



Australian Government
Department of the Environment

Christmas Island Biodiversity Conservation Plan

DRAFT



March 2014

Prepared by: Director of National Parks

Made under the *Environment Protection and Biodiversity Conservation Act 1999*

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Note: This recovery plan sets out the actions necessary to stop the decline of, and support the recovery of, 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 individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds are subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

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CHRISTMAS ISLAND
BIODIVERSITY
CONSERVATION PLAN
DRAFT

Invitation to comment

Before ‘making’ a recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Minister must consider all comments made. Under s.275 of the EPBC Act, comments are invited on the draft Christmas Island Biodiversity Conservation Plan.

All comments submitted by the due date (below) will be carefully considered and this draft plan will be revised accordingly.

To ensure your comments are clear and concise please:

- list your points in order, numbered according to the relevant parts and page numbers of the draft plan
- state whether you agree or disagree with statements and give your reasons
- if you disagree, suggest alternatives
- include any matters you may wish to raise that are relevant to the plan but not covered by the draft plan.

Comments on the draft plan must be submitted by 9 July 2014 and may be emailed to recoveryplans@environment.gov.au or posted to:

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Terrestrial Species Conservation Section
Wildlife, Heritage and Marine Division
Department of the Environment
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CANBERRA ACT 2601

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Finally, the Director acknowledges the Christmas Island based Working Group, established to contribute to and provide advice for the plan's preparation. The Working Group comprised representatives of the Shire of Christmas Island; Australian Government departments and agencies with biodiversity conservation and/or land management responsibilities on Christmas Island; Christmas Island Phosphates; and the then Administrator of the Indian Ocean Territories, who was the Chair of the Working Group.

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Executive summary

Both residents and visitors recognise Christmas Island as a very important and unique part of Australia's and the world's natural heritage.

Christmas Island is of international conservation significance and value for many reasons which include: the presence of several internationally threatened species and many endemic species (species found nowhere else in the world), including internationally significant seabird breeding areas; the presence of over 20 land crab species, most notably tens of millions of red crabs; subterranean ecosystems that contain endemic species; two wetlands of international importance, The Dales and Hosnies Spring; and the largely pristine coral reef marine ecosystems, which include internationally threatened and/or significant fauna.

Christmas Island's native species and their habitats have been subject to a range of threatening processes since settlement. These include invasive species, such as crazy ants, cats, rats and weeds; as well as direct human impacts, such as vehicle impacts on red and robber crabs and vegetation fragmentation from clearing of native vegetation, resulting in the loss habitat for many threatened species.

This biodiversity conservation plan meets the requirements of a recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* and has been developed to provide the management and research actions necessary to stop the decline of, and support the recovery of, terrestrial threatened species listed under the Act. It includes actions needed to protect their habitats, including the recovery of red crabs, which are responsible for maintaining the health of Christmas Island's forests. The recovery of Christmas Island's native species and their habitats will rely on the use of the latest information from research and scientific studies, as well as a coordinated approach and cooperation between stakeholders, both on and off-the island.

This plan has been prepared based on the latest available information from research, scientific and natural heritage studies, and under the advice of a Working Group comprising:

- Shire of Christmas Island
- Department of Regional Australia, Local Government, Arts and Sport (now the Department of Infrastructure and Regional Development)
- Department of Immigration and Citizenship (now the Department of Immigration and Border Protection)
- Christmas Island Phosphates
- DAFF Biosecurity (now the Department of Agriculture)
- The Director of National Parks
- The Administrator of the Indian Ocean Territories, who was the Chair of the Working Group.

The long-term vision for the natural environment of Christmas Island is: *Resilient ecosystems with self-sustaining populations of native species*. Achieving this vision will conserve Christmas Island's native species and their habitats and may also provide socio-economic benefits for the Christmas Island community by maintaining populations of iconic species, such as red crabs and seabirds like the Abbott's booby, which are major attractions for nature-based tourism, as well as helping to support environmental educational and research activities.

The plan's objectives, which will help achieve the long-term vision, are to:

1. Maintain the ecological integrity of forest ecosystems.
2. Maintain or increase populations of significant species.
3. Maintain the ecological character of Ramsar wetlands.
4. Contribute to maintaining groundwater ecosystems.
5. Increase community and stakeholder understanding of, and engagement in, the recovery of ecosystems and native species.
6. Effectively coordinate and implement actions to address threatening processes and recover ecosystems and native species.

The actions in this plan have been designed to protect and ensure as far as possible the recovery and continued survival of Christmas Island's threatened and iconic species and their habitats, avoiding the species declines of the past. The plan will be implemented in an adaptive manner to ensure that actions for recovering and reversing the decline of the island's native species and their habitats are based on the most up-to-date information, from management, monitoring and research programs.

Executive summary in Bahasa Malay

Ringkasan eksekutif

Pulau Krismas diakui oleh penduduk mahupun pelawat sebagai warisan semula jadi yang sangat penting dan unik bagi Australia dan dunia.

Pulau Krismas memiliki nilai pemuliharaan yang tinggi di mata antarabangsa, antara lain kerana: wujudnya sebilangan spesies yang terancam di peringkat antarabangsa dan banyak spesies yang endemik (tidak ditemui di mana-mana tempat lain di dunia), termasuk kawasan pembiakan burung-burung laut yang besar; wujudnya lebih 20 spesies ketam (ketam darat), terutama ketam merah yang berpuluh juta bilangannya; ekosistem bawah tanah yang mengandungi pelbagai spesies endemik; dua taman tanah lembap yang penting di mata antarabangsa, iaitu The Dales dan Hosnies Spring; serta ekosistem terumbu karang laut yang sebahagian besarnya masih belum diceroboh, merangkumi spesies fauna terancam dan/atau penting di mata antarabangsa.

Spesies asli Pulau Krismas dan habitatnya telah diancam oleh berbagai-bagai proses sejak pulau ini didiami manusia. Ancaman ini termasuk pelbagai spesies penceroboh, seperti semut kuning, kucing, tikus dan rumpai; juga kesan langsung kegiatan manusia, seperti kesan kenderaan pada ketam merah dan ketam kelapa, serta fragmentasi tumbuh-tumbuhan akibat penebangan tumbuh-tumbuhan asli, menyebabkan hilangnya habitat untuk banyak spesies terancam.

Rancangan pemuliharaan kepelbagaian hayat ini memenuhi syarat-syarat rancangan pemulihan di bawah *Akta Perlindungan Alam Sekitar dan Pemuliharaan Kepelbagaian Hayat 1999*. Rancangan ini dibangunkan bagi mewujudkan tindakan pengurusan dan penyelidikan yang perlu demi menghalang kemerosotan pelbagai spesies darat terancam yang disenaraikan dalam Akta, serta menyokong pemulihannya. Rancangan ini merangkumi tindakan yang perlu bagi melindungi habitat spesies tersebut, termasuk pemulihan ketam merah yang berperanan menjaga kesihatan hutan Pulau Krismas. Pemulihan pelbagai spesies asli Pulau Krismas dan habitatnya akan menggunakan maklumat terkini daripada kajian penyelidikan dan sains, serta pendekatan dan kerjasama terselaras antara pelbagai pihak berkepentingan, baik di pulau ini mahu pun bukan.

Rancangan ini disiapkan berdasarkan maklumat terbaru daripada kajian penyelidikan, sains dan warisan alami, serta dengan nasihat sebuah Kumpulan Kerja yang terdiri daripada:

- Daerah Pulau Krismas (Shire of Christmas Island)
- Jabatan Australia Rantauan, Kerajaan Tempatan, Seni dan Sukan (kini Jabatan Infrastruktur dan Pembangunan Serantau)
- Jabatan Imigresen dan Kewarganegaraan (kini Jabatan Imigresen dan Perlindungan Sempadan)
- Christmas Island Phosphates
- DAFF Biosecurity (kini Jabatan Pertanian)
- Pengarah Taman Negara
- Pentadbir Wilayah Lautan Hindi, yang pernah menjadi Pengerusi Kumpulan Kerja.

Visi jangka panjang bagi persekitaran semula jadi Pulau Krismas adalah: *Ekosistem yang berdaya tahan, mengandungi pelbagai spesies asli yang lestari populasinya*. Pencapaian visi ini akan memulihara pelbagai spesies asli Pulau Krismas dan habitatnya, dan mungkin juga membawa manfaat sosioekonomi untuk masyarakat Pulau Krismas, dengan memelihara populasi spesies ikonik seperti ketam merah dan burung-burung laut seperti burung booby Abbott, yang merupakan daya tarikan utama pelancongan alam semula jadi, selain menyokong aktiviti pendidikan alam sekitar dan penyelidikan.

Objektif rancangan ini, yang akan membantu mencapai visi jangka panjang tersebut, adalah:

1. Memelihara keutuhan ekologi ekosistem hutan.
2. Memelihara atau meningkatkan populasi pelbagai spesies utama.
3. Memelihara sifat ekologi taman tanah lembap Ramsar.
4. Membantu memelihara ekosistem air tanah.
5. Meningkatkan kefahaman masyarakat dan pihak berkepentingan, serta penglibatan mereka, dalam pemulihan ekosistem dan spesies asli.
6. Menyelaraskan dan melaksanakan tindakan secara berkesan bagi mengendalikan ancaman proses serta memulihkan ekosistem dan spesies asli.

Tindakan-tindakan dalam rancangan ini direka untuk seberapa dapat melindungi dan memastikan pemulihan dan kelangsungan hidup pelbagai spesies terancam dan ikonik Pulau Krismas serta habitatnya, demi mengelakkan kemerosotan spesies yang pernah terjadi. Rancangan ini akan disesuaikan pelaksanaannya, agar tindakan bagi memulihkan dan membetulkan kemerosotan spesies asli pulau ini dan habitatnya dilakukan mengikut maklumat paling terkini, daripada pelbagai program pengurusan, pemantauan dan penyelidikan.

Executive summary in Mandarin

执行摘要

居民和访客都认为圣诞岛是澳大利亚以及世界自然遗产中非常重要和独一无二的一部分。

圣诞岛具有国际保护意义和价值的原因很多，包括：一些国际濒危物种的存在以及许多地方性物种（在世界其他地方找不到的物种），包括国际重大

海鸟繁殖区域，超过20个存在的陆地蟹种类，尤其重要的是数以千万计的红蟹；包含有地方物种的地下生态系统；具有国际重要性的两个湿地，The Dales 和 Hosnies Spring；以及大量的原始珊瑚礁海洋生态系统，包括国际濒危以及/或者重要动物群。

圣诞岛的本土物种以及他们的栖息地自移居开始就已经遭受一系列的濒危过程。这些包括入侵物种，像疯狂的蚂蚁，猫，老鼠，以及杂草，还有直接的人类影响，例如机动车对红蟹和椰子蟹的影响，以及清除本地植被产生的植被破坏，导致

很多濒危物种失去栖息地。

根据环境保护和生物多样性保护法案1999, 这个生物多样性保护计划符合恢复计划的要求，而且进一步发展，从而

提供管理和研究措施, 使列在法案内的濒危物种不再减少并支持恢复这些物种。这包括必要的行动来保护他们的家园，包括恢复红蟹数量，使圣诞岛的森林健康状态得到保持。本土物种以及他们的栖息地的恢复将会依赖于来自调查和科学研究的最新信息的使用，以及岛内外的协调措施和利益相关者间的合作。

这一计划的制备源自调查，以及科学和自然遗产研究得出的最新信息

同时还接受了以下成员组成的合作团队的指导：

- 圣诞岛行政区
- 澳大利亚区域署，本地政府，艺术和体育（现为基础设施和区域发展部）
- 移民及公民事务部（现为移民及边境保护部）
- 圣诞岛磷酸盐
- DAFF 检疫安全（现为农业部）
- 国家公园主管
- 印度洋地区行政管理员，也是合作团队主席。

圣诞岛自然环境的远期目标为：具备一个可自身维持本地物种数量的高适应性生态系统。达到这一目标需要保护圣诞岛本地物种及其栖息地，同时通过维持标志性

物种的数量，例如红蟹和Abbott's booby海鸟这些主要自然旅游景观，来给圣诞岛带来社会经济收益；同时也帮助扶持环境教育和研究活动。

为了有助于实现远期目标，这个计划的宗旨为：

1. 保持森林生态系统的生态完整性。
2. 维持或者增加重要物种的数量。
3. 维持Ramsar湿地的生态特征。
4. 致力于保持地下水的生态系统。
5. 增加社区及利益相关者对生态系统及本地物种恢复的理解和参与。
6. 有效协调及采取措施来解决濒危进程及恢复生态系统和本地物种。

这一计划的实行是为了尽可能保护并确保圣诞岛濒危和标志性物种及其栖息地的恢复和生存的持续，避免过去物种的恶化。这一计划的实行采用合适的手法。通过管理、监控和研究项目来确保以最新信息为依据采取行动，从而恢复和逆转岛上本地生物数量及其栖息地的削减。



Part 1—Introduction

1.1 Vision

The long-term vision for the natural environment of Christmas Island is:
Resilient ecosystems with self-sustaining populations of native species

This biodiversity conservation plan, which is a recovery plan for the purposes of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), sets out a range of objectives and actions which will contribute to the achievement of this long-term vision for 17 threatened taxa listed under the Act in a more holistic manner.

1.2 Why conserve Christmas Island native species and their habitats

As identified in the Christmas Island 2018 Plan “*The natural environment of Christmas Island is one of our greatest assets. We recognise its uniqueness in a global arena and the need to protect its biodiversity*” (Change Sustainable Solutions 2011), Christmas Island’s native species and their habitats are of international conservation significance and value for many reasons. Christmas Island:

- supports 17 taxa which are listed as threatened under the EPBC Act
- is an internationally significant seabird island, providing habitat for thousands of seabirds including the endemic and threatened Abbott’s booby (*Papasula abbotti*) and Christmas Island frigatebird (*Fregata andrewsi*)
- supports over 20 land crab species, including tens of millions of red crabs (*Gecarcoidea natalis*), which shape and maintain the health of the island’s unique rainforests and are internationally renowned for their annual breeding migration
- provides habitat for a range of endemic species including the Christmas Island goshawk (*Accipiter hiogaster natalis*), Christmas Island hawk-owl (*Ninox natalis*), Lister’s gecko (*Lepidodactylus listeri*), at least 18 plant taxa and many subterranean/cave dwelling invertebrates
- has two wetlands, The Dales and Hosnies Spring, which are Wetlands of International Importance under the Ramsar Convention
- has largely pristine marine environments which support coral reefs and threatened whale sharks (*Rhincodon typus*) and green turtles (*Chelonia mydas*).

Despite the island’s conservation values, there have been declines or extinctions of some of Christmas Island’s endemic and other significant native species. This plan recognises the need to conserve and/or recover threatened, endemic and other significant species and their habitats in a more holistic way.

Part 3 of this plan describes Christmas Island’s natural features and values in more detail.

Christmas Island’s native species and their habitats are not only significant from a conservation perspective, but can also provide social and economic benefits for the Christmas Island and other Australian communities, and help define the island’s unique character. Christmas Island’s native species and their habitats provide:

- natural attractions, such as seabirds, land crabs and marine life, for bird watchers, scuba divers and other nature-focused tourists, which can help support Christmas Island’s tourism enterprises, especially if/as tourism expands in future years

- important ecosystem services and products that are used by and benefit the Christmas Island community and visitors, such as water filtration and the protection of fish habitat
- opportunities for unique research and educational activities, particularly the study of oceanic island ecology and biogeography, threatened and endemic species, invasive species dynamics and red crab ecology. For example, in recent years there have been several international school visits focused on the study of the island's ecology and native species. These activities are not only valuable in their own right for their educational value but can also help support the island's economy
- nature-based recreational opportunities for Christmas Island's community, such as rainforest walks and observing wildlife which contribute to the health and well-being of the community.

1.3 Purpose and scope of the plan

The primary purpose of the Christmas Island Biodiversity Conservation Plan is to provide the research and management actions necessary to stop the decline of, and support the recovery of, threatened species on Christmas Island so that the chances of their long-term survival in nature are maximised. A major focus of this plan is to address threatening processes, particularly invasive species, affecting threatened species listed under the EPBC Act as well as other species, notably red crabs, which are pivotal to the ecological integrity of the island's ecosystems. Actions in this plan are also intended to benefit the broader Christmas Island ecosystem.

This plan is a formal national recovery plan for all species on Christmas Island which are nationally listed as critically endangered, endangered or vulnerable under the EPBC Act (Table 1) and inhabit the island's terrestrial environments. Some of these species, such as seabirds and land crabs, also utilise marine or wetland habitats. This plan replaces a number of formerly adopted recovery plans for individual species endemic to Christmas Island (Appendix J) but does not replace existing threat abatement plans.

Due to the relatively high proportion of endemic and/or threatened species, as well as the intrinsic vulnerability of oceanic island species and their habitats (particularly to invasive species), the scope of this plan covers:

- native terrestrial species listed as threatened under the EPBC Act (Table 1)
- species which have an important role in the ecological integrity of the island's ecosystem
- species of conservation concern (those which have a substantial decline on Christmas Island)
- all endemic vertebrate species
- species which have a high level of international and community conservation interest
- ecosystems and habitats critical for the survival of significant species (see Part 3.2 of this plan) including maintenance of critical ecological processes.

The scope recognises the need to recover populations of existing threatened species as well as reduce the likelihood of native species that are currently not threatened becoming so in the future. Consequently, the plan provides an integrated and holistic approach to the conservation and recovery of the island's threatened native species, which is reflected in the plan's objectives and management and research actions (Part 6 of this plan).

The scope is mandated to focus on listed threatened species only but as a regional biodiversity conservation plan it aims at more broad-ranging conservation, including other matters of National Environmental Significance and biodiversity conservation in general.

Table 1: Terrestrial plants and animals of Christmas Island listed as threatened

Species Name	Common Name	EPBC Act Status ^{1, 2}
VASCULAR PLANTS		
<i>Asplenium listeri</i>	Christmas Island spleenwort ³	CE
<i>Pneumatopteris truncata</i>	a fern	CE
<i>Tectaria devexa</i> var. <i>minor</i> ⁴	a fern ³	EN
MAMMALS		
<i>Crocidura trichura</i>	Christmas Island shrew ³	EN
<i>Pipistrellus murrayi</i>	Christmas Island pipistrelle ³	CE
<i>Pteropus melanotus natalis</i>	Christmas Island flying-fox	CE
<i>Rattus macleari</i> ⁵	Maclear's rat	EX
<i>Rattus nativitatis</i> ⁵	bulldog rat	EX
FOREST BIRDS		
<i>Accipiter hiogaster natalis</i> ⁶	Christmas Island goshawk ³	EN
<i>Chalcophaps indica natalis</i>	emerald dove (Christmas Island)	EN
<i>Ninox natalis</i>	Christmas Island hawk-owl ³	VU
<i>Turdus poliocephalus erythropleurus</i>	Christmas Island thrush	EN
SEABIRDS		
<i>Fregata andrewsi</i>	Christmas Island frigatebird ³	VU
<i>Papasula abbotti</i>	Abbott's booby ³	EN
REPTILES		
<i>Cryptoblepharus egeriae</i>	blue-tailed skink	CE
<i>Cyrtodactylus sadleiri</i>	giant gecko	EN
<i>Emoia nativitatis</i>	forest skink	CE
<i>Lepidodactylus listeri</i>	Lister's gecko ³	CE
<i>Ramphotyphlops exocoeti</i> ⁷	Christmas Island blind snake ³	VU

(1) EX—Extinct; CE—Critically Endangered; EN—Endangered; VU—Vulnerable

(2) EPBC Act status of species at the time of preparing the plan

(3) Recovery plan covering this species has previously been adopted (nine plans for 10 species)

(4) Species is listed, but only *Tectaria devexa* var. *minor* occurs on Christmas Island

(5) Not covered by this plan due to EPBC Act status as extinct

(6) At the time of listing this subspecies was known as *Accipiter fasciatus natalis*

(7) At the time of listing this species was known as *Typhlops exocoeti*

The EPBC Act provisions relating to the referral, assessment and approval of actions are not affected by this plan. Similarly, the EPBC Act exemptions are not affected by this plan. This plan does not (see Part 1.5 of this plan for details):

- affect the operation of activities undertaken consistent with an approval under the EPBC Act
- affect the operation of exemptions under the EPBC Act, including activities undertaken consistent with a 'prior authorisation' or that constitute a 'continuing use' or
- change the environmental referral and assessment requirements of the EPBC Act in relation to development proposals.

