recovery Action	Year of Implementation					Total
	1	2	3	4	5	
Action 2: Investigate current status and distribution#	58000	-	-	-	-	58000
Action 6: Establish captive population¥	50000	30000	30000	30000	30000	170000
Action 7: Manage located populations	10000	10000	10000	10000	10000	50000
Action 8: Identify and describe habitat critical	29000	29000	-	-	-	58000
Action 9: Identify threatening processes	15000	15000	-	-	-	30000
TOTAL COST	162000	84000	40000	40000	40000	366000

= Depending on the year of location of extant populations; ¥ = This cost is assuming no reintroduction of captive shrews into the wild; * = Costs covered by Parks Australia North core duties.

Resource Allocation

The cost estimates are dependent on the year of location of extant shrew populations. Resources have been allocated for the full five years to conduct surveys to locate shrew populations over one month periods in the wet and dry seasons of each year.

Some of the actions outlined (e.g. Actions 4) 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 (e.g. Action 4) 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.

A number of Actions are already ongoing (e.g. Action 3, 4 and 9) and may be considered as core duties of PAN.

The establishment of captive breeding populations could be in association with the establishment of captive populations of critically endangered endemic avifauna in mainland zoos (Garnett & Crowley 2000). This strategy would reduce transportation costs (e.g. for release back into the wild) and quarantine procedures to ensure non-exposure to potentially

fatal diseases. Alternatively, a captive breeding population could be established on Christmas Island under the guidance of PAN staff and used to aid in interpretation and community awareness programs.

Following the location of extant populations of the shrew, research is required in the same year and subsequent year over the wet and dry seasons, to identify and describe habitat critical to survival (in terms of foraging, breeding and sheltering) and threatening processes. Effective management of the located shrew populations will be ongoing and encompass both management practices covered as core PAN duties, and specialist actions that will only be identified following research into the shrew's ecology.

The community awareness program will involve the preparation of an informative brochure that can be widely distributed amongst island residents. The other aspect of this program involves information sessions that can be given by PAN staff as part of an overall awareness program on the value of the endemic Christmas Island fauna.

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APPENDIX 1: TARGETED SURVEY

Objective: To locate extant populations of the Christmas Island Shrew.

Personnel:

The survey must be undertaken by a consultant with either previous field survey experience of Crocidurine shrews or extensive expertise using a wide range of survey techniques in targeted surveys for small mammal species within Australia. The consultant must have good lateral thought with the ability to use adaptive targeted survey strategies.

Duration:

To be conducted for one month sample periods in both the dry and wet seasons of each year for the five-year timeframe of the Recovery Plan or until extant populations have been located and the distribution fully assessed.

Approach:

Following from the survey of Meek (2000), a stratified survey across all primary plateau and terrace rainforest communities and in ecotones between these and other vegetation communities should be undertaken using a variety of additional or modified techniques.

Site Selection:

Sites should be selected in primary plateau and terrace rainforest at 2km² intervals across the island. All sites need to be outside of crazy ant infestations or sites treated by aerial baiting in September 2002. Initially it is recommended survey effort be concentrated on the western section of the island (west of Margaret Beaches on the north coast and South Point on the south coast), with the following areas to be investigated as high priority:

- 1985 shrew localities: plateau rainforest adjacent to the Shrine in LB4 and terrace rainforest at No 1 Dale.
- plateau rainforest linking the two 1985 localities, including Ferguson, Murray, Bean and Camp Hill areas.
- terrace rainforest between North West Point and Egeria Point.
- terrace and plateau rainforest from Jones Point east to The Blowholes.
- terrace and plateau rainforest along north coast from North West Point east to the eastern end of Margaret Beaches.

Logistically it is not feasible to obtain coverage of the entire island on each visit, both in terms of distances involved and the requirement to check traps frequently. Instead, it is recommended that a number of contiguous 2km² areas be surveyed simultaneously.

For each 2km² sector, the following land features be selected on different survey visits:

a. Coastal 2km² areas:

- Ecotone of terrace rainforest and coastal vegetation or shoreline.
- Terrace rainforest on ecotone with inland cliffs and scree slopes.
- Primary rainforest on ecotone with inland cliffs and scree slopes.

b. Inland 2km² areas:

- Primary rainforest with rock outcropping.
- Primary rainforest without rock outcropping.

The location of each site must be permanently marked and accurate coordinates recorded using a GPS to enable revisits.

Survey Timing and Duration:

Where possible, survey visits to be timed to coincide with reduced land crab activity (e.g. Robber Crab moulting period in March/April). Each site to be sampled for seven consecutive days, which is longer than normally necessary to reach asymptotes in species accumulation curves for small insectivores, such as shrews (after Goodman & Jenkins 1998).

Survey Techniques:

Survey techniques typically used to detect and capture shrews are pitfall trapping and live trapping using a variety of trap designs, such as Sherman, Longworth and Elliott traps. Standard techniques are difficult to use on the island due to the problem of crab interference. All survey methods must take crab interference into consideration.

Survey techniques listed below are to be used at all standard sites selected. Additionally, the consultant must have the option to use an adaptive survey strategy trialling new techniques or modifications to the following listed techniques. Additional strategies could include the use of waterproofed infra-red video camera systems at permanent feeding stations, both on the ground and in the canopy (e.g. following the field-tested design of Ross Meggs; Faunatech, P.O. Box 1655, Bairnsdale, Victoria, 3875; goodgear@faunatech.com.au); automated playback that would enable sampling a number of localities simultaneously; and use of shrew pheromone from SE Asian shrews as an attractant. Where time permits, opportunistic sampling using the standard survey techniques listed below at additional locations is to be encouraged.

1. Pitfall Trapping

Pitfall trapping is a common technique for locating Crocidurine shrews in the Northern Hemisphere and Asia. Lister (1888) recorded the capture of three individuals in pitfall traps on the island, but did not specify the nature of the traps used. Meek (2000) used pitfall traplines (12 pits along a 25 m line; diameter 250 mm and 80 mm) at three sites in the Dales - Winifred Beach area. Rolls of rigid underground powerline cable cover (300 mm X 4 mm) were used as a drift fence. Segments of PVC tubing (100 mm X 40 mm) were placed at the bottom of pits to act as refuge sites for captured animals from Robber Crab predation.

Establish ten pitfall traps of PVC tubing (maximum diameter: 80mm, minimum depth: 250mm, each trap capped by heavy duty wire mesh (e.g. steel) at a distance of 5m apart with the upper rims flush with ground level. Drift fence similar to that used by Meek (2000) or utilise mobile crab fences developed by PAN (M. Jeffrey, pers. comm.). The small diameter tubing coupled with the wire mesh capping of a spacing to exclude Robber Crabs and the majority of other crabs. This wire mesh is to be hooked into place at the top of each pit. Each pitfall trap to have non-absorbent cotton wool or coconut fibre to be placed in the base to serve as shelter. Additionally, each pitfall trap to have a securely fitting lid for when pits not in use.

2. Live Trapping

Lines of twenty-five Longworth/Sherman/or finely tuned Elliott traps be established at intervals of 10m on the ground (after Haim *et al.* 1997), with an additional 10 traps sited in trees (including canopy) or rock faces, preferably in proximity to epiphytes. Traps to be baited with a range of baits including: rolled oats, peanut butter and sunflower seeds, as well as a presumed shrew specific mixture of *ikan billis* (fish) soup powder, flour and water (after Meek 2000). Each trap to be surrounded by guyed or tied-down wire mesh of sufficient mesh spacing to allow shrew passage but to prevent Robber Crab interference. To provide protection against high temperatures non-absorbent cotton wool or other insulative material

must be placed in each trap. Traps must be checked twice daily (early morning and late afternoon) to minimise shrew mortality.

3. *Call Playback*

Earlier naturalists commented on the short shrill squeak of the shrew commonly heard throughout the island (Lister 1888, Andrews 1900). No information is provided as to the time of day or conditions when calls were heard. At each site, conduct two call playback sessions: within two hours after dawn and within two hours following dusk. Each session to consist of a thirty minute listening period, followed by a ten-minute period of playing the call of related *Crocidura* shrews, followed by another thirty minute listening period.

4. *Active Searching*

The shrew was recorded living in holes in rocks and roots of trees (Andrews 1900). At each site, spend one person hour actively searching under rocks, ground debris and at the base of trees with the aid of a rake and gemmie bar.

5. *Artificial Habitat and Nest Burrows*

At each site, position ten sheets of artificial habitat (such as corrugated iron sheeting) flush with the ground adjacent to the base of trees or amongst rocks. These sheets to be regularly checked.

At each site, place ten artificial nest burrows (made of two layers of PVC tubing) at the base of canopy trees, following the same design and dimensions as used for the Earless Dragon *Tympanocryptis lineata pinguicolla* (designed by P. Robertson, Wildlife Profiles P/L, P.O. Box 500 Heidelberg, Victoria 3084; wildlife.profiles@bigpond.com).

6. *Hair Funnels and Hair Tubes*

Shrews readily investigate novel objects and frequently defaecate on the inside of such objects (Churchfield *et al.* 2000). At each site, locate five hair funnels (Faunatech) and five hair tubes (following the design of Suckling 1978) 20 m apart on the ground, and five hair funnels and five hair tubes in trees (including in the canopy) or on rock faces adjacent to epiphytes. The hair funnels/hair tubes are to be baited with the same mixture as for Longworth/Elliott traps. Each trap to be surrounded by guyed or tied-down wire mesh of sufficient mesh spacing to allow shrew passage, but to prevent Robber Crab interference. These traps to be regularly checked for hairs and scats.

7. *Epiphyte and Loose Bark Search*

There is a possibility that the shrew uses epiphytes as shelter sites (Meek 2000). At each site, where feasible, search epiphyte clumps on the trunk and in the canopy, and strips of loose bark on trunks and logs for sheltering shrews. This search to be conducted by manual light beating of the clump/bark with the aim of disturbing sheltering shrews.

8. *Predator Gut and Scat Analysis*

At each site, any predator scats and regurgitations be collected for analysis after each survey period. Additionally, encourage Parks Australia North staff to retain and be trained to identify the gut contents of all feral cats killed during control programs and randomly.

Both on site and elsewhere, locate nests of the Nankeen Kestrel *Falco cenchroides*, Christmas Island Goshawk *Accipiter fasciatus natalis* and Christmas Island Hawk-Owl *Ninox natalis*, for the collection and analysis of regurgitated and discarded material.