This plan is not a recovery plan for Christmas Island’s territorial marine ecosystems and species, but it recognises their conservation significance, particularly in relation to interactions between terrestrial and marine ecosystems and species. Consequently, the focus of the marine component of this plan is on actions for species that rely on both terrestrial and marine ecosystems for their survival (e.g. red crabs and other land crabs, seabirds and anchialine systems).

1.4 Interaction with other documents and other management programs

Existing terrestrial recovery plans

This plan will replace eight of the existing recovery plans¹ for 10 terrestrial species on Christmas Island which have been previously adopted under the EPBC Act (see Table 1). However, these plans may continue to be used as reference documents to inform the implementation of this plan.

A number of key threatening processes listed under the EPBC Act occur on Christmas Island, some of which are covered by threat abatement plans made under the Act (Table 2—see Part 4.1 of this plan for further details of threats). This plan does not replace the relevant threat abatement plans but, where appropriate, includes relevant actions from and complements these plans.

Table 2: Relevant national threat abatement plans

<i>Threat abatement plan to reduce the impacts of tramp ants on biodiversity in Australia and its territories</i> (DEH 2006)
<i>Threat abatement plan for predation by feral cats</i> (DEWHA 2008)
<i>Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares</i> (DEWHA 2009)

Christmas Island National Park Management Plan and related environmental plans and reports

This plan is consistent with and will support implementation of the *Christmas Island National Park Management Plan* (DNP 2014). Similarly, the management plan will support the implementation of this plan in relation to actions that apply to the Christmas Island National Park. This plan may also inform the preparation and implementation of other land and marine management plans on Christmas Island.

In 2009 the then Australian Government Minister for the Environment formed a scientific Expert Working Group (EWG), primarily in response to the decline of the Christmas Island pipistrelle, to provide the Minister with advice about biodiversity decline on Christmas Island. In its final report in 2010, the EWG found that the extremely high biodiversity values of Christmas Island are in a parlous state and made 32 broad-ranging recommendations aimed at reversing the decline of the island’s biodiversity. The majority of those recommendations were accepted by the Australian Government in its 2011 response to the report, either without qualification or in principle subject to the availability of additional resources.

¹ The exception is the existing *Tectaria devexa* recovery plan, which includes actions for the Queensland distribution of *Tectaria devexa* var. *devexa*.

This plan is a mechanism to give effect to relevant recommendations made by the EWG, recognising that some of those recommendations are outside its scope. Appendix A sets out the EWG's recommendations and the Australian Government's response to each, together with an indication as to how those recommendations are reflected in the recovery actions in this plan.

In 2010 Ecological Character Descriptions (ECDs) were prepared for The Dales (Butcher & Hale 2010) and Hosnies Spring (Hale & Butcher 2010) Ramsar sites. The ECDs describe, and aim to assist with monitoring and maintaining, the ecological character of The Dales and Hosnies Spring; this biodiversity conservation plan includes actions to support these aims.

Marine recovery and threat abatement plans

As noted in Part 1.3, marine ecosystems and species priorities and actions are not specifically addressed by this plan except for terrestrial species that rely on both terrestrial and marine ecosystems for their survival. Table 3 lists the recovery plans and threat abatement plans which may be specifically relevant to marine areas of Christmas Island. While these plans have not been incorporated into this plan, relevant actions have been considered.

Table 3: National recovery plans and threat abatement plans relevant to marine areas

<i>Recovery plan for marine turtles in Australia</i> (EA 2003)
<i>Whale shark (Rhincodon typus) recovery plan 2005–2010</i> (DEH 2005)
<i>Threat abatement plan 2006 for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations</i> (DEWR 2006)
<i>Threat abatement plan for the impacts of marine debris on vertebrate marine life</i> (DEWHA 2009a)

Through the process of preparing this plan several marine conservation priorities were identified, which may help inform the management of the island's marine areas, particularly the coral reef ecosystems that fringe the island. However, these priorities should not be seen as a definitive list of marine conservation priorities for Christmas Island.

- (a) researching and monitoring marine ecosystem and species diversity and richness
 - collecting further/baseline data on coral reef species diversity and richness, including species of conservation significance, like hybrid fauna and ecological indicator species
 - identifying and mapping marine ecosystems and habitats
 - monitoring coral reef condition and changes, including reef structure; species diversity and richness; ecological indicator species and species under threat/at risk of local extinction and whale sharks migratory patterns
 - genetic studies of fish, particularly deep and mid water fish, to help determine migration movements
- (b) identifying and monitoring threats to and impacts on marine ecosystems and species
 - assessing threats to marine environments and species
 - monitoring threats to and impacts on marine environments including coral disease, coral bleaching, climate change, marine pests and threats of terrestrial origin, such as pollution including effluent, chemicals, fuels/oils and phosphate runoff

(c) minimising threats to and impacts on marine environments, marine species and the marine habitat of species that rely on marine ecosystems such as seabirds and land crabs

- introduction and adoption of sustainable fish bag/take limits
- establishment of oil spill response capability
- minimising the likelihood of introducing marine pests including through the rapid disposal of asylum seeker boats and effective management of ship ballast water
- minimising pollution of marine environments from boats/ships and terrestrial sources such as effluent outflow and oil/fuel spillages
- minimising impacts of marine debris on marine species such as nesting sea turtles
- control of loss of plastic from land to the marine environment to protect sea life

(d) education and awareness raising activities

- conducting educational and awareness raising activities that help promote the island's marine conservation values and ways of minimising impacts on marine environments and species (e.g. sustainable fish bag/take limits and minimal impact visitor use guidelines).

Crown land management plan

Territories Administration is responsible for the administration of Crown Land on Christmas Island. In 2009 Territories Administration commissioned the preparation of a *Report for Crown Land Management Plan for the Indian Ocean Territories—Christmas Island* (CLMP). Its purpose was to assess Crown Land to enable informed decisions to be made on its most suitable future uses. Crown Land comprises Uncommitted Crown land; leased Crown land, including mining and commercial land; vested land; reserved land; and Crown land under management orders. The assessment included identifying the conservation, economic, cultural and social values of Crown Land, as well as appropriate potential future land uses, development priorities and management options.

The CLMP recognised the importance of the island's environmental assets, including the threatened Abbott's booby and Ramsar listed wetlands (The Dales and Hosnies Spring). As this biodiversity conservation plan describes these and other conservation assets (particularly threatened species, their habitats and major threats affecting them), it may help proponents and decision-makers in the planning and assessment of developments and approvals, including those that may trigger the environmental assessment provisions of the EPBC Act (see Part 1.5 of this plan) or other relevant applied Western Australian legislation. This biodiversity conservation plan may also support or complement some of the priorities and opportunities outlined in the CLMP, such as evaluating the island's groundwater resources and expanding the island's research and educational facilities and opportunities.

Local planning and community directions

The Christmas Island Local Planning Strategy (LPS) is prepared by the Shire of Christmas Island. The LPS sets out the long-term planning directions for the local government, applies State and regional planning policies and provides the rationale for the zones and other provisions of the Town Planning Scheme (TPS). The Shire administers the TPS which is the statutory mechanism under Western Australian planning legislation for managing shire-related land uses on the Island. The TPS governs the way land may be used and developed through land use zoning and defines what developments are acceptable (from a town planning perspective) within these designated zones. It is not within the scope or the purpose of this biodiversity conservation plan to prescribe or define the types of actions and land uses that may or may not be considered, assessed or approved under the TPS and LPS or other plans, such as the CLMP and economic development plans. However, assessments of specific development proposals submitted to the Shire for consideration under the TPS and LPS may also need to be assessed under the environmental assessment requirements of the EPBC Act, as well as any applicable applied Western Australian legislation.

In 2011 the Shire of Christmas Island prepared the *Our Future: Christmas Island 2018 Plan* (Change Sustainable Solutions 2011). The 2018 Plan articulates shared community directions and priorities for the future of Christmas Island across a broad range of themes: land use planning; infrastructure planning; economic diversification; community capacity and well-being; governance and institutional capacity; and protecting the natural environment. This biodiversity conservation plan will help support community directions and priorities identified in the 2018 Plan, particularly in relation to protecting the natural environment. For instance the 2018 Plan states that *'it is our duty as a concerned community to ensure that these beautiful attributes of Christmas Island remain intact or are indeed improved, now and into the future'* (Change Sustainable Solutions 2011). The 2018 Plan includes reference to this biodiversity conservation plan, the need for collaborative cat and rat management, and the development of sustainable nature-based tourism, which will rely on healthy populations of native species for activities such as birdwatching and observing the red crab migration.

Other island stakeholders have environmental management plans in place to address particular issues, such as that of Christmas Island Phosphates to reduce impacts on red crabs from mining operations (also see Part 5.1 of this plan).

1.5 Legislative context

Legislation relevant to this biodiversity conservation plan includes the following:

Environment Protection and Biodiversity Conservation Act 1999* and *Environment Protection and Biodiversity Conservation Regulations

The Commonwealth EPBC Act is the primary environmental legislation that applies to Christmas Island. The relevant matters regulated by the EPBC Act and EPBC Regulations include:

- listing of nationally threatened species and ecological communities, migratory species, and marine species
- preparation of conservation advice and/or recovery plans for threatened species and communities, and additional protection for listed species in Commonwealth areas
- compliance with recovery plans by Commonwealth agencies
- implementation of recovery plans within Commonwealth areas
- listing of key threatening processes and preparation of threat abatement plans
- protection and management of Commonwealth reserves, declared Ramsar wetlands, and National and Commonwealth Heritage places
- assessment and approval of actions likely to have a significant impact on matters of national environmental significance. For Christmas Island these are:
 - listed threatened species (see Table 1)
 - migratory species protected under international agreements (see Appendix B)
 - Ramsar wetlands of international importance (Hosnies Spring and The Dales)
 - Commonwealth marine areas
- assessment and approval of actions that are likely to have a significant impact on the environment, on Commonwealth land (all of Christmas Island) or by Commonwealth agencies
- international movement of wildlife and wildlife products
- conservation of biodiversity in Commonwealth areas, including regulation of actions affecting members of native species on crown land.

Christmas Island National Park is a Commonwealth reserve established under the EPBC Act and covers approximately 63 per cent of Christmas Island's land area. The park includes a marine area (extending 50 metres seaward of the low water mark of the park's terrestrial areas) and both the island's declared Ramsar wetlands.

Part 9 of the EPBC Regulations provides for the protection and conservation of biodiversity in Commonwealth areas outside the park (i.e. all land outside the park) and prohibits and/or regulates actions affecting members of the species identified in Schedule 12 to the Regulations, and their habitat.

This biodiversity conservation plan does not change the environmental referral and assessment provisions of the EPBC Act—these provisions apply regardless of this plan—and the biodiversity conservation plan does not affect the operation of activities undertaken consistent with existing approvals under the EPBC Act. Under the EPBC Act any person proposing to undertake an action which is likely have a significant impact on a matter of national environmental significance (listed above) or which is likely to have a significant impact on the environment on Commonwealth land (Christmas Island), should refer the action to the Minister for the Environment. The Minister will determine whether a referred action requires assessment and approval under the EPBC Act. Further guidance in deciding whether to submit a referral (for a decision on whether assessment and approval is required) is available in *Significant Impact Guidelines—Matters of National Environmental Significance* (DEWHA 2009b) and *Significant Impact Guidelines—Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies* (DEWHA 2010).

This biodiversity conservation plan does not affect the operation of exemptions under the EPBC Act. Sections 43A and 43B of the EPBC Act exempt certain actions from the assessment and approval provisions of the EPBC Act. They apply to lawful continuations of land use that started before 16 July 2000 or actions that were legally authorised before 16 July 2000, the date of commencement of the EPBC Act. These exemptions allow for the continuation of activities that were fully approved by state and local governments before the EPBC Act came into force ('prior authorisation'), or otherwise lawful activities which commenced before the EPBC Act came into force, and which have continued without substantial interruption ('continuing uses'). Further details on these provisions can be found in the Practice Guide titled *Prior authorisation and continuing use exemptions—Sections 43A and 43B* (DEWHA 2009c).

WA environment protection legislation

In addition to any relevant EPBC Act and EPBC Regulation requirements, vegetation clearance on Christmas Island is also regulated by the Western Australia (WA) *Environmental Protection Act 1986*. The clearing provisions of this Act are described in the *Environmental Protection Amendment Act 2003* and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

Other relevant WA legislation and Christmas Island subordinate legislation

At the commencement of this plan a range of other WA laws are applied to Christmas Island under the *Christmas Island Act 1958* as laws of the Territory, and administered by the WA government under arrangements with Territories Administration. The applied laws relevant to this plan include:

- *Agriculture and Related Resources Protection Act 1976*
- *Animal Welfare Act 2002*
- *Approvals and Related Reforms (No.4) (Planning) Act 2009*
- *Cat Act (Christmas Island) 2011*
- *Dog Act 1976*
- *Fish Resources Management Act 1995*

- *Mining Act 1978*
- *Plan Diseases Act 1914*
- *Road Traffic Act 1974*
- *Soil and Land Conservation Act 1945.*

In addition to legislation referred to elsewhere in this plan other Commonwealth Acts, and Territories Ordinances made under the Christmas Island Act are relevant either directly or indirectly to this plan, including:

- *Administrative Ordinance 1968*
- *Cats Local Law 2010*
- *Fisheries Management Act 1991*
- *Importation of Dogs and Cats Ordinance 1973*
- *Lands Ordinance 1987.*

Quarantine legislation

The Department of Agriculture administers a range of legislation in order to protect Australia's animal, plant and human health status and to maintain market access for Australian food and other agricultural exports. In 2004 quarantine legislation—the *Quarantine (Christmas Island) Proclamation 2004*—was introduced for Christmas Island under the *Quarantine Act 1908*.

1.6 Planning approach

The approach of using a regional recovery plan or multi-species plan, rather than maintaining single species recovery plans, is consistent with that adopted for other regions including Norfolk Island and Lord Howe Island. During the planning process a number of key elements were identified as essential for the preparation and implementation of this plan.

Coordinated ecosystem and holistic approaches

Addressing many threats, particularly invasive species, that impact on individual and multiple native species may require some actions, particularly the control of invasive species like cats, crazy ants and weeds, to occur in a coordinated manner over different land tenures in order to achieve intended recovery outcomes. This allows more efficient use of conservation resources, and complementary and consistent approaches between responsible parties.

Use the best available evidence and adaptive management approaches

This plan has been prepared using the best available information and advice from local knowledge; research and monitoring studies/papers/reports; relevant plans; and recommendations from a range of researchers and other natural resource management experts. Much of this information was collated in a *Regional Recovery Plan Issues Paper—Conservation status and threats to the flora and fauna of the Christmas Island Region* (DNP 2008c) which was prepared to assist with the preparation of this plan.

Other expert opinion and scientific information used includes the final report of the Expert Working Group (2010); advice from the Crazy Ant Scientific Advisory Panel and other scientific experts; existing recovery plans and information from conservation focused research, studies; and monitoring programs carried out by the DNP, such as the Island Wide Survey and Biodiversity Monitoring Program (DNP 2008b).

Despite the considerable scientific information regarding the island's natural heritage and native (and invasive) species, there are many recovery knowledge gaps such as the key threats leading to the decline of some species. The plan acknowledges this by including research and ongoing monitoring actions so that management responses can be adapted as new information and evidence arises, ensuring the capacity to adapt and respond to uncertainty and change.

Engagement of land managers/holders and other relevant stakeholders

The approach used in developing this plan recognised the need to engage major island-based stakeholders and land holders/managers before and during the preparation of this plan, and accordingly, a Christmas Island Recovery Plan Working Group (the working group) was formed. The working group comprised island-based representatives of the then Department of Regional Australia, Local Government, Arts and Sport (now the Department of Infrastructure and Regional Development and referred to in this plan as Territories Administration); the Shire of Christmas Island (SOCI); the then Department of Immigration and Citizenship (now the Department of Immigration and Border Protection—DIBP); Christmas Island Phosphates (CIP); DAFF Biosecurity (now the Department of Agriculture); the Director of National Parks (DNP); and the Administrator of the Indian Ocean Territories, who chaired the Working Group.

The Working Group's terms of reference were to:

- advise on the recovery planning process, particularly communication and engagement strategies for the Christmas Island community and stakeholders
- provide advice and input into the content of the recovery plan, including what priorities should be addressed in the plan and providing comments on drafts
- where possible, work together to integrate and coordinate land management planning processes on Christmas Island, including conducting community and stakeholder consultation
- promote information sharing between the working group and Christmas Island community/stakeholders including working group members' own organisations
- make recommendations for the implementation of the recovery plan, such as future stakeholder engagement and identifying funding and partnership opportunities.

It is acknowledged that a diverse group of participants in such a team will not always share a common view on all matters. However, the Working Group provided a forum for members to raise issues on a range of matters associated with the preparation of this plan.

Other activities were also conducted to engage on and off-island stakeholders. These included community and stakeholder meetings and presentations that included CIP; Territories Administration; the Department of Agriculture; Customs; SOCI; the Christmas Island Economic Development Consultative Group (EDCG); Christmas Island Tourism Association (CITA); and community meetings. In addition, flyers and other information about the recovery plan were prepared and distributed in the local paper (*The Islander*) and by email. Letters, advising of the intent to prepare and opportunity to provide input into the recovery plan, were also sent to several off-island conservation groups and management agencies.

Part 2—Description of Christmas Island

2.1 Socio-economic aspects of Christmas Island

Christmas Island is located in the Indian Ocean, approximately 2800 kilometres west of Darwin, 2600 kilometres north-west of Perth and 500 kilometres south of the Indonesian capital Jakarta. It covers an area of 135 square kilometres, with 73 kilometres of coastline (Figure 1).

The people of Christmas Island

Prior to its settlement in 1888 there were no permanent inhabitants of Christmas Island and there are no peoples considered indigenous to the island. Most Christmas Island residents were born in mainland Australia or Malaysia and are of Chinese, Australian/European and Malaysian origin. English is widely spoken but many residents are bi- or multi-lingual, speaking Malay, Mandarin, Cantonese or other languages. Religious diversity is evident through Chinese temples (Buddhist, Taoist, Confucian), a Christian church, a Muslim Mosque and a Baha'i Centre; many religious and cultural festivals are observed during the year.

In 2011 the resident population of Christmas Island was recorded as 2072 people. The population may have exceeded 4000 people at various times over the past few years due to fluctuating numbers of asylum seekers in detention and staff employed in detention management activities.

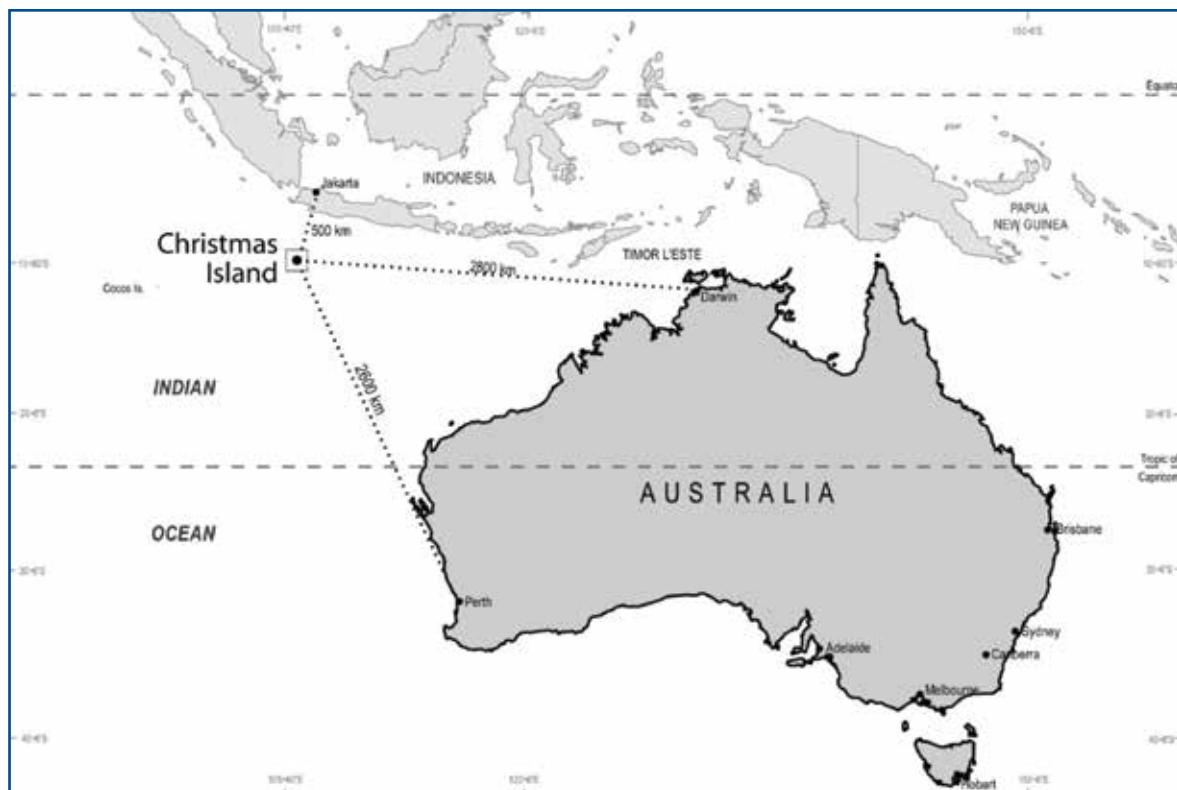


Figure 1: Location of Christmas Island

History and governance

Settlement of Christmas Island commenced when the island was annexed by the British Crown in 1888 and George Clunies-Ross from Cocos (Keeling) Islands established a settlement at Flying Fish Cove in November 1888. In 1891 Clunies-Ross and John Murray (a Scottish scientist) negotiated a joint lease to export timber, phosphate and other minerals and in 1897 formed the Christmas Island Phosphate Company. Soon after C.W. Andrews of the British Museum was commissioned by Murray to undertake a ten-month study of the island's natural history. Such a study, conducted prior to the commencement of phosphate mining, provided a rare opportunity to assess the flora, fauna and geology of the island and establish a scientific baseline. Andrews did a comprehensive study when he returned in 1908, providing the opportunity to assess the impact of ten years of settlement; his monograph remains the classic scientific reference on the island's natural history.

Phosphate mining commenced in 1898 and in 1900 the first phosphate shipments were made. Mining continued up until World War II, ceased during the war and resumed in 1946; it has continued since except for 1988 to 1989. After the war, the lease and assets of the Christmas Island Phosphate Company were sold to the Australian and New Zealand governments. In 1949 the Christmas Island Phosphate Commission was formed by the governments. More mine workers were employed from Malaysia, Singapore and the Cocos (Keeling) Islands, and established strong religious and cultural practices that continue today. Mining was increasingly mechanised, but working conditions remained poor. This led to the formation in 1975 of the Union of Christmas Island Workers, which successfully campaigned for improved working conditions.

On 1 January 1958, Christmas Island, which had until then been administered as part of the Colony of Singapore, became a separate colony of Great Britain. On 1 October 1958, sovereignty was transferred to Australia and has since remained an external territory of Australia.



In 1967 the British Phosphate Commission sponsored Dr J.B. Nelson, an ornithologist, to study the status of Abbott's booby. The report he produced triggered world-wide interest in the conservation of the species (Gray 1995).

In 1980 Mr W.W. Sweetland was commissioned to investigate the future of phosphate mining. From 1981 to 1987 mining was conducted by the government owned Phosphate Mining Company of Christmas Island and Phosphate Mining Corporation of Christmas Island. In 1987 the Australian government ceased mining and began winding up the corporation. Mining resumed in 1990 when a mining lease was issued to a private company, Phosphate Resources Limited, trading as Christmas Island Phosphates (CIP). In 1997 Phosphate Resources Limited was granted a 21-year lease which restricts mining to previously mined areas. In June 2013 Phosphate Resources Limited was granted a renewed mine lease which expires in 2034.

Administration

Christmas Island is administered as an external territory of the Commonwealth of Australia. The location of major land tenures and uses are shown in Figure 2. The *Christmas Island Act 1958* provides the basis for the Territory's administrative and legislative systems including, from 1992, the application of a range of laws of Western Australia.

The Territories Administration administers Christmas Island, including the provision of state government-type services and manages associated infrastructure including essential services like power and water supply infrastructure and facilities, as well as Uncommitted Crown Land. Some areas of Uncommitted Crown Land, such as previously uncleared evergreen tall rainforest, provide habitat for threatened species like the Abbott's booby. In recent years there have been upgrades/expansions of some essential services including sewage, power and water infrastructure. Future infrastructure developments are also planned, including new housing developments. The Territories Administration provides some services through service delivery arrangements with WA government departments. For instance, the management of water supply is the responsibility of the WA Water Corporation, under an arrangement with Territories Administration.

SOCI has a central role in implementing and administering the Town Planning Scheme (TPS) and managing public roadsides and recreational areas. SOCI is also responsible for a range of social and municipal services, including waste collection and domestic animal control such as administration of local (pet) cat by-laws. Lands managed by SOCI are used for a range of purposes including residential, light industrial, commercial and recreational purposes. SOCI has proposed, through the TPS, the expansion, upgrade or development of these areas. The TPS identifies areas of land considered suitable (from a town planning perspective) for residential, commercial and light industrial uses and developments, including tourism developments.

Land tenure

Current land tenures and their areas and major uses are outlined in Table 4. Major land managers, owners and/or lease holders are the Director of National Parks; Territories Administration; the Shire of Christmas Island; Christmas Island Phosphates and the Department of Immigration and Citizenship. There are also small private (e.g. commercial and residential) land holdings.

Table 4: Land tenure and uses on Christmas Island

Land tenure and uses	Percent of island
National park	63%
Mine lease	13.7%
Uncommitted Crown Land	19.2%
Other committed land	4.1%

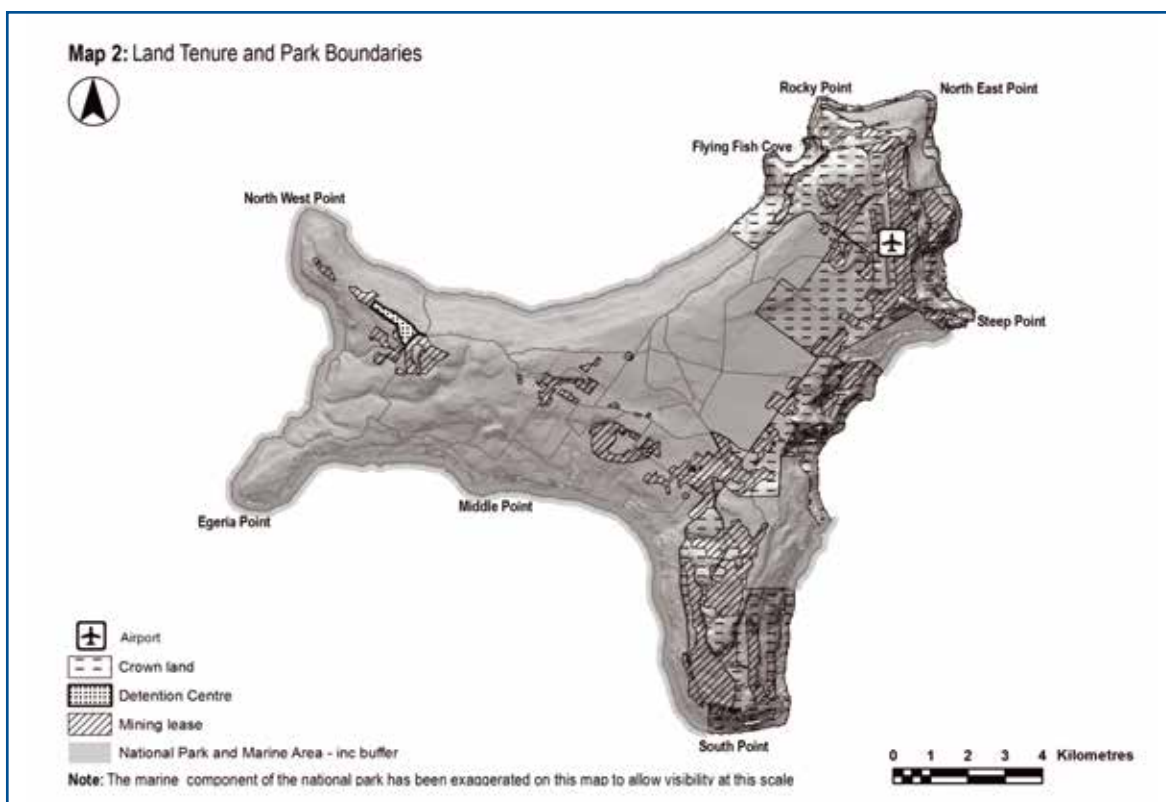


Figure 2: Land tenure and park boundaries

Land use and management

Christmas Island National Park (CINP or the park) is a Commonwealth reserve managed by the Director of National Parks (DNP) in accordance with the EPBC Act and the park's management plan. The park covers approximately 63 per cent of the island's land area and includes a small but ecologically significant marine area. The park is managed primarily for: the preservation of the area in its natural condition and the encouragement and regulation of the appropriate use, appreciation and enjoyment of the area by the public. Visitor facilities in the park include board walks and walking trails that lead to natural features and attractions such as The Dales Ramsar wetland site. There is also a small research facility (the Pink House) located in the centre of the island and a headquarters and nursery facility located on Crown Land in the north-east (residential/settled) part of the island.

DIBP manages several facilities on Christmas Island. The major DIBP facility is the Immigration Detention Centre (IDC) at the north-western end of the island. This was built in 2007, with expansion and upgrading to include supporting infrastructure such as staff accommodation since 2007. At the time of preparing this plan, other DIBP facilities included the Phosphate Hill Detention Centre and staff accommodation at Poon Saan.

Christmas Island Phosphates (CIP) has phosphate mining leases covering approximately 1982 hectares (14 per cent) of Christmas Island, as well as associated infrastructure, including phosphate drying and port loading facilities located at the north-east of the island. CIP's mining leases were assessed and approved under the *Environment Protection (Impact of Proposals) Act 1974* (EPIP Act) and are valid to 2019. The EPIP Act approval only enables mining to occur on specific areas of land (mostly in the eastern part of the island) where the original native vegetation has been previously cleared. Under the previous and renewed mine lease with the Territories Administration, CIP pays a conservation levy (per tonne of phosphate shipped) to the Commonwealth. This

levy funds the Christmas Island Minesite to Forest Rehabilitation (CIMFR) Program, conducted by the DNP on behalf of the Commonwealth through a Memorandum of Understanding between the DNP and Territories Administration. A new MoU was negotiated and a long term rehabilitation plan was prepared by the DNP in 2012, covering the period 2012 to 2020.

There is also number of other existing developments including a resort and a number of other visitor accommodation facilities, as well as new development proposals. A small market garden grows produce for local consumption and in 2010 a study was prepared for CIP to assess the feasibility of establishing a sustainable horticultural industry in the Indian Ocean Territories. There are also small areas of private land for residential and commercial purposes and a public golf course. The island has an international airport as well as significant seaport facilities and an extension to the existing wharf facilities at Flying Fish Cove was proposed at the time of preparing this plan.

Uncommitted Crown Land covers approximately 19 per cent of Christmas Island and may be considered suitable for a number of future land uses including recreation, conservation and new developments/commercial activities.

Economy and industry

Phosphate mining is the major industry on the island. Phosphate Resources Limited—trading as Christmas Island Phosphates (CIP)—reported a 2012–13 after tax profit of \$20.9 million for mine operations (PRL 2013) and in 2011 employed over 100 Christmas Island residents. At the time of preparing this plan the industry is a major source of employment and is one of the critical foundations for the island economy.

Many island residents are employed directly or indirectly to deliver government services which include the administration of the Territory (e.g. providing services like police, power, water, health, schools and local government services) as well as national park management and asylum seeker processing and care activities.

The island's natural attractions help support a small number of on- and off-island tourism businesses including diving/boating, land-based tours and wildlife/bird watching tours. There are a few nature-focused tour operators who are based on or visit Christmas Island (e.g. dive and land based tour operators) and the current contribution of tourism to the island's economy and employment is relatively modest. However, the *Inquiry into the changing economic environment of the Indian Ocean Territories* (Parliament of the Commonwealth of Australia 2010) identified tourism as a viable growth industry that has the potential to be further developed and spur the growth of complementary industries to assist in diversifying the economy (also see Part 7.5 of this plan).

2.2 Climate and geography of Christmas Island

Climate

Christmas Island lies at the southern edge of the equatorial low pressure belt that moves north and south of the equator during the year, resulting in a tropical, equatorial, oceanic climate with distinct wet and dry seasons. The wet season is generally from November to April when the north-west monsoon blows. Passing cyclones and high ocean swells arising from low pressures systems from the north sometimes affect the island during the wet season. For the rest of the year south-east trade winds bring slightly lower temperatures and humidity and less rain.

Mean annual rainfall is approximately 2000 millimetres with little temperature variation during the year (daytime mean temperature of 27–29°C and overnight mean temperature of 24°C). Relative humidity is generally constant at 80–90 per cent.

Landscape, geology and soils

Christmas Island is formed on the peak of a basaltic volcanic seamount which rises steeply for about 5000 metres from the ocean floor. The highest point on the island, Murray Hill, is 361 metres above sea level. The island has undergone a series of geological uplifts and successive layering of coral reefs over the basaltic volcanic core at each stage of uplifting, leading to the development of a near-continuous limestone cap. Successive uplifting events led to the excavation of new cliffs by the ocean, forming stepped terraces and inland cliffs. The lowest, most recent terrace was probably formed about 120 000 years ago. The island is surrounded by a narrow fringing coral reef shelf.

Most of the coastline consists of sheer rocky and often undercut cliffs 10 to 20 metres high, interspersed with a few sand and coral rubble beaches. Behind the coastal cliffs is the shore terrace which varies between about 50 and 200 metres wide, while inland cliffs and terraces are found between the shore terrace and the central plateau. The central plateau has an elevation mostly between 180 and 240 metres.



There is little to no runoff across the island as most rainfall infiltrates into the limestone and soil substrate and recharges groundwater drainage systems and/or flows to the ocean. There are only a few surface drainage systems, most notably The Dales and Hosnies Spring, where groundwater accumulates at the base of the interface between the limestone cap and volcanic basaltic core of the island.

A major geological feature of Christmas Island is its limestone karst landforms and subterranean cave ecosystems. For example, there are at least 95 known karst features including approximately 30 caves (Spate & Webb 1998). The island's carbonate karst setting has important implications for many aspects of management of the island's natural resources including ecology, hydrology, waste management and water resources. Karst management has been well-studied internationally (e.g. Gillieson 1996; Ford & Williams 2007) which can inform appropriate management regimes for the island.

The majority of Christmas Island's soils are classified as phosphatic. These were most likely derived from marine sediments (both organic and inorganic) before the island rose above the sea surface, and from seabird guano reacting with limestone (Trueman 1965, Gray 1995). These soils are deepest on the central plateau, becoming progressively thinner towards the lower terraces. Remaining substrates are mostly derived from weathered parent materials including limestone (terra rossa soils) or volcanic basalt (krasnozem soils). Soils derived from basaltic extrusive rocks occur in fault zones or areas of past volcanic activity. The soils are usually neutral to slightly alkaline (pH 7.0–8.0).

Part 3—Ecology and biodiversity of Christmas Island

Christmas Island is known as an oceanic island because it has always been isolated from and never connected to other land masses. This gives it some ecological characteristics that are similar to other oceanic islands, as well as several distinct and unique ecological characteristics including:

- its importance as a seabird rookery of international importance and endemic bird area of international significance
- the dominance of land crabs, particularly red crabs, which significantly influence the ecology of the island's forests.

Ecological characteristics of Christmas Island that are similar to many other oceanic islands include:

- a relatively high proportion of endemic terrestrial species
- evolutionary isolation for thousands or millions of years
- native species that have evolved with few competitors
- many species with small population sizes.

Like other oceanic islands, these characteristics make Christmas Island particularly vulnerable to threats such as those posed by introduced invasive species.

3.1 Ecosystems and ecological processes

For the purposes of this plan the major ecosystems/habitats identified and described are forest ecosystems, wetland ecosystems, subterranean and groundwater ecosystems, and marine and coastal ecosystems.

3.1.1 Forest ecosystems

Christmas Island's forest ecosystems have developed their present structure and composition largely due to the influences of warm temperatures, rainfall levels and patterns, geological history, geographic isolation and fauna interactions, particularly those of the red crab. These influences have created unique forest ecosystems that provide essential habitat for many of the island's flora and fauna species.

Christmas Island's vegetation has been described in *Flora of Australia* Vol 50 (Commonwealth of Australia 1993) and by several subsequent authors (most recently Claussen in 2005) all identifying four primary vegetation types (see Table 5 and Figure 3):

- evergreen tall closed forest ('primary rainforest') which occurs in areas with deep soils on the plateau but is also found on deep soil terraces
- semi-deciduous closed forest ('marginal rainforest') which is found on shallower soils and is common on terraces and slopes leading from the plateau to the coast and on shallow soil plateau areas
- deciduous scrub which is restricted to areas with very little soil on terraces, steep slopes and inland cliffs
- coastal fringe shrubland and herbland which is the least common vegetation type and occurs between the scrub and the coastal cliffs in more exposed areas.

Beyond this broad classification there is limited knowledge of the types of vegetation and location across the island.

The rainforests of Christmas Island are biogeographically significant; species have evolved from being either shoreline forest or early rainforest succession species to those that fill a tall climax rainforest role. The presence of seventeen endemic plant species in the climax rainforest community contributes to the place's significance for understanding evolutionary relationships. Notable examples include a rare fern *Asplenium listeri*, a tall tree-like pandanus *Pandanus elatus* and a palm *Arenga listeri*.

The ecological integrity of forest ecosystems is vital to their value for threatened species. Ecological integrity is “the ability of an ecological system to support and maintain a community of organisms that has a species composition, diversity, and functional organization comparable to those of natural habitats within a region. An ecological system has integrity, or a species population is viable, when its dominant ecological characteristics (e.g. elements of composition, structure, function, and ecological processes) occur within their natural ranges of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions” (Parrish et al. 2003).

The ecological integrity of the island's forests is dependent on the red crab, the most numerous and widespread crab on Christmas Island. Red crabs are omnivorous and opportunistic, feeding on green and dead leaves, fruits, seeds, seedlings, carrion and some animals. Through the differential predation of fruit, seeds and seedlings they influence the species composition of plants in Christmas Island forest and may provide biotic resistance to invasive weeds. The crabs have a significant role recycling nutrients by burying and consuming leaf litter on the forest floor. This influences growth rates of plants and the composition of invertebrate assemblages. The crabs also prey on and control the invasive giant African land snail (*Achatina fulica*). It is likely that their burrowing influences rainwater permeation and dehydration of forest soils, although this has not been studied. The habitat and survival of a range of other species, many endemic, are, or are likely to be, linked to the ecology of the red crab. The removal or decline of red crabs has a dramatic effect on the forest ecology of Christmas Island (Green et al. 1998) and results in many adverse and cascading ecological effects.

Also considered a key component of the island's rainforest ecosystem is the Christmas Island flying-fox (*Pteropus melanotus natalis*) which is a primary seed disperser and pollinator for a variety of rain-forest trees and other plants (Tidemann 1985). The floral characteristics of some forest trees indicate that they are principally pollinated by this species (DNP 2008b). Christmas Island white-eyes (*Zosterops natalis*) are abundant and have brush-tipped tongues, which are important for plant pollination of diurnal flowers. White-eyes also disperse the seeds of very small-fruited plants and could have a large influence on the population levels of some insects. Christmas Island imperial pigeons (*Ducula whartoni*) are abundant and swallow fruits whole, so will also disperse many seeds. Changes in the abundance and behaviours of the white-eye and imperial pigeon may also disrupt key ecosystem processes such as seed dispersal (Davis et al. 2009). Other animals, including insects and forest birds such as the Christmas Island thrush (*Turdus poliocephalus erythropleurus*) and emerald dove (*Chalcophaps indica natalis*), may also pollinate and disperse some plant species.

Other species may also have forest pollination, seed dispersal, nutrient cycling or other important ecosystem functions. Examples include seabirds cycling nutrients from their droppings, invertebrates which may be the prey of some species or have other important ecosystem functions. Such interactions are poorly or not understood for Christmas Island.

Since settlement of Christmas Island, approximately 25 per cent of the island's original landscape and vegetation has been cleared for mining and settlement, resulting in fragmentation of the island's native forest ecosystems. Some previously cleared or disturbed areas can support low second-growth forest of native colonising trees such as *Macaranga tanarius*, *Claoxylon indicum* and introduced exotic plants such as *Leucaena leucocephala*. Nonetheless mined sites tend to have little soil remaining and are generally comprised of dense fern (*Nephrolepis multiflora*) herblands, as well as introduced scramblers and occasional low trees. Some previously mined sites have been rehabilitated with native and non-native flora species.

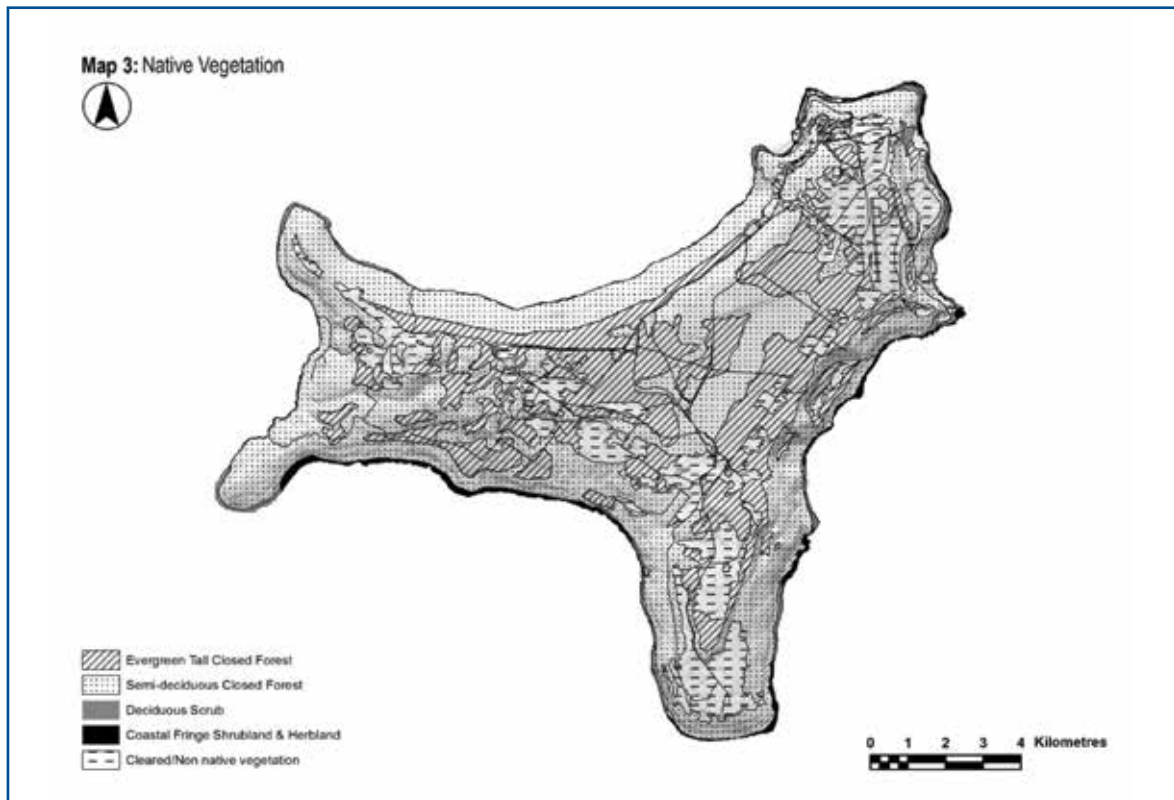


Figure 3: Native vegetation

Table 5: Description and distribution of rainforest vegetation

Vegetation Type	Vegetation Structure	Description and Key Species	Distribution
Evergreen tall closed forest ('primary rainforest')	Complex mesophyll vine forest with tall emergents	Dense to open, 25–35 metres in height with scattered emergents (principally <i>Hernandia ovigera</i> , <i>Planchonella nitida</i> , <i>Syzygium nervosum</i>) to 50 metres. Many layers comprising specialist sub-canopy and mid-stratum species (e.g. <i>Barringtonia racemosa</i> , <i>Cryptocarya nitens</i> , <i>Pisonia umbellifera</i>) mixed with medium-sized individuals of canopy species. Stem diameters irregular and range up to 130cm dbh. Host tree crowns do not extend more than one-third down the stem. Plank buttressing well developed; epiphytic ferns, orchids and climbers prominent.	Best developed in sheltered valleys and drainage depressions on the plateau; a lower stature form is present on steeper slopes sheltered from the prevailing south-easterly trade winds.
	Complex mesophyll vine forest	Similar to above but with emergent layer not as prominent (less than 8 metres between maximum height of canopy and maximum height of emergent trees).	Widespread on gentle slopes and plains of the plateau, often interspersed with mesophyll vine forest where outcropping limestone or limestone ridges are present.
	Mesophyll vine forest	Canopy height varies between 20 and 30 metres and uneven but emergents rarely present. Compared to complex mesophyll vine forest, plank buttressing and epiphytes less common and stem diameters of canopy trees more regular; <i>Hernandia ovigera</i> not present. A specialised class of this structural type occurs as low-diversity forests associated with freshwater seepages.	Occurs on thinner soils and more exposed areas on the plateau and in more sheltered areas on terraces. <i>Inocarpus</i> forest at The Dales and mangrove forest at Hosnies Spring are sites for the freshwater seepage class.
	Mesophyll vine forest with <i>Ficus</i>	Canopy of lower stature (18–24 metres) than mesophyll vine forest, with <i>Ficus microcarpa</i> often dominant.	Generally occurs on undifferentiated limestone outcrops surrounded by complex mesophyll vine forest on the plateau. Also present on limestone scree and rubble slopes in sheltered situations.
Semi-deciduous closed forest ('marginal rainforest')	Semi-deciduous mesophyll vine forest	Canopy even but varying in height from 14 to 25 metres depending on site conditions. Emergent trees to 32 metres common, often widely spaced but sometimes clumped; principally deciduous species (e.g. <i>Terminalia catappa</i> , <i>Celtis timorensis</i> , <i>Gynerosaurus americanus</i>). Both deciduous and evergreen species in the canopy and mid-stratum layers but increasing dominance of deciduous species on thinning soils and more exposed sites.	Common on terraces. A variant with <i>Ficus macrocarpa</i> intergrades with mesophyll vine forest with on more exposed scree slopes.
Deciduous scrub	Deciduous vine thicket	Uneven canopy, 6–8 metres in height, varying from dense to open. Occasional emergents to 10 metres. Most emergents and canopy species deciduous and branch from base or mid-stem height. Annual or perennial herbs common in ground layers. Dense pandanus thickets also present in some areas.	Common on inland cliffs and exposed karst areas and on exposed terrace areas on skeletal soils.
Herbland	Sclerophyllous shrublands and heathlands	Low stature sclerophyllous vegetation often interspersed with pandanus thickets.	Confined to shoreline and coastal cliffs where wind and exposure to salt spray affect vegetation stature.

Source: Adapted from Reddell & Zimmermann (2003) and Claussen (2005)



3.1.2 Wetland ecosystems

Christmas Island's landscape has a lack of surface runoff, but there are perennial streams at Dolly Beach, the Ravine, Ross Hill Gardens, Jones Spring, Waterfall, Freshwater Spring, The Dales and Hosnies Spring. The Dales and Hosnies Spring (Figure 4) are listed under the Ramsar Convention as Wetlands of International Importance and are declared Ramsar wetlands under the EPBC Act. The conservation values of other streams and springs are not well described but they support species such as red, blue (*Discoplax celeste*) and robber crabs (*Birgus latro*).

Consistent with the requirements under the Ramsar Convention (Appendix B), Ecological Character Descriptions are available for The Dales (Butcher & Hale 2010) and Hosnies Spring (Hale & Butcher 2010). These describe each wetland, its critical components and ecosystem services, threats to the ecological character of the wetland and limits of acceptable change.

Hosnies Spring is an area of permanent shallow freshwater wetland fed by a natural spring system located approximately 30 metres above sea level and 120 metres inland from the seaward cliff. The wetland is covered by a stand of mangroves including *Bruguiera gymnorhiza* and *B. sexangula* estimated to be 120 000 years old. The margins of the wetland are well defined by limestone cliffs to the north and west and a sharp transition to a hibiscus and pandanus community to the south. The area that surrounds the wetland site is predominantly rainforest characterised by 20 to 30 metre canopy of evergreen and deciduous trees such as *Pisonia grandis* and *Barringtonia racemosa* with a conspicuous lack of herb and shrub layers. There is a narrow band of coastal scrub of hardy species such as *Scaevola taccada* at the seaward margin of the shore terrace with an unvegetated area of limestone pinnacles on top of the sea cliffs. The cliff descends some 17 metres almost vertically to the rocky marine shore below. The site extends 50 metres seaward of the low water mark and includes areas of shallow, coral reef.

Hosnies Spring is remarkable for a number of reasons:

- it is one of the few permanent freshwater areas on Christmas Island
- the mangroves occur at an elevation not recorded elsewhere in the world
- the age of the mangrove stand is extraordinary
- the size of the individual trees is very large.

The site also supports a large numbers of crabs, in particular red, robber and blue crabs. Of note is the presence of endemic bird species including the Christmas Island imperial pigeon, emerald dove, goshawk, hawk-owl, thrush and white-eye. In addition, the Christmas Island flying-fox is found at this site.

The Dales Ramsar site is a series of seven dales (or valleys), three of which support permanent springs and four with intermittent streams. The Dales are surrounded predominantly by semi-deciduous forest. On the seaward side at the edge of the shore terrace is a line of coastal shrubland which merges with sea cliffs and rocky marine shores. The site extends seaward 50 metres and includes part of a narrow shallow and sloping reef. Mixed amongst the terrestrial and marine environments are a range of karst features, highly representative of the Christmas Island environment. The combination of this variety of habitats and the presence of permanent surface water provides the physical habitat to support several endemic, threatened and wetland dependent species.

The Dales site plays host to the annual red crab migration and provides critical habitat for blue crabs as well other land crabs. A diverse community of tree species and epiphytes also occurs here. At Hugh's Dale, and in parts of Anderson Dale and Sydney's Dale, there are mono-specific stands of Tahitian chestnut (*Inocarpus fagifer*) and the rare epiphytic ribbon fern (*Ophioglossum pendulum*). The endemic arenga palm (*Arenga listeri*) and endemic Ridley's orchid (*Brachypeza archytas*)—not to be confused with *Zeuxine exilis*, the rare Ridley's ground orchid—are common in The Dales. *Terminalia catappa* grows to an unusual size on Christmas Island and several large specimens occur in The Dales. A number of endemic fauna species occur within The Dales including Abbott's booby and Christmas Island hawk-owl, thrush and goshawk. The native fish, the brown gudgeon (*Eleotris fusca*), has also been sighted within The Dales.

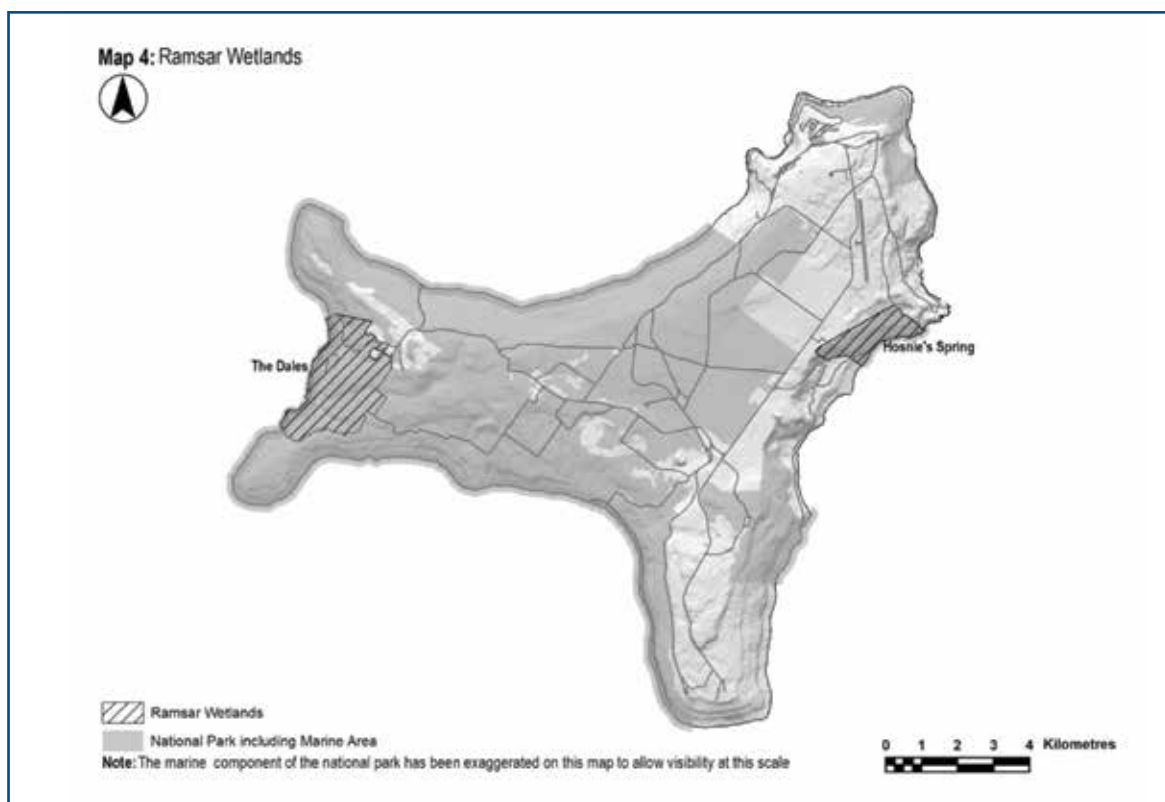


Figure 4: Ramsar wetlands

3.1.3 Subterranean and groundwater ecosystems

The limited availability of permanent, above-ground freshwater sources restricts the abundance and type of freshwater aquatic vertebrates on Christmas Island. On the other hand, Christmas Island's subterranean ecosystems are diverse and include terrestrial, aquatic/freshwater, marine and anchialine habitats (Humphreys & Eberhard 1998).

The subterranean fauna of Christmas Island consists of a range of cave-dwelling species, including one of only two known blind scorpions in Australia (EWG 2010), stygofauna and anchialine fauna. Some aquatic taxa are endemic while others, such as the shrimp *Macrobrachium lar*, are closely related to populations in the Pacific. Christmas Island has one of only two anchialine systems known in the southern hemisphere (Humphreys & Eberhard 2001). Christmas Island is also the only known global location where representatives from both types of anchialine fauna communities, the procaridid type—which is restricted to isolated seamounts—and the remiped type, co-occur (EWG 2010). The island's numerous caves also provide habitat for the Christmas Island swiftlet (*Collocalia linchi natalis*).

Christmas Island's subterranean fauna remains relatively poorly known and surveyed and little is known or understood about ground water flow rates or quality and the flow requirements of native species. Undoubtedly, many additional taxa remain undiscovered (Humphreys & Eberhard 2001). The high degree of endemism and the ancient lineages of several species highlight the global conservation significance of Christmas Island's subterranean fauna (EWG 2010). No formal conservation status or listing has been assigned to any cave species of Christmas Island. However, Schedule 12 of the EPBC Regulations protects obligate cave-dwelling species.

Most of the water that enters Christmas Island's aquifers reaches the sea as submarine groundwater, while some of it discharges to the sea as surface water flow. Many ecosystems and species on Christmas Island, including its

Ramsar wetlands and cave/subterranean ecosystems, depend on continued submarine or surface groundwater flows. For example, the island's stygofauna is dependent on groundwater, while the anchialine systems depend on the balance between freshwater outflow and marine inflow (EWG 2010). As well as maintaining anchialine systems, freshwater discharge is likely to locally influence the marine biota on the periphery of the anchialine system through salinity and nutrient effects, and may thus support novel biota (EWG 2010).

3.1.4 Marine and coastal ecosystems

Christmas Island's territorial waters extend 12 nautical miles from the island's shoreline but the description below largely focuses on the coastal waters and fringing reef systems immediately surrounding Christmas Island. Brewer et al. (2009) provides a detailed description of the deep oceanic waters of the Christmas Island–Central Ridge subregion that surrounds Christmas Island. This plan only covers marine areas to the extent of the interaction between marine and terrestrial habitats for some species.

Christmas Island's largely intact fringing reefs and adjacent deep waters support a number of marine and coastal ecosystems and species typical of the Indian Ocean region. Although species diversity is lower than in some other places in the Indian Ocean region, there are fewer threats and pressures (e.g. pollution, fishing pressures and habitat degradation/loss) than for many other coral reef systems in the region.

Christmas Island's marine and coastal ecosystems include:

- shore rock platforms—occurring at many locations around the island but more extensively on the western coastline between North West Point and Egeria Point. There are also tidal rock pools which are maintained by wave splash and tidal surge
- beaches—formed of sand and coral and shell rubble, often with limestone outcrops. Dolly Beach and West White Beach are two of the largest beaches on the island, while Dolly Beach and Greta Beach hold sufficient sand to provide habitat for hermit (*Coenobita* spp.) and ghost crabs (*Ocypode* spp.) and enable green turtles to dig nests
- shallow fringing coral reef shelves—the subsurface marine habitat immediately surrounding the island consists of a relatively narrow and shallow fringing coral reef shelf about 20 to 100 metres wide in approximately 6 to 20 metres of water depth. Caves are also located in some of the island's rocky sea cliffs that adjoin the coral reef shelves. Coral reef shelves also contain areas of sand and rubble
- mid and deep marine waters—the shallow coral reef shelves drop off steeply to the island's mid and deep marine water habitats which include outer reef seaward slopes, vertical walls that lead to deeper oceanic waters.

The shallow fringing coral reef shelf surrounding Christmas Island is extremely limited in area and this, combined with the island's geographic isolation, limits the diversity of shallow marine species. However, over 600 marine fish species have been recorded, including endemic and hybrid reef fish (Allen et al. 2007, Hobbs et al. 2008), making the island an internationally significant marine hybrid hotspot (Hobbs et al. 2008).

Whale sharks are the world's largest fish, one of only three filter-feeding sharks (DEH 2005) and are listed as vulnerable under the EPBC Act. The whale shark recovery plan (DEH 2005) identifies the waters of Christmas Island as being part of Australia's critical habitat for this species' survival and protection. Whale sharks aggregate seasonally around Christmas Island, usually between November and April, feeding on red crab and other planktonic larvae (Hobbs et al. 2009).

Small numbers of green turtles, and more rarely hawksbill turtles (*Eretmochelys imbricata*), nest on Christmas Island while endangered loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles are also thought to forage in its marine habitats (Brewer et al. 2009). Short-beaked common dolphins (*Delphinus delphis*) and long-snouted spinner dolphins (*Stenella longirostris*) have been recorded feeding and possibly breeding around Christmas Island, while three (possibly four) species of whale have been infrequently sighted near the island (Brewer et al. 2009).

The marine invertebrate fauna recorded around Christmas Island includes at least 89 reef-building scleractinian coral species (Done & Marsh 2004), more than 200 species of decapod crustaceans, and about 490 mollusc and 90 echinoderm species including some endemic species (Brewer et al. 2009). Future surveys are likely to increase the number of coral reef species recorded around Christmas Island.

The oceanic surface waters of the Central Ridge subregion that surrounds Christmas Island are influenced by a range of ecological processes. The region is influenced by the Indonesian Throughflow—south-easterly and north-westerly monsoon winds which impact on currents and upwelling from Java's coastal waters. These factors, as well as local processes interacting with the Christmas Island seamount, influence marine productivity and nutrients (Brewer et al. 2009). In addition, a drop in water temperatures associated with current up-welling supports seasonal influxes of larger pelagic fish species (Brewer et al. 2009).

There are important ecological interactions between Christmas Island's terrestrial and marine ecosystems and the species these support. The surrounding ocean exerts a strong influence on the climate and therefore the structure and function of the island's terrestrial ecosystems, which in turn provide critical resources for many of the island's terrestrial species. For example, all of the island's seabirds are dependent on the ocean for their dietary needs but require terrestrial habitats for roosting and breeding. Land crabs depend on marine ecosystems for their survival as they migrate to the ocean for spawning and recruitment, while migrating whale sharks feed on red crab larvae (Hobbs et al. 2009). Marine turtles that nest on a few of the island's beaches spend the rest of their life cycle in the ocean. While some of the interactions are relatively well understood, there are still gaps in knowledge in relation to some interactions, particularly the marine and juvenile lifecycles of red and other land crabs.

3.2 Species

This section provides broad overview of the flora and fauna of Christmas Island.

3.2.1 Significant species

A key consideration in development of this plan is recognition that protection and recovery of significant species relies on the conservation and recovery of the assemblage of species that make up the ecosystems and habitats on which those species rely, especially the plants that make-up the island's rainforest ecosystems.

For the purposes of this plan, a significant species is a native terrestrial species which meets one or more of the following criteria:

1. A species listed (or under consideration for listing) as threatened under the EPBC Act.
2. A species with an important or 'keystone' role in maintaining the island's ecology or which characterises a significant ecosystem.
3. Species which are of conservation concern (those which have a substantial decline on Christmas Island) but not listed as threatened.
4. An endemic vertebrate.
5. A species of international conservation significance with strong community support for its conservation.

Table 6 identifies those species considered significant species at the time of this plan's preparation, based on the above criteria. Additional species may be identified as significant during the life of this plan, in particular under criterion 3, such as through monitoring, survey or research actions. The individual species profiles (Appendix K) provide more detailed descriptions and management information for significant species.

3.2.2 Overview of flora species

Terrestrial vegetation communities of Christmas Island comprise several types of rainforest, dominated by plants that are pan-tropical tramp species, most probably of South Asian origin.

Christmas Island has over 240 native flora species, with at least 18 known to be worldwide endemics (Appendix C) including a tall tree-like pandanus, *Pandanus elatus* and a palm *Arenga listeri*, as well as the critically endangered fern *Asplenium listeri*. About half of the non-endemic native species are not known to occur anywhere else in Australia or its Territories. The native flora has strong taxonomic affinities with those of the Indonesian and Malaysian regions (Reddell & Zimmermann 2003) and many species have distributions extending from south-east Asia to Australia (north-east Queensland), New Guinea and the Pacific Islands (Du Puy 1988). Three species are listed as threatened under the EPBC Act (Table 1, Appendix B). Appendix E provides a summary of the non-endemic vascular plants of possible conservation concern and their abundance and distribution. Appendix K includes detailed profiles for significant flora species on Christmas Island.

Exotic species now comprise a major component of the island's flora. At least 390 exotic species are known (Swarbrick 1997) with 221 of these identified as posing a current or potential weed threat (DNP 2009a). Details on the impacts of exotic plant species on significant native species is provided in Part 4 of this plan.

Some important features of Christmas Island's flora are:

- many species occurring in different habitats compared to their distribution in Indonesia and Malaysia and often occur in larger forms
- fewer flora species compared with continental forest ecosystems, largely reflecting the island's remoteness and limited availability of freshwater sources
- low structural diversity due to the ecological role of land crabs, particularly red crabs
- the presence of at least 18 endemic species and three ferns listed as threatened under the EPBC Act
- relict populations of species that have been isolated since the island's tectonic uplift, including coastal mangroves at Hosnies Spring and the cycad, *Cycas rumphii*.

The conservation status of much of Christmas Island's flora is unclear. Other than one extensive flora survey (Holmes & Holmes 2002) which identified 53 species of possible conservation concern, there has been little recent survey effort. Information about distribution, abundance, population trends and threats is poorly understood for most species. Some endemic species appear to have restricted distributions and small population sizes, and could qualify for listing as threatened under the EPBC Act.

Along the shore terrace, especially the northern coastline, tall forests and salt tolerant species such as *Pandanus* spp., *Pemphis acidula* and *Scaevola taccada* grow on the cliff tops. A number of deciduous species are common to this area such as *Gyrocarpus americanus*, *Terminalia catappa* and *Erythrina variegata*. This area includes some of the most diverse forest on the island with about 25 canopy species (Gray 1995).

The rainforest canopy of the central plateau contains about 12 dominant species, some of which are deciduous during the dry season (such as *Terminalia catappa*). A number of emergent tree species (*Hernandia ovigera*, *Planchonella nitida* and *Syzygium nervosum*) play an important role in the island's ecosystem through providing nesting sites for Abbott's booby. A number of other species found in this forest are unusual for occurring as large forest trees; in other locations in the tropics they normally occur as small to medium trees growing close to the shore. This vegetation community also includes a number of seashore plants found some distance from the ocean (Gray 1995).

Table 6: Species of Christmas Island identified as significant

Species		Significance criteria
Vascular plants		
<i>Asplenium listeri</i>	Christmas Island spleenwort	1
<i>Bruguiera gymnorhiza</i> , <i>B. sexangula</i>	mangroves	2
<i>Pneumatopteris truncata</i>	a fern	1
<i>Tectaria devexa</i> var. <i>minor</i>	a fern	1
Seabirds		
<i>Fregata andrewsi</i>	Christmas Island frigatebird	1,4
<i>Papasula abbotti</i>	Abbott's booby	1,4
<i>Phaethon lepturus fulvus</i>	golden bosun, white-tailed tropicbird	4
Forest birds		
<i>Accipiter hiogaster natalis</i>	Christmas Island goshawk	1,4
<i>Chalcophaps indica natalis</i>	Christmas Island emerald dove	1,4
<i>Collocalia linchi natalis</i>	Christmas Island swiftlet	4
<i>Ducula whartoni</i>	Christmas Island imperial pigeon	2,4
<i>Ninox natalis</i>	Christmas Island hawk-owl	1,4
<i>Turdus poliocephalus erythropleurus</i>	Christmas Island thrush	1,4
<i>Zosterops natalis</i>	Christmas Island white-eye	2,4
Mammals		
<i>Crocidura trichura</i>	Christmas Island shrew	1,4
<i>Pipistrellus murrayi</i>	Christmas Island pipistrelle	1,4
<i>Pteropus melanotus natalis</i>	Christmas Island flying-fox	1,2,4
Reptiles		
<i>Cryptoblepharus egeriae</i>	blue-tailed skink	1,4
<i>Cyrtodactylus sadleiri</i>	giant gecko	1,4
<i>Emoia atrocostata</i>	coastal skink	3
<i>Emoia nativitatis</i>	forest skink	1,4
<i>Lepidodactylus listeri</i>	Lister's gecko	1,4
<i>Ramphotyphlops exocoeti</i>	Christmas Island blind snake	1,4
Land crabs		
<i>Birgus latro</i>	robber crab	5
<i>Discoplax celeste</i>	blue crab	2
<i>Gecarcoidea natalis</i>	red crab	2,3,5

A number of plant species are known only from one or a few sites with a small number of individuals and are potentially of conservation concern. Some of these species are pioneer, edge or disturbance specialists that may have always had a precarious foothold in the ecology of the island but are now likely to be out-competed by the many more vigorous exotic plants (EWG 2010). Other species provide an important food source e.g. the palm *Arenga listeri* which is important in the diet of robber crabs.

The plateau forest's understorey consists of a small number of species, predominantly *Pandanus elatus*, while ferns are a feature of some areas. The threatened Christmas Island spleenwort *Asplenium listeri* is endemic to Christmas Island and was originally known from a single location. Although additional locations are now known there is thought to be less than 300 individuals (Holmes & Holmes 2002). The species appears to favour limestone rock crevices at the highest parts of inland cliff terraces and often occurs below strangler fig (*Ficus microcarpa*) (Butz 2004b). *Tectaria devexa* is a threatened terrestrial fern which occurs as two known varieties. The var. *minor* occurs in Sri Lanka and Christmas Island, while the var. *devexa* occurs in Queensland. On Christmas Island *T. devexa* var. *minor* grows in shaded positions in the evergreen tall closed forest on the plateau where it may be the only forest floor species. It does not appear to be very widespread and is not abundant in any of its known occurrences (Butz 2004a). The only Australian occurrence of the threatened fern *Pneumatopteris truncata* is located on Christmas Island.

Due to higher moisture retention and fertility, vegetation on the higher terraces is more diverse than that of the plateau. It includes strangler fig, the stinging tree (*Dendrocnide peltata*) and the succulent shrub *Procris pedunculata*. A feature of the wet season is the appearance of a number of flowers in the rainforest, including orchids (such as *Thrixspermum carinatifolium*) and hoyas (*Hoya aldrichii*) (Gray 1995). Ridley's orchid (*Brachypeza archytas*) and Ridley's ground orchid (*Zeuxine exilis*) are endemic to Christmas Island. Eleven orchids occur on Christmas Island, eight of which are epiphytes.

During the wet season algae, ferns, mosses, fungi and lichens come to life in the rainforest, including the stinkhorn fungus (*Dictyophora* spp.) (Gray 1995).

The stands of *Bruguiera gymnorhiza* and *B. sexangula* mangroves at Hosnies Spring are some of the largest specimens of these species in the world. While mangroves normally occur in saltwater environments, the Christmas Island populations have adapted to grow in freshwater over 30 metres above sea level, making them especially significant. The mangroves play an important role in defining the ecological character of Hosnies Spring and as such have an important role in the ecosystem of the wetlands.

3.2.3 Overview of fauna species

Christmas Island's native fauna is notable for the high proportion of species and subspecies which are either endemic (only occur on Christmas Island) or have their only Australian occurrence on the island. The island's proximity to the Indonesian Archipelago explains why the fauna has Indonesian–Malay rather than Australian affinity. As an oceanic island isolated from other land-masses, the native fauna species assemblage is characterised by species able to utilise wind, ocean currents or flight to colonise this remote site. Christmas Island's fauna is dominated by large numbers of resident seabirds and a diverse range of land crabs, most notably red crabs. Appendix B lists fauna species for Christmas Island that are listed under the EPBC Act and appendices F to H provide information on the island's fauna species. Appendix K includes detailed profiles for significant fauna species on Christmas Island.

Birds

Christmas Island has 14 species of resident native birds, two of which are self-introduced, and nine regular breeding seabirds. The remaining birds are non-breeding migrants or occasional visitors. Appendix F provides a summary of the birds of Christmas Island and their status and abundance. Christmas Island is of international conservation significance as a seabird breeding area and because many of its bird species are endemic; there are three endemic seabird taxa and seven endemic land bird taxa. In recognition of the island's international conservation significance for birds, it has been declared an Endemic Bird Area by Birdlife International. In addition to birds playing a significant role in the environment, the Christmas Island community has a strong connection to several species, particularly the golden bosun (*Phaethon lepturus fulvus*) an endemic subspecies of the white-tailed tropicbird and the wildlife symbol of Christmas Island, which appears on the island's flag.



The endangered and endemic Abbott's booby now occurs only on Christmas Island, having formerly bred on other Indian Ocean islands (DEH 2004). It nests in tall trees of the western and southern plateau rainforest. The other two endemic seabirds are the endangered Christmas Island frigatebird (*Fregata andrewsi*) and the golden bosun; the three endemic seabirds are also listed as migratory species under the EPBC Act. The most numerous of the island's seabirds is the pan-tropical red-footed booby (*Sula sula*) which nests colonially in trees on many parts of the shore and inland terraces. The widespread brown booby (*Sula leucogaster*) nests on the ground at the edge of the seacliff and inland cliffs. Other seabirds breeding on Christmas Island include the silver bosun or red-tailed tropicbird (*Phaethon rubricauda*), great frigatebird (*Fregata minor*), lesser frigatebird (*Fregata ariel*) and common noddy (*Anous stolidus*). The island supports more than one per cent of the world's populations of silver bosun, great frigatebirds, red-footed boobies and brown boobies.

Prior to settlement only eight land and freshwater birds were resident on the island, seven of which are endemic species or subspecies. The Christmas Island swiftlet (*Collocalia linchi natalis*) feeds on flying insects and nests in caves or overhangs. The Christmas Island imperial pigeon feeds mainly on fruits from the rainforest and settled areas, while the emerald dove feeds on fruits, seeds and insects from the forest floor. The Christmas Island hawk-owl and goshawk feed on small mammals, birds, reptiles and invertebrates. The Christmas Island white-eye and thrush feed on fruit, nectar and insects.

The original resident bird fauna remains intact but has been joined by a range of self-introduced and introduced species (Johnstone & Darnell 2004). The Nankeen kestrel (*Falco cenchroides*) and the white-faced heron (*Egretta novaehollandiae*) self-established from Australia since settlement and utilise open habitats created by vegetation clearing.

In addition to resident land and seabirds, at least 104 vagrant or migrant bird species—largely of south-east Asian origin—have been recorded on the island from time to time (Johnstone & Darnell 2004). Nineteen species are regularly recorded as non-breeding migrants or occasional visitors, including migratory shorebirds.

While several bird species have been studied on Christmas Island, there is little robust information available on population sizes or long-term trends for most species. Six of the island's endemic birds are listed as threatened under the EPBC Act (Table 1, Appendix B) while the conservation status of the golden bosun is unknown. The silver bosun is not listed as threatened under the EPBC Act, but at times chick recruitment has significantly declined at the Settlement nesting colony due to cat (*Felis catus*) predation and other factors that may be related to food availability. Although listed as threatened, the Christmas Island thrush and emerald dove appear to be numerous and stable.

Mammals

Five endemic native mammals have been recorded on Christmas Island with only one, the Christmas Island flying-fox, now known to remain. Two endemic rats became extinct soon after settlement. The Christmas Island pipistrelle (*Pipistrellus murrayi*) and the Christmas Island shrew (*Crocidura trichura*) are thought to be extinct but, given their last recordings occurred relatively recently, they are not officially confirmed as such in legislation and opportunistic monitoring is undertaken. Appendix G provides a summary of the mammals of Christmas Island and their status and abundance.

Maclear's rat (*Rattus macleari*) and the Christmas Island rat or bulldog rat (*Rattus nativitatis*) were two large, nocturnal, endemic rats that became extinct shortly after introduction of the black rat (*Rattus rattus*) in the early 1900s. The extinction of both endemic rats was likely due to a pathogenic trypanosome carried by fleas that were hosted by black rats (Wyatt et al. 2008).

The endemic Christmas Island shrew is the only known occurrence of the shrew family on Australian territory. This species was once extremely common across the island and had a distinctive shrill squeak but declined rapidly following settlement, possibly because of the introduction of a disease (Schulz 2004). It was thought to be extinct before two specimens were found in 1985 but it has not been sighted since. The shrew is listed as endangered under the EPBC Act but is now likely to be extinct. Formerly considered a subspecies of a more widely distributed species, molecular studies have confirmed it as a separate species endemic to Christmas Island (Eldridge et al. 2009).

The Christmas Island pipistrelle was previously common and widespread on Christmas Island. However, since the 1990s this small insectivorous bat declined markedly in distribution and abundance, the cause of which is not fully understood (Lumsden et al. 2007). Fixed detector stations have failed to record this species since mid-2009 and, while it is listed as critically endangered under the EPBC Act, it is now presumed extinct.

The Christmas Island flying-fox is found across the island and is largely diurnal. The flying-fox has been recorded feeding on fruits, flowers and seeds and is likely to play an important role in seed dispersal and pollination. Several studies and reports indicate that flying-fox numbers have declined significantly over recent years and because of this decline it was listed under the EPBC Act as critically endangered in 2014.

Reptiles

Christmas Island has six species of native terrestrial reptiles, five of them endemic. In addition two marine turtles are recorded as nesting on the island. Appendix G provides a summary of the reptiles of Christmas Island and their status and abundance.

Endemic species are the blue-tailed skink, forest skink (*Emoia nativitatis*), giant gecko (*Cyrtodactylus saddleiri*), Lister's gecko (*Lepidodactylus listeri*) and the burrowing Christmas Island blind snake (*Ramphotyphlops exocoeti*). The coastal skink (*Emoia atrocostata*) is a wide-ranging skink found on many other islands through the Pacific and Indian Oceans. On Christmas Island it occupies (or occupied) the rocky coastal intertidal zone and adjacent fringing limestone rock outcrops.

All of Christmas Island's native terrestrial reptiles have undergone rapid population declines and are highly threatened (Schulz & Barker 2008). The blue-tailed skink, forest skink and coastal skink have undergone dramatic range contractions since the late 1990s and may now be extinct in the wild. Lister's gecko had not been recorded for more than 20 years until a small population was found in 2009 (Smith et al. 2012). CINP staff also confirmed a sighting of the Christmas Island blind snake in 2009, the first time it had been recorded since 1986 (Smith et al. 2012). The species was apparently more abundant prior to recent decades, being described as 'fairly common' between 1938 and 1940 (Gibson-Hill 1947) although it may have been confused with the introduced flowerpot snake (*Ramphotyphlops braminus*). Due to its cryptic habits, the Christmas Island blind snake is difficult to locate through surveys, but the extremely low number of confirmed records suggests that this species is probably in very low numbers.

The giant gecko is now the only regularly encountered native reptile species, particularly in the evergreen tall closed forest of the central plateau, but it too is uncommon and declining in abundance and distribution (Schulz & Barker 2008). Its decline has been most marked since the late 1990s, when it was considered to be abundant and widespread (Cogger & Sadler 2000).

All of the five endemic reptiles are listed as threatened under the EPBC Act. The reason for declines of native terrestrial reptiles is poorly understood and it is not possible to attribute the declines to specific threatening processes (see Part 4 of this plan).

Two marine turtles, the green turtle and hawksbill turtle, are found in Christmas Island's marine waters and occasionally nest on some of the island's beaches (Dolly and Greta beaches) in small numbers. Both are listed as vulnerable under the EPBC Act and a recovery plan (Environment Australia 2003) provides a national framework for their conservation management. This plan does not identify Christmas Island as habitat critical for their survival.

Fish

The limited availability of permanent, above-ground freshwater sources restricts the abundance and type of freshwater aquatic vertebrates on Christmas Island. At least seven freshwater fish species have been recorded from pools and streams however these are largely introduced. A single freshwater eel (*Anguilla bicolor*) was captured in 1983 and there have been more recent sightings at Hugh's Dale. The only other native freshwater species is the brown gudgeon. Both species have marine life-stages, accounting for their presence on Christmas Island, and are widely distributed in the Indonesian–Malaysian Archipelago and beyond (Allen et al. 2007).

Invertebrates

A large number of endemic species from a range of invertebrate groups are known to occur. While none of Christmas Island's invertebrate fauna is currently listed as threatened under the EPBC Act, populations of several species (notably red crabs) have declined over recent decades and there is a possibility that some invertebrate species have become extinct.

Crustaceans, particularly in the form of land crabs, are the most conspicuous invertebrate fauna of Christmas Island. They are remarkable for their diversity and abundance, and for the role they play in the island's rainforest ecology. Christmas Island supports over 20 terrestrial and intertidal crab species of which 14 are regarded as true land crabs, depending on the ocean only for their larval development. This diversity and abundance of land crabs is not matched on any other island. Appendix H provides a list of land and shoreline crabs of Christmas Island and their status, abundance and distribution.

The red crab occurs only on Christmas Island (and sporadically on North Keeling Island) and is the most conspicuous and abundant land crab. At the beginning of the wet season (usually October/November), most adult red crabs suddenly begin a spectacular migration from the forest to the coast to breed. The red crab annual breeding migration is recognised as one of the world's spectacular wildlife events with tens of millions of adult red crabs migrating to the coast where they mate in burrows close to the ocean. Females then deposit fertile eggs in the ocean, and return to the forest. After about a month in the ocean—growing through several stages—the larvae gather in pools close to the shore for one to two days before growing into young crabs that leave the water to begin their inland migration. In most years very few or no baby crabs emerge from the sea, but the occasional very successful breeding year results in a large return of young red crabs. The ecological role that red crabs have on the unique structure, characteristics and plant composition of Christmas Island's forests is profound (Lake & O'Dowd 1991). While there has been a substantial amount of research into red crab biology and ecology there are still a number of unknown or poorly known aspects, particularly their juvenile lifecycles and aspects of their migration, including the factors influencing the size and patterns of their migration.

There are also a number of other important land crab species. Blue crabs have a restricted distribution on Christmas Island in wetland areas, which includes The Dales area of CINP where it is locally common; formally considered a form of a widely distributed species, it now constitutes an endemic species (Ng & Davie 2012). Christmas Island also supports the world's largest population of the world's largest terrestrial invertebrate, the robber crab, which may attain a mass of over 2.5 kg. Robber crabs have a wide distribution across many Indian and Pacific oceanic islands but in most of their range they are now scarce, heavily hunted and in serious decline. Although abundant on Christmas Island their exact conservation status is unknown. There are a number of other endemic crabs on Christmas Island which are not listed, and whose population is uncertain. These include Jackson's crab (*Karstama jacksoni*) and the recently described Christmas Island yellow-eyed crab (*Chiromantes garfunkel*).

Christmas Island's ant fauna is mostly composed of species that are regarded as worldwide tramps or are widespread in the Indonesian–Australian region and none are considered endemic. Fifty-two species have been recorded, most of which are likely to have been accidentally introduced through human habitation, of which crazy ants are the most prominent and most destructive (see Part 4.1 of this plan). Ant species likely to be native to the island include *Camponotus melichloros*, *Leptogenys harmsi*, *Pachycondyla christmasi*, *Odontomachus simillimus*, and possibly *Hypoponera confinis* (Framenau & Thomas 2008).

Most of the 28 butterfly species recorded on Christmas Island are likely to be introduced, as they feed only on introduced plants. The number of butterfly species native to the island is difficult to determine, but by 1900 naturalists had found nine species, including one endemic species, the Christmas Emperor (*Charaxes andrewsi*) (DNP 2011a).

Thirty-eight snail species have been recorded from Christmas Island, including 22 introduced species and nine endemic species (Kessner 2006). However, the ecological role of native land snails is poorly known.

There is a suite of subterranean invertebrates, including one of only two known blind scorpions in Australia (EWG 2010), stygofauna and anchialine fauna. Some aquatic taxa are endemic while others, are closely related to populations in the Pacific. The island's subterranean fauna remains relatively poorly known and surveyed. Undoubtedly, many additional taxa remain undiscovered (Humphreys & Eberhard 2001). The high degree of endemism and the ancient lineages of several species highlight the global conservation significance of Christmas Island's subterranean fauna (EWG 2010). No formal conservation status or listing has been assigned to any cave species of Christmas Island. However, Schedule 12 of the EPBC Regulations protects obligate cave-dwelling species.



Part 4—Threats

Since the settlement of Christmas Island, the natural environment has been modified by threatening processes associated with introduced invasive species, and human activities or a combination of both. Some threatening processes interact, or may interact, leading to compounding ecological impacts. Although some existing and potential threats are clearly identified, threatening processes responsible for the decline of some species are poorly understood or not known and this lack of information is a barrier to addressing such declines.

In general, oceanic island species and ecological communities are far more vulnerable to decline and extinction than mainland populations. The factors responsible for this include small population sizes, small geographic ranges, limited genetic diversity due to small numbers of founding individuals, limited dispersal opportunities or refuges, evolution under limited exposure to predators, pathogens, disease and competitors, and the limited ecological resistance of simplistic island ecosystems to disturbance (e.g. exotic species invasions). As an oceanic island, these factors all apply to Christmas Island.

The threats described below have been assessed for their risk to the significant species of Christmas Island without any recovery action, based on the pervasiveness of the threat and the impacts to species essential to the ecosystem (see Appendix I for details). Potential threats outside Christmas Island (described below) such as possible hunting of frigatebirds and Abbott's booby, habitat clearing on other (non-Australian) islands, and marine threats which may affect terrestrial species, are not included in the risk assessment. These threats are beyond the scope of this plan.

Invasive species pose the greatest known threats to Christmas Island's ecology and biodiversity, and their impacts may be exacerbated by other threatening processes, such as climate change. Invasive species are exotic introduced species which adversely affect native species or their habitat and may result in negative environmental and/or economic impacts. As identified in the EWG report (2010), "elements of Christmas Island's biodiversity have declined and are currently in severe decline because of introduced species and diseases. The addition of more invasive species to the already high load can only make matters worse". The species profiles (Appendix K) provide more details of the specific threats known or thought to be operating on significant Christmas Island species.

4.1 Known threatening processes

Four 'key threatening processes' listed under the EPBC Act are considered to apply to Christmas Island (Table 7). These threats are discussed in further detail below.

Table 7: Key threatening processes relevant to Christmas Island

Key Threatening Process	Threat Abatement Plan
Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (<i>Anoplolepis gracilipes</i>) on Christmas Island, Indian Ocean	Yes
Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases	No
Predation by exotic rats on Australian offshore islands of less than 1000 km ² (100 000 ha)	Yes
Predation by feral cats	Yes

In addition to these listed key threatening processes, a number of other threatening processes are known to be affecting the ecology and biodiversity of Christmas Island.

4.1.1 Introduced species

Yellow crazy ants and scale insects

Major threat risk

The yellow crazy ant (*Anoplolepis gracilipes*) is a ‘tramp ant’ species accidentally introduced to Christmas Island between 1915 and 1934 (O’Dowd et al. 1999). Yellow crazy ants (‘crazy ants’) are recognised by the IUCN and the Global Invasive Species Program as one of the world’s 100 worst invasive species (Lowe et al. 2000). On Christmas Island crazy ants are recognised as the most significant and pervasive threatening process affecting biodiversity, as reflected by their listing as a key threatening process and as identified in a threat abatement plan to reduce the impacts of tramp ants on biodiversity in Australia and its territories (DEH 2006).

Crazy ants establish nests in a variety of locations, including holes in the ground (e.g. crab burrows), tree bases and hollows, logs, and under rocks (O’Dowd et al. 1999, O’Dowd et al. 2003, Abbott 2005). Highest densities are at ground level, but they are also active high into the forest canopy (O’Dowd et al. 2003, Abbott 2005).

Crazy ants apparently occurred in low numbers with no obvious impact on the island’s biodiversity until the late 1980s, when the first multi-queen high density colonies, referred to as ‘supercolonies’, were recorded (Framenau & Thomas 2008). A supercolony is determined based on the density of ants that results in red crab mortality and is counted using a standardised monitoring method. By 2001 it was estimated that supercolonies covered 25 per cent of the island’s rainforest areas (O’Dowd et al. 2003) before an aerial baiting program was implemented in 2002. By 2009 supercolonies had again increased and were estimated, through the Island Wide Survey, as covering an area of just under 800 hectares, before further aerial baiting programs were undertaken in 2009 and 2012. Baiting programs only target mapped supercolonies, which are lethal to red crabs. Crazy ants at sub-supercolony densities are widely distributed across the island (Abbott 2005), with many high density colonies present (Figure 5).

Crazy ants form mutualistic associations with scale insects which suck sap from trees and secrete carbohydrate-rich honeydew on which the ants feed. The ants protect the scale insects from parasitoids, parasites and predators. The formation of crazy ant supercolonies has been particularly associated with high densities of the cryptogenic lac scale *Tachardina aurantiaca* and the introduced scale *Coccus celatus* (O’Dowd et al. 2003).

Crazy ants and scale insects have a variety of known and potential direct, indirect and interacting impacts on Christmas Island’s species and their habitats. Their most significant impact is on the mortality of land crabs, which in turn can cause significant changes to forest habitats. Ants spray formic acid and crabs are either killed directly in ant-invaded forest, or during the annual migration when large numbers of crabs intercept supercolonies. Other crabs such as blue crabs and robber crabs are also affected.

Forests from which red crabs have been removed have been called ‘ghost forests’. There are two types of ghost forest—those from which crazy ant supercolonies have been eliminated but in which red crab recovery has been limited and those in which red crabs have disappeared due to their death during migration through distant supercolony areas. By 2003, it was estimated that 10–15 million red crabs had been killed, removing or severely depleting local populations over an area of 25 square kilometres (O’Dowd et al. 2003).

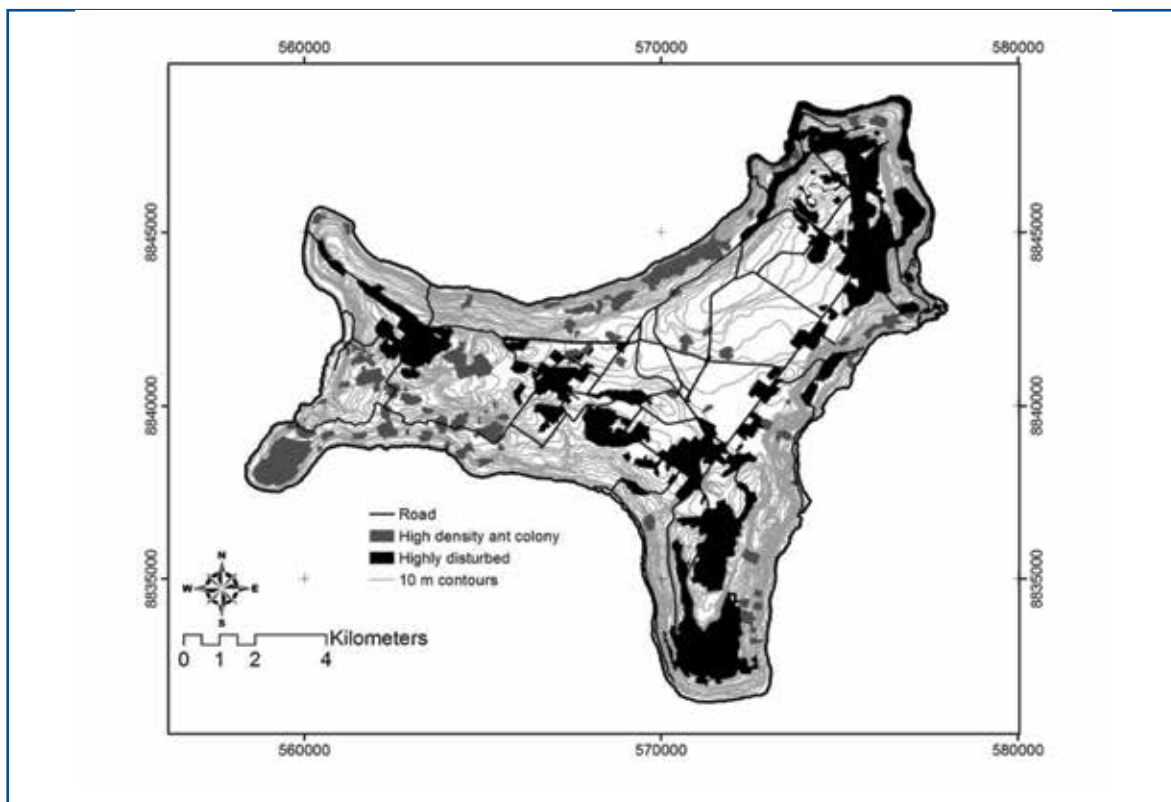


Figure 5: High density crazy ant colonies

Source: Boland et al. 2011

The removal or reduction of red crabs is likely to result in long-term changes to the forest structure, species composition and habitat quality, through the disruption of ecological processes such as nutrient cycling and seed recruitment and dispersal. Removal of red crabs can also result in the increased abundance and distribution of other invasive fauna. For example, red crabs prey on introduced giant African land snails and restrict their invasion of rainforest (Lake & O'Dowd 1991) and reductions in the number of red crabs, due to crazy ants, may result in an increase in giant African land snails. Other invasive fauna species may also be advantaged by removal of red crabs.

High densities of scale insects in association with crazy ant supercolonies have resulted in canopy dieback and tree death due to the removal of large quantities of sap and the accumulation of excess honeydew on the leaves promoting the growth of photosynthesis-reducing sooty moulds (O'Dowd et al. 2003). Seed production and the growth rates of adult and juvenile trees can also be affected (O'Dowd et al. 2003, Abbott & Green 2007). Lac scale insects can reduce growth rates of adult and juvenile trees and lower seed production in Tahitian chestnuts (Abbott & Green 2007) as well as leading to high mortality of chestnuts through canopy dieback.

Red crabs can help suppress the growth of some weed species through the consumption of seedlings (Green et al. 2004). Removal of red crabs from forests by crazy ants and increased light levels from canopy dieback has facilitated the invasion of several shade-intolerant weed species including *Capsicum frutescens*, *Carica papaya*, *Cordia curassavica* and *Muntingia calabura* (Green et al. 2004).

Crazy ants affect some of the island's bird species through direct interference and through altered resource availability and habitat structure (Davis et al. 2008, Davis et al. 2009). Altered foraging behaviour, fewer reproductive behaviours, and altered nest sites location by Christmas Island thrushes have been observed in ant-invaded forest and higher nest failures and fewer juvenile thrushes have also been recorded (Davis et al. 2008). However, these birds are common so the cumulative effect of crazy ants is hard to quantify. Crazy ant supercolonies have been found to reduce frugivory by the Christmas Island thrush and white-eye through direct interference as well as the likely indirect impacts on resource availability and habitat structure (Davis et al. 2009). Despite that reduction, the white-eye has been found to be more abundant and have greater foraging success in ant-invaded forest, probably due to the increased abundance of scale-insect prey (Davis et al. 2008). The evidence suggests little ecologically significant impact, if any, on thrushes or white-eyes. Studies showed that the Christmas Island emerald dove was 9–14 times less abundant in ant-invaded forest. As emerald doves forage on the forest floor and often nest low in the vegetation (where crazy ant densities are high), crazy ants may harass nesting adults and/or predate on nestlings and juveniles.

Crazy ant impacts on other tree-nesting or seabird species are not known. It is possible that crazy ants may directly or indirectly impact Christmas Island swiftlet, imperial pigeons, red-footed booby, Christmas Island frigatebird, Abbott's booby, golden bosun, silver bosun, goshawk and hawk-owl.

While the exact causes for the rapid decline and likely extinction of the pipistrelle are unclear, it is possible that crazy ants contributed through a range of mechanisms e.g. directly interfering with bats or young at roosts, excluding bats from their preferred roost sites, facilitating increases in potential predators such as giant centipedes (*Scolopendra subspinipes*), wolf snakes (*Lycodon aulicus*), cats and rats and reductions in invertebrate prey numbers (Schulz & Lumsden 2004; Lumsden et al. 2007; EWG 2010). There is no direct evidence that crazy ants significantly affect the Christmas Island flying-fox but they are considered a potential threat, with potential impacts being disturbance to roosting and foraging patterns including reduced fruit handling, tree death or reduced fruit and pollen production as a result of scale and sooty mould.

The impacts of crazy ants on native reptiles are unclear. There is observational evidence of lizards being killed by crazy ants; however, the persistence of some endemic lizards has previously been recorded in crazy ant supercolonies, suggesting that crazy ants are unlikely to be solely responsible for reptile decline across the island. Potential impacts may include direct predation and habitat alteration, and crazy ants facilitating increases in other potential reptile predators and/or competitors (Schulz & Barker 2008). While there are many direct impacts which are apparent in the short term, there is likely to also be a number of indirect impacts, such as changes in plant species composition due to differential mortality caused by scale host specificity, which may take many decades to manifest.

Crazy ants are likely to prey on a range of litter and canopy invertebrates but the impact of crazy ants and other exotic ants on native invertebrate fauna are not well understood. There is the possibility that some management activities undertaken to control crazy ants, such as the use of chemical baits, may also provide some risks to native species, if the risks are not managed effectively.

Given how widespread crazy ants are on the island, they represent a major threat and their effective management is essential to the recovery of many species on Christmas Island.

Cats

Major threat risk

Cats are considered a key threatening process affecting biodiversity on Christmas Island, as reflected by the relevant national threat abatement plan (DEWHA 2008). Cats became established on Christmas Island about 1904 and are now widespread and abundant (Algar & Johnston 2010). Surveys in 2008 suggested an index abundance of 1.34 cats per km along the vehicle survey route (Algar & Johnston 2010) but abundance across the island is unlikely to be uniform, with generally more cats (feral, stray and domestic) in settled areas such as around the island's tip site. While pet cats pose some threat to wildlife, feral and stray animals are of greater concern due to their higher numbers and capacity to reproduce (Shire by-laws introduced in 2010 require all pet cats to be de-sexed and registered).

Eight threatened species are identified as being at risk in part from impact by cats including the emerald dove, hawk-owl, thrush, Lister's gecko, blue-tailed skink, forest skink, Christmas Island blind snake and the flying-fox. Ground-nesting seabirds are also at risk; predation by cats, and also rats, at the silver bosun nesting colony at the Settlement area in 2005 and 2006 resulted in a nil survival rate of chicks in that colony (Algar & Johnston 2010). As part of a collaborative cat management program, approximately 450 feral cats were removed from settled areas of the island and surrounding forest areas, with survival of chicks at the Settlement nesting colony increasing to 66 per cent in response.

However, as studies into cat abundance have only recently occurred, it is difficult to determine at this stage the extent to which changes in the cat population affect mortality rates of native species, compared with other factors.

Rodents

Major threat risk

Two introduced rodent species occur on Christmas Island, the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*). On other oceanic islands, introduced rodents have had serious impacts on species including bats, seabirds, forest birds, native plants, reptiles and insects. Black rats were responsible for the extinction of native rats on Christmas Island through disease (Wyatt et al. 2008).

Along with cats, black rats are potentially implicated in the decline of species such as emerald dove, thrush, white-eye, silver bosun (through predation of eggs) and native reptiles. Rats may have also contributed to the decline of the pipistrelle.

Black rats are widespread across the island (but are more common in settled areas) and can be considered to be a potential threat across the entire island. Rat management at critical sites is likely to be important for the recovery of several species such as ground-nesting seabirds. However, further studies are required to assess the types and levels of impacts on native species before major control programs across the island are considered. This is because, unlike many other oceanic islands, the native fauna of Christmas Island included two endemic rodents with which other native species co-evolved. In addition, the ecological dominance of land crabs (especially red crabs) may play some role in limiting black rat numbers. House mice are found on the island but their distribution, numbers and impacts are not known.

Giant centipedes

Giant centipedes were introduced to the island around settlement. They became abundant by 1907 (Andrews 1909) and may have undergone further increases in the last 10 to 20 years. They are now found in all habitats across the island. Giant centipedes may predate on a range of native species, particularly native reptiles (Schulz & Barker 2008) such as the blue-tailed skink, Christmas Island blind snake and Lister's gecko. DNA studies in 2011 confirmed that centipedes feed on reptiles on Christmas Island but were inconclusive as to whether native or introduced species were consumed (Donnellan et al. 2011).

Giant centipedes have been observed climbing roost trees of the Christmas Island pipistrelle and similar centipedes in South America are known to catch small insectivorous bats (Lumsden et al. 2007). Giant centipedes are widespread and can be considered a threat across the entire island, especially given the evidence that they predate on reptiles.

Giant African land snails

The giant African land snail is listed in the top 100 of the world's worst invasive alien species (Lowe et al. 2000). They were probably introduced to Christmas Island as a food source during World War II (Sproul 1983). A reduction of the red crab population by crazy ants has increased the potential for snails to expand their range. The impacts of giant African land snails are not well understood but snails have been observed feeding on a wide variety of plants, and could potentially have impacts on listed threatened ferns and other plant species. Giant African land snails are widespread and can be considered to be a threat across the entire island.

Wolf snakes and other exotic reptiles

Five exotic reptile species have been accidentally introduced to Christmas Island since settlement—the Asian (or barking) house gecko (*Hemidactylus frenatus*), Pacific gecko (*Gehyra mutilata*), grass skink (*Lygosoma bowringii*), flowerpot snake and wolf snake. The wolf snake may have been introduced to Christmas Island from the north in the 1980s (Schulz & Barker 2008) and it was estimated to be in the many thousands by the early 1990s.

These exotic reptiles potentially threaten native reptiles. Wolf snakes are now found across the entire island including in evergreen tall closed forests. In other parts of its natural range it is often closely associated with human dwellings and gardens, feeding predominantly on geckos. On Christmas Island the wolf snake is known to threaten native reptiles via predation and may also be implicated in the decline of the pipistrelle. Analysis of wolf snake stomach contents in 2010 by DNP staff found blue-tailed skink remains and Lister's gecko was last seen in large numbers prior to the snake's introduction (Cogger 2005). The two introduced geckos and grass skink may have contributed to the decline of native reptiles through competition, while the flowerpot snake may compete with the endemic Christmas Island blind snake (Cogger 2006). There is also potential for introduced reptiles to spread disease amongst native reptiles.

Weeds

A survey of the exotic flora of Christmas Island in 1996 identified approximately 390 exotic species some of which are naturalised while others are under cultivation or in gardens as ornamentals (Swarbrick 1997). Of these species, 221 have been identified as posing a current or potential weed threat (DNP 2009a). Minesite rehabilitation in the 1970s and 1980s often included a wide range of exotic species but this practice has since been discontinued.

Weeds threaten the survival and distribution of native plants through competition for habitat space and resources which turn diminishes biodiversity and the integrity of ecosystems and reduces habitat for native fauna. High risk weeds on Christmas Island are those considered to pose the greatest threat or potential threat to endemic and native species. The weeds considered to be of highest management priority for control are Siam weed (*Chromolaena odorata*) and species that have or may be likely to invade shaded/intact rainforest (e.g. *Clausena excavata*). Siam weed was first detected in 2010 in a single site on the north south baseline on the north-east of the island; it is now thought to have been eradicated, subject to the results of further monitoring. Parthenium weed (*Parthenium hysterophorus*) occurs on the island and, while its distribution keeps changing, it may have some impact on rehabilitated sites.

Weeds are now particularly prevalent in highly disturbed areas including mine fields, roads and tracks and rainforest margins. Some weed species may also invade evergreen tall closed forests, semi-deciduous and deciduous thickets and there is recent evidence that some shade-tolerant sleeper weeds are now spreading into areas where they were previously not detected, making them a high risk to rainforests. One species of particular concern is *Clausena excavata*, which as well as being shade-tolerant is resistant to crab herbivory (Green et al. 2004).

Undisturbed evergreen tall closed forest is relatively resistant to weeds that require full or part sun, but the expansion of shade tolerant weeds into evergreen tall closed forest poses a serious threat. Undisturbed semi-deciduous closed forest is less resistant to weed invasion, as it provides niches and light for weeds to establish and spread. Weeds may appear below the frequent canopy gaps provided by tree falls. Disturbed rainforest, rainforest margins, roadsides and rehabilitated minesites are extremely susceptible to weed invasion (DNP 2009a).

The replacement and exclusion of various native understorey and canopy species by weed competition, shading or chemical suppression (allelopathy) can occur, especially when monocultures of species such as *Clausena excavata*, *Leucaena leucocephala*, *Delonix regia* and *Cordia curassavica* are allowed to dominate. Invasive weeds have the potential to affect the distribution of endemic and threatened flora species as well as other rare and threatened indigenous plants by direct competition for habitat space and resources (Holmes & Holmes 2002). Competition from invasive weeds may affect the three listed threatened ferns (*Tectaria devexa* var. *minor*, *Pneumatopteris truncata* and spleenwort). Weeds can threaten the integrity of ecosystems, especially if combined with other threatening processes such as habitat clearing and crazy ants (DNP 2009a).

Three invasive weed species may threaten the endemic Christmas Island frigatebird. The disturbed fringes of the Cemetery breeding colony may be at risk of being invaded by the coastal vine *Antigonon leptopus*, which can smother nest trees and restrict access by frigatebirds. *Leucaena leucocephala* has formed monocultural stands around the edges of some frigatebird nesting habitat, reducing recruitment of preferred native nest tree species (e.g. *Terminalia catappa*, *Celtis timorensis*). The spread of *Clausena excavata* throughout the Cemetery breeding colony has the potential to form monocultures, out-competing preferred nest tree species and thus reduce recruitment of nest trees (DNP 2009a).

Three invasive weed species may represent a threat to the endangered endemic Abbott's booby. The invasive vine *Mucuna albertisii* can form enormous vine towers in canopy gaps and forest edges; it occurs directly adjacent to existing nest sites and would exclude birds from trees that it smothers. The woody weeds *Clausena excavata* and *Aleurites moluccanus* have the ability to germinate in full shade under intact rainforest and are a potential threat to the survival of the bird's preferred nest tree species (e.g. *Planchonella nitida*, *Syzygium nervosum*, *Celtis timorensis*) (DNP 2009a). Invasive weeds also threaten the success of forest rehabilitation efforts, which is largely focused on rehabilitating Abbott's booby habitat.

The cliff-nesting habitat of silver bosun and brown boobies is threatened by the spread of *Antigonon leptopus*, particularly in settled areas. Weeds, especially newly introduced species, are a potential threat to the goshawk and hawk-owl as these could form vine towers over nesting trees (Hill 2004a, 2004b).

Invasive weeds may also cause localized impacts on other fauna species, including invertebrates, by changing vegetation structure and habitat values.

Introduction of new invasive terrestrial species

Major threat risk

As identified in the final report of the Expert Working Group (2010), many of the current biodiversity conservation problems on Christmas Island are due to introduced species, and the introduction of new invasive species could have catastrophic effects on the island's biodiversity. The past introductions of many exotic species that now threaten native species, are the result of previously inadequate biosecurity/quarantine measures or from deliberate introduction for human use. If additional invasive species are introduced and become established through inadequate biosecurity and/or eradication/response measures, then further declines of native species are anticipated.

4.1.2 Traffic-induced mortality and disturbance

Major threat risk

Red and robber crabs are frequently killed on the island's roads and, while measures are taken to reduce impacts on crabs, substantial mortality still occurs. The construction and operation of the IDC has greatly increased vehicle traffic on the island, leading to large increases in red and robber crab mortality. This is particularly an issue on Murray Road because of the high numbers of crabs and high traffic volumes.

Based on surveys, 425,000 red crabs were estimated to have been killed by vehicles during the IDC's construction phase in 2005–06 and losses following commencement of the IDC's operation continued to be significant. Although no formal surveys have been conducted since 2005–06, it was estimated that vehicles killed at least 400,000 red crabs in 2010 however more effective road management activities (including closures) undertaken since then have led to reductions. A study of robber crab mortality recorded 854 deaths from vehicles in 2010, 667 deaths in 2011 and 677 deaths in 2012 (DNP unpub. data).

There have been previous reports of road mortalities of other species, including the hawk-owl, pipistrelle, emerald dove and swiftlet. Increased traffic has also led to a reduction of use of nests by the goshawk in habitat near roads. The level of mortality or disturbance on these and other species is unknown but it is not considered to be a major threat.

4.1.3 Habitat disturbance and loss

Major threat risk

Christmas Island has a long history of vegetation and habitat disturbance, most notably as a result of phosphate mining and settlement. Mining commenced in 1898 and vegetation clearing reached a peak with a 1969 grid line survey in which vegetation was cleared across the island in a grid of lines up to nine metres wide and 20 to 30 metres apart (Corbett et al. 2003). Additionally, during the 1970s, all existing mining leases were completely cleared by the British Phosphate Commission.

Approximately 25 per cent of the island's original rainforest has been cleared. Further removal of previously uncleared primary rainforest could be a major threat to several significant species. Clearing for mining up to 1987 resulted in the removal of approximately one-third of the primary rainforest nesting habitat of Abbott's booby (Reville et al. 1987) as well as critical habitat for other species. In addition, the resulting mosaic of cleared and forested areas allowed wind to enter the canopy causing increased turbulence particularly in areas downwind of clearings, resulting in higher adult mortality and lower breeding success of Abbott's booby (Reville et al. 1987, 1990). Clearing not only results in habitat loss but can also increase the spread of introduced species, such as weeds. Habitat removal arising from past clearing (whether through mining, road construction or other activity) may have also impacted on the spleenwort, *Tectaria devexa* var. *minor*, *Pneumatopteris truncata*, goshawk, hawk-owl, shrew and flying-fox. Further removal of previously uncleared rainforest would potentially threaten these and other species, in particular Abbott's booby and the Christmas Island frigatebird, through direct impacts and/or by reducing the area of their critical habitat.

Mining conducted by CIP under the previous and renewed mine lease only occurs on areas that have previously been cleared of their original native vegetation and that now contain a mix of secondary regrowth native vegetation and weeds. As primary/tall evergreen rainforest is not now cleared for mining, mining on existing leases is not generally considered to be a major threat when compared to the removal of previously uncleared primary rainforest or other threats, particularly existing and new invasive species. While mining (or other forms of land clearing) on secondary regrowth areas may have local impacts, these impacts may be mitigated to some degree by, for example, timing works on specific sites to avoid the red crab migration or seabird nesting times.

Figure 2 illustrates the land tenure on the island and the areas of mining lease illustrate the locations where clearing for mining has occurred. Similarly other developments, such as new buildings, that involve clearing of secondary regrowth areas (i.e. that have previously been cleared) may not pose a major threat to threatened species if any negative impacts can be mitigated or reduced. However, such proposals may need to be assessed under the environmental referral and assessment provisions of the EPBC Act and these provisions apply regardless of this plan (see Part 1.5 of this plan for details).

4.1.4 Pathogens, disease and parasites

The extent by which introduced pathogens, disease and parasites currently impact on native species is poorly understood, although there is some evidence of their impact and/or presence, including their role in past extinctions.

The disease-causing parasite *Trypanosoma lewisi* carried by black rats and transmitted by fleas has been demonstrated as the cause of extinction of Christmas Island's endemic Maclear's rat in the early 1900s (Wyatt et al. 2008) and possibly also the endemic bulldog rat. A study by Adams et al. (2008) showed that Christmas Island's cats contained a number of parasites, most commonly *Toxoplasma gondii*, but their impacts on native species on Christmas Island are not known.

In 2011 the DNP contracted Taronga Zoo to undertake an assessment of disease prevalence in native and invasive species (Hall et al. 2011). While this assessment did not identify any major known disease threats, it is still possible that disease may have an impact on blue-tailed skink, giant gecko, coastal skink, forest skink, Lister's gecko, Christmas Island blind snake and the flying-fox. There is a potential that disease also contributed to the decline of the shrew.

While not currently a major issue, the introduction of any avian diseases has the potential to impact all the land birds of Christmas Island. Disease may also impact on plant health but there is little information in relation to the impact of potential diseases on Christmas Island's flora.

4.1.5 Climatic impacts

Cyclones and storm events

Christmas Island currently does not experience frequent cyclones though occasional severe tropical storms or cyclones do occur. These events can impact on forest ecosystems through the creation of light gaps that may be invaded by weeds, and damage to coral reef systems. A 1988 cyclone blew Abbott's booby chicks from their nests resulting in their death (Reville et al. 1990). The same cyclone may have had a serious impact on the flying-fox and frigatebird populations (Corbett et al. 2003). Cyclones and storm events are naturally occurring events and disturbance may provide some ecosystem benefits e.g. through new native plant regeneration in forest canopy gaps. However, climate change may affect the frequency and/or intensity of cyclones and storm events and increase the scale or frequency of forest disturbance, thereby increasing the vulnerability of vegetation patches to other threats, particularly weed invasions.

Climate change

Changing climatic conditions may include less predictable onset of the monsoon season, more prolonged dry spells and increased intensity of storms (Hyder Consulting 2008).

Species and communities most at risk from the impacts of climate change include:

- fern species, including listed threatened species, that might be susceptible to changes in rainfall
- semi-deciduous forest on shallow soil that may be put under water stress through prolonged dry spells
- seabirds, which might be sensitive to changing oceanic conditions and coral reef systems
- red, blue and robber crabs, as well as other land crabs.

Some of the effects of climate change could include exacerbation of other threats:

- changes to vegetation resulting from drier conditions might result in conditions more susceptible to wildfire, particularly on the coastal terraces and in areas of semi-deciduous forest
- increased cyclone frequency or intensity may result in forest canopy tree losses and increased opportunities for weed invasion of forest canopy gaps.

4.1.6 Chemical use

A range of fuels, oils and chemicals, including chemicals used for controlling invasive species like crazy ants, weeds and rodents, could potentially have impacts on native species and their habitat.

Fipronil bait is currently the only known effective broadscale means of controlling crazy ants on Christmas Island (EWG 2010) and is only used to bait crazy ant supercolonies. Fipronil may exist in a number of metabolite forms of significant toxicity and are a potential threat to native species. However, studies of Fipronil use on Christmas Island have not detected any significant off-target impacts or accumulation of Fipronil in the environment (CESAR Consultants 2011, 2013) and delivery methods are routinely employed which minimise its known or potential impacts (Boland et al. 2011). For example, baiting is done in the dry season when crab activity and rainfall is low; robber crabs are physically removed or food lures are used to attract them away from areas that are to be baited; and baiting does not occur near the ocean or wetlands.

The indiscriminate use of second-generation rodent poisons as part of rodent control activities is a potential threat to predatory species through secondary poisoning; species particularly at risk include the goshawk, the hawk-owl and the robber crab. Heavy metal poisoning (including from drinking at contaminated sites) is an unknown but potential threat to a number of species including the Christmas Island frigatebird and the flying-fox.

4.1.7 Small population size

Current small population size is a potential risk to the long-term survival of a number of declining species due to, for example, inbreeding or vulnerability to threatening processes. The fern *Tectaria devexa* var. *minor*, hawk-owl and native reptiles are prime examples.

4.2 Likely or potential threatening processes

4.2.1 Introduced species

Other introduced invertebrates

In addition to crazy ants, Christmas Island has been invaded by many other tramp ant species (Framenau & Thomas 2008), some of which may be potential sleeper species. These sleeper species may, under appropriate conditions, become as threatening as other invasive species on the island. A species of high concern is the big-headed ant (*Pheidole megacephala*).

There are numerous species of other exotic invertebrates on Christmas Island which could pose significant threats to native species. For example, a high number of introduced land snails (Kessner 2006) have been recorded and feral honeybees (*Apis mellifera*) were identified as a potential threat to the pipistrelle (Lumsden et al. 2007). Bees may also threaten nesting seabirds and land birds. However, in general the potential impacts of exotic invertebrates (other than those already identified as threats) are poorly understood.

Introduced and self-introduced birds

Feral fowl (*Gallus gallus*) are common in settled areas and occur in and around the fringes of rainforests. Their impacts are unknown, but they may have direct impacts through predation on some native invertebrate species such as land snails and may provide a vector for diseases that pose risks to native birds. Java sparrows (*Lonchura oryzivora*) were introduced between 1908 and 1923 and tree sparrows (*Passer montanus*) were a ship-assisted introduction in the 1980s (Johnstone & Darnell 2004). Both species are established around the settled areas. Their impacts are not known, but they may compete with white-eyes particularly in settled areas.

The Nankeen kestrel self-colonised between 1940 and 1950 and is now common in settled and cleared areas. There is no evidence that it is having an impact on threatened species, but large insects and lizards, including the forest skink, form part of its prey elsewhere in its range and it is known to prey on the Christmas Island swiftlet (Lumsden et al. 2007).

Introduced fish

Several introduced freshwater fish are found on Christmas Island including the Asian bony tongue (*Scleropages formosus*), tilapia (*Oreochromis* spp.), guppy (*Poecilia reticulata*), mosquito fish (*Gambusia affinis*), and swordtail (*Xiphophorus maculatus*) (Humphreys & Eberhard 2001). Some of these species are potential threats to native fauna, including fauna in anchialine systems.

4.2.2 Water use and condition

Christmas Island's wetland ecosystems and stygofauna depend on groundwater flows while anchialine ecosystems and their fauna depend on the balance between fresh groundwater flow and the underlying intrusion of marine water. Almost all water used for human purposes on Christmas Island is groundwater. Over recent years there has been an increasing pressure on water resources due to an expanding population. If climate change does result in reduced rainfall, reductions in available water that recharges groundwater systems may occur. Although some monitoring bores are established, there is no detailed groundwater model or adequate monitoring program for the extraction of groundwater (EWG 2010). Therefore, the level of usefulness of present groundwater use monitoring in determining human impacts on the environment is unknown (EWG 2010). This is a major knowledge gap, as groundwater extraction resulting in a decrease in flow and loss of permanent surface water has been described as a threat to both The Dales and Hosnies Spring (Hale & Butcher 2010, Butcher & Hale 2010). Assessed as having a medium likelihood of occurring, the result could be a change in the wetland type, and a loss of mangroves and blue crabs.

4.2.3 Impact of recreational activities

Christmas Island's unique natural heritage provides tourists, visitors and residents with opportunities to participate in a range of recreational activities, which can also help promote appreciation and understanding of the island's natural conservation values. However, if recreational activities and/or visitor sites are poorly or inappropriately managed, these activities could pose a threat to native species and their habitat e.g. visitors impacting on plant regeneration in sensitive sites such as wetlands.

4.2.4 Fire

Forest fires are not currently regarded as a major threat on Christmas Island. However, if dry seasons become more severe or more frequent as the climate changes, or forest vulnerability increases because of increased forest complexity and fuel loads through red crab removal, then impact from fires may become an issue for many species that are not adapted to fire (EWG 2010). Fire is a potential threat to the Christmas Island spleenwort, *Tectaria devexa* var. *minor* and *Pneumatopteris truncata* and could also be a potential threat to other species in the future.

4.2.5 Threats or changes to marine habitat

Disturbance to, and/or changes in the condition of, the marine environment beyond the territorial waters of Christmas Island may affect significant terrestrial species.

Over-fishing, direct interaction with long-line fishers or interaction with lost fishing gear are potential threats to seabirds. Research (Hennicke 2007) suggests the foraging success of Abbott's booby is dependent on subsurface predators such as yellowfin tuna (*Thunnus albacares*) and billfish forcing potential prey fish close to the water surface. Over-fishing of predators may pose a risk to the Abbott's booby, Christmas Island frigatebird and other seabirds through reduced access to prey species.

Other potential marine threats which may affect significant terrestrial species include:

- changes in marine conditions, for example sea temperature and currents may lead to sustained increases in mortality of immature stages of land crabs
- marine pollution which is a global threat to seabirds and therefore a potential threat to Abbott's booby, Christmas Island frigatebird, golden bosun and other seabirds
- changes in sea surface temperature could affect the Christmas Island frigatebird, Abbott's booby and golden bosun.

Marine changes and threats are beyond the scope of this plan.

4.2.6 Extralimital hunting of seabirds

As migratory species, hunting in areas outside Christmas Island such as Indonesia is a potential threat to Abbott's booby and Christmas Island frigatebird. As the terrestrial range within Australia for each species is currently restricted to Christmas Island and this threat does not occur on Christmas Island, actions to abate this potential threat are not included.

4.3 Processes considered and determined not to currently be a threat

4.3.1 Predation or disturbance by dogs

A small number of pet and feral dogs (*Canis familiaris*) are present on Christmas Island. Their impact on the island's native fauna has not been measured but their direct impacts are not thought to currently be significant.

4.3.2 Overfishing and hunting within the Territory of Christmas Island

Recreational fishing, including charter fishing, is a popular activity on Christmas Island. Generally, deepwater marine species rather than reef species are targeted (Brewer et al. 2009). Currently fishing does not appear to be impacting on fish stocks or coral reef health, but changes in fishing intensity could reduce stock sizes of some species due to small population size, the small amount of coral reef habitat and the island's isolation (Gilligan et al. 2008). Over-fishing of reef species could result in the local decline of some species, particularly as re-colonisation from other seeding reef sites may be difficult (Gilligan et al. 2008). Overfishing may have a subsequent impact on seabirds such as Abbott's, brown and red-footed booby. However, while fishing can impact on seabirds, impacts are more likely to be associated with increases in commercial fishing outside of territorial waters rather than recreational fishing for local consumption.

Imperial pigeons, flying-foxes, robber crabs, blue crabs and turtle eggs were commonly taken for food in the past but hunting is now considered rare or not to occur and therefore is not considered a threat. However, small takes of robber crabs are still thought to occur.

4.3.3 Illegal collecting

In some areas of Australia illegal collection of ferns and/or orchids is considered a threat or potential threat to these taxa, particularly when a species is desirable to collectors and the plant population small and restricted. Illegal collecting was regarded as a potential threat to the Christmas Island spleenwort and the fern *Tectaria devexa* var. *minor* at the time their respective recovery plans were drafted (Butz 2004a; 2004b). On Christmas Island illegal collection of plants is considered rare or not to occur.

Part 5—Overview of previous and existing biodiversity management

Although Christmas Island has faced substantial conservation challenges and biodiversity decline over recent decades, there have also been some significant achievements and programs for the conservation, recovery, restoration and monitoring of Christmas Island's native species and ecosystems. The major recovery programs that had recently been or were being implemented at the time of preparing this plan are described below. Appendix J summarises and reviews the existing recovery plans and provides the status of recovery actions to which these programs have contributed.

As identified by the Expert Working Group report, the lessons from the pipistrelle must be applied to other species. The early recognition of the rapid change in the island's ecological function in the mid-1990s should "have initiated an urgent and comprehensive review followed by management actions" (EWG 2010). As described in Appendix J, a number of the single species recovery plan monitoring actions have not been undertaken, or the monitoring which has been undertaken was not able to provide appropriate information on species' population trends, distributions and sizes. It will be important to continue and build on the regular Island Wide Survey (IWS) and the integrated species surveys to ensure that regular monitoring is conducted to collect the appropriate information, and that the outcomes of this are used to adapt management practices.

The Expert Working Group emphasised the need for adaptive management to be a stronger focus of recovery plans. Robust monitoring processes and timely analysis are required to ensure the results of monitoring are effective in shaping decisive management actions. While this plan will be reviewed within five years, the results of the IWS and other monitoring programs must be used to routinely consider appropriateness of actions and to alter management and control actions.

5.1 Management of threats

5.1.1 Introduced species

Crazy ant control

To provide scientific advice for the management of the crazy ant control program, the Crazy Ant Scientific Advisory Panel was formed by the DNP and relevant researchers. Crazy ant baiting using Fipronil, including aerial baiting in 2002, 2009 and 2012, has been conducted by the DNP and since 2001 a biennial IWS has been used to monitor red crab distribution and abundance; map the distribution of crazy ant supercolonies and to help plan and assess the success of baiting programs. Post-bait monitoring shows that crazy ant numbers in supercolonies are reduced by at least 99 per cent immediately after baiting. However, over time supercolonies can form again. As part of the 2009 and 2012 baiting programs, studies were conducted to assess the off-target impacts of baiting with Fipronil bait (CESAR Consultants 2011, 2013). These studies showed that Fipronil bait did not accumulate in the environment and no off-target impacts were detected. Although the impact on robber crabs was not specifically tested, a baiting strategy uses food lures to attract robber crabs away from areas to be baited. In 2009 the DNP contracted La Trobe University to undertake a three-year research project for the feasibility of indirect biological control of crazy ants. In 2011 the DNP expanded crazy ant control measures, including further biological control research and investigation of alternative control methods, as part of a suite of integrated control options. Eradication of crazy ants from Christmas Island is not considered possible, so sustained control or suppression of supercolonies is essential.



In 2009 CIP commenced boric acid bait station trials for crazy ant control and published the results of these studies in 2012 (Stewart et al. 2012). These trials involved the use of a fluid form of boric acid (borax) contained within a bait dispenser, covered with a wire mesh to minimise the likelihood of crabs taking borax bait as well as damaging the bait dispenser. While this method may not be suitable for the landscape scale control of crazy ants, it is potentially suitable for targeted control of crazy ants in sensitive areas like wetlands.

Cat and rat management

The Shire of Christmas Island has a range of requirements for owners of domestic cats to ensure the threat posed by cats is appropriately managed (SOI 2007). These include:

- owners must apply for a permit to keep a cat
- cats must be sterilised
- cats must be able to be identified
- cats can be impounded if found by the Shire Ranger
- cats are not to be abandoned.

Under the current service delivery agreement between the Commonwealth and the WA government, the provisions of the WA *Cat Act 2011* apply.

As part of a collaborative national project, in 2008 and 2009 trials were conducted on Christmas Island to assess the efficacy of the Curiosity® feral cat bait. Trials showed that the bait and baiting strategy was effective at controlling feral cats with an 87 per cent decline of cats in areas trialled (Johnston et al. 2010). Following these trials feral cat management efforts on Christmas Island increased.

In 2010 SOCI and DNP coordinated the preparation a cat and black rat management plan (Algar & Johnston 2010), which was supported by CIP and prepared for SOCI by consultants funded by Territories Administration. Initial implementation of the plan comprised the introduction of new Shire by-laws for pet cat ownership in 2010 which include the prohibition of imports of new cats onto the island and compulsory de-sexing (jointly funded by SOCI, Territories Administration, CIP and DNP). A total of 152 pet cats were registered and de-sexed and there has been positive community support for the program. Under stage 2 of the plan, approximately 500 feral cats were removed from settled areas via a collaborative control program from 2010 to 2013. Rat control has also been conducted in selected seabird nesting sites around the Settlement area.

Weed management

A weed management plan for 2005 to 2010 was prepared for the island, and updated to cover 2010 to 2015 (DNP 2009a). This plan outlines the strategy for weed management on the island. Significant weed management efforts are associated with the CIMFR program to control weeds affecting the regeneration of native plants. In addition to weed control undertaken as part of the CIMFR program, weed control work over an area of 250 hectares was conducted from 2006 to 2009 via funding from the Natural Heritage Trust, primarily on the plateau areas. Other weed management programs include a control program for parthenium weed conducted by the WA Department of Agriculture and Food (DAFWA) under a service delivery arrangement with Territories Administration.

In 2010 Siam weed was first detected on Christmas Island. If established it could severely affect the island's forests, especially rehabilitated forests. Efforts by the DNP, in combination with DAFWA, have resulted in the eradication of the single known infestation but regular surveys are needed with possible follow-up control.

Other island stakeholders, such as the Shire, also conduct weed management activities, although these are largely for amenity rather than conservation focused outcomes and CIP is also expected to conduct some weed control on its mine leases.

Quarantine/Biosecurity

There has been an Australian government quarantine presence on the island since 1994 and in 2004 quarantine legislation—*Quarantine (Christmas Island) Proclamation 2004*—came into force under the *Quarantine Act 1908*. This legislation allows the import of some species by permit.

The Australian Government Department of Agriculture carries out quarantine and biosecurity services under a service delivery arrangement with Territories Administration. Services conducted under this arrangement include screening of airport passengers and freight, inspections of ships and ship cargo and regulating plant and animal imports.

In 2000, a survey of the island found a number of target or highly invasive plants that are a threat to the Australian mainland. This is a result of the island's close proximity to South-East Asia and the lack of robust quarantine presence on the island.

In 2010, the final report of the Expert Working Group identified biosecurity hazards as a major threat to the island's native species and their habitats. In addition to the maintenance and review of quarantine, the Expert Working Group recommended that quarantine management be upgraded to a standard consistent with the island's biodiversity values (EWG 2010). In response to the recommendations in the EWG report, Parks Australia and the Department of Agriculture have commenced an examination of biosecurity procedures and requirements (refer to Action 2 in Section 6.3 of this plan).

5.1.2 Mitigating vehicle impacts on red and robber crabs

The DNP and relevant stakeholders, including SOCI, implement strategies to reduce the numbers of red crabs killed by vehicles during their early wet season breeding migration. Specially designed crab underpasses and fences have been constructed on some roads along main crab migration routes to channel crabs safely under the road. Some roads within and outside of the national park are also closed during the migration. Education and awareness-raising activities are also conducted. Regular migration updates are provided to the community by Parks Australia and a local conservation group 'Island Care' has prepared red crab protection road signs. Christmas Island District High School and a visiting school have prepared signage to promote the conservation of red and robber crabs. In recent years the Christmas Island community has played a significant role in the protection of crabs during the red crab migration. This includes some community members actively removing crabs from roads during times of high red crab movements and supporting other red crab protection activities, such as road management activities.

Other organisations, such as DIBP, also promote awareness of issues associated with crab deaths from vehicles amongst their staff, and CIP also has a red crab management plan to reduce the impacts of their operations on migrating red crabs.

In 2010 the DNP developed a program to monitor and raise awareness of robber crab mortality from traffic. Although this program has helped to reduce crab deaths, mortality continues to occur and it is essential to maintain education activities, as well as other impact reduction measures, including setting and enforcing of appropriate vehicle speed limits. The Australian Federal Police (AFP) has supported the DNP to reduce red and robber crab deaths, for instance, by promoting driving techniques that help maximise driver safety and minimise crab deaths and enforcing speed limits.



5.1.3 Minimising the impacts of human activities

Under the EPBC Act there are processes for assessing the impacts of proposed actions that may have an impact on matters of national environmental significance. In addition WA vegetation clearance legislation applies to Christmas Island. Refer to Part 1.5 of this plan for details.

CIP operates under a mining lease granted by the Commonwealth in 1997 which was approved under the *Environmental Protection (Impact of Proposals) Act 1974*. A renewed lease was granted in 2013. The previous and renewed mine lease includes conditions to:

- not clear, degrade or damage any primary rainforest on Christmas Island
- comply with all requirements of an Environmental Management Plan
- pay a conservation levy to the Commonwealth for the rehabilitation of mining leases on Christmas Island
- implement a dust suppression program.

5.1.4 Climate change

Both the Territories Administration and Parks Australia have prepared a number of strategic documents on the impact of climate change on Christmas Island. The Indian Ocean Territory Climate Change Risk Assessment (AECOM 2010) assesses the risk associated with the future impacts of climate change on Christmas Island. It includes an assessment of the impacts on the economy, tourism, infrastructure, as well as ecosystems and biodiversity. The report can be used as a guide to future decision-making.

Parks Australia has established five objectives which focus the work of each park in regards to climate change (DNP 2009b):

- To understand the implications of climate change.
- To implement adaptation measures to maximise the resilience of the reserves.
- To reduce the carbon foot print of the reserves.
- To work with communities, industries and stakeholders to mitigate and adapt to climate change.
- To communicate the implications of, and the management response to, climate change.

The Christmas Island National Park Climate Change Strategy 2011–2016 (DNP 2011b) outlines the likely impacts of climate change on the national park and includes a series of actions built around the above objectives.

5.2 Species and ecosystem recovery and management

5.2.1 Minesite to forest rehabilitation

The Christmas Island Minesite to Forest Rehabilitation (CIMFR) program is conducted by the DNP through an agreement with Territories Administration, and is funded by a conservation levy paid by CIP to Territories Administration. In 2012 a long-term CIMFR program plan was prepared which outlines the priorities and approaches for the program from 2012 to 2020 (DNP 2012g).

Rehabilitation work undertaken by the program aims to “establish a tall, dense native forest tree canopy with a similar species composition and structure to that of the surrounding forest, to help mitigate wind turbulence impacting Abbott’s booby nesting sites” (DNP 2012g). Priority areas selected for rehabilitation are based on three main criteria (DNP 2012g):

- the fauna conservation priorities and potential for the recovery of their habitat
- the conservation value for vegetation and landscape priorities
- the economic and logistical feasibility of rehabilitating sites.

In addition to Abbott’s booby, other native species which also benefit from the forest rehabilitation works are land crabs, particularly red crabs; forest birds, including the Christmas Island hawk-owl, goshawk, white-eye, emerald dove, imperial pigeon and thrush; and a number of tall evergreen forest flora species.

Many former minesites have been colonised by weeds which have the potential to invade adjacent forest. The CIMFR program contributes to a functioning forest ecosystem by providing adequate soil depth and sufficient plant biomass to allow the recolonisation of red crabs and restoring forest areas which in the long-term will provide emergent trees suitable for Abbott’s booby roosting and recolonisation. Experience to date indicates that the rehabilitated sites become self-sustaining after seven to ten years.

In the context of the CIMFR Program, rehabilitation refers to the establishment of ecological attributes and function approaching native forest within the first decade. Key parameters include (DNP 2012g):

- development of forest vegetation structure (a canopy height of greater than eight metres and a canopy cover of greater than 80 per cent)
- high plant species richness (greater than 30 species on site)
- recruitment of local flora species (greater than 5000 individuals per hectare)
- nutrient cycling (leaf litter breakdown and organic matter build-up in soil)
- food web productivity and return of native fauna (e.g. land crabs, forest birds and Abbott’s booby).

Rehabilitation work on Christmas Island has involved numerous aspects including seed collection, nursery operation, earthworks, soil replacement, tree planting, fertilising, track maintenance and particularly weed management. Between 1998 and 2012, 200 hectares have been rehabilitated through the program, and approximately a further 450 hectares of high conservation area may have rehabilitation value and feasibility/potential. Details of monitoring proposed for this program are outlined in the rehabilitation program plan (DNP 2012g).

Standard minesite rehabilitation practice now includes:

- rebuilding the landscape, replacing soil and planting a range of native plant species
- controlling weeds in rehabilitated sites until native plants dominate and are self-sustaining
- maintaining and developing good nutrition balances and cycles within rehabilitated sites until native plants become self-sustaining
- conducting biophysical monitoring to assess the effectiveness of rehabilitation efforts
- prioritising the selection of sites to those with the greatest conservation benefit potential and that are cost effective to rehabilitate
- preparing and adaptively implementing a long term rehabilitation plan and securing associated funding.

5.2.2 Wetlands

In 2010 Ecological Character Descriptions (ECDs) were prepared for Christmas Island's two declared Ramsar wetlands, The Dales (Butcher & Hale 2010) and Hosnies Spring (Hale & Butcher 2010). The ECDs describe the wetlands' ecological character and threats likely to impact on their ecological character, as well as the monitoring required to enable changes to their ecological character to be detected. While no specific on-ground actions have occurred in relation to wetlands, conservation activities in or adjacent to wetland areas will help maintain native flora and fauna of wetland areas. For example crazy ant control will help maintain red crabs across the whole island, and Siam weed control will reduce the risk of spread into wetlands.

5.2.3 Native reptile recovery

In 2008 the DNP funded a terrestrial reptile survey of Christmas Island (Schulz & Barker 2008). The results of this survey led to increased recovery efforts for a number of reptile species from 2009. These have involved developing and implementing a captive breeding program for several species; increasing public awareness; increased and more robust monitoring; and investigation of threatening processes, particularly invasive fauna species and disease. A reptile advisory panel established in 2011 provides advice to DNP on activities for the recovery of Christmas Island terrestrial reptiles.

The reptile recovery program has included the establishment of a successful island-based captive breeding program for two native species (blue-tailed skink and Lister's gecko). In 2011 the captive breeding program was extended off-island in partnership with Taronga Zoo.

In 2010 Taronga Zoo was contracted by DNP to provide services for assessing disease threats to native reptiles. Results of this work did not indicate that disease was a threat; however, ongoing monitoring of disease threats for native reptiles and other species is likely to be needed (Hall et al. 2011).

5.3 Research and monitoring

5.3.1 Research

Christmas Island National Park is or has been involved in several research collaborations which have contributed to increasing understanding and supporting the management of native (and invasive) species and their habitats (Table 8). Major research projects undertaken since 2007 include the impact of crazy ants; the foraging ecology of the Abbott's booby; the efficacy of the Curiosity® feral cat bait; taxonomic study of the Christmas Island shrew; and crazy ant biological control.

Despite research, there are still gaps in knowledge in areas such as the impacts and control of crazy ants, the population trends and ecology of significant species, threats to declining species, groundwater resources, the ecology of crabs, vegetation classifications, cave fauna and invertebrates.

Table 8: Some research studies conducted on Christmas Island since 2002

2002	Survey of plants of conservation concern (Holmes and Holmes)
2003	Island wide survey (IWS) PhD on crazy ants (Abbott's booby)
2005	Island wide survey (IWS)
2006-07	Goshawk monitoring (Holdsworth) Pipistrelle survey (Lumsden et al.) Investigation of the foraging ecology of Abbott's booby (conducted in conjunction with Hamburg University) Island wide survey (IWS)
2008	survey of native reptiles (Barker and Schulz) Marine resources study (Gilligan et al.) Biodiversity monitoring program Efficacy trial of the Curiosity® feral cat bait as part of a national trial program
2009	Monitoring for the Christmas Island pipistrelle Taxonomic study of the Christmas Island shrew Surveys for the pipistrelle (Australasian Bat Society) Island wide survey (IWS) Borax bait station trials for crazy ant control commence (CIP)
2010	Development of Ecological Character Descriptions (ECDs) for The Dales and Hosnies Spring Ramsar sites Expert Working Group final report Crazy ant biological control research commences (La Trobe University) Robber crab vehicle impact study commences (DNP) Studies to inform cat and rat management (WA Department of Environment and Conservation in partnership with the DNP and SOCI)
2011	Disease investigation by Taronga Zoo Fipronil impact assessment (CESAR Consultants) Island wide survey (IWS) Studies to inform cat and rat management continued (WA Department of Environment and Conservation in partnership with the DNP and SOCI) Research papers on red crab, Abbott's booby, crazy ant management published
2012	Targeted survey for flying-fox (DNP/consultant) Targeted survey for hawk-owl (DNP/consultant) Targeted survey for native reptiles (DNP) Expert-based conservation workshop for flying-fox Research papers on reptiles published
2013	Completion of crazy ant biological control research Island wide survey (IWS) Targeted survey for flying-fox (DNP) Targeted survey for hawk-owl (DNP) Fipronil impact assessment (CESAR Consultants)

5.3.2 Monitoring



A range of biodiversity and threatened species monitoring programs are conducted by independent researchers, universities, the DNP and other government and non-government researchers. These programs include sea and land bird population studies; land crab population studies; studies of invasive species distribution and abundance; and biodiversity monitoring including through the Island Wide Survey (Table 8).

Biophysical monitoring under the CIMFR program commenced in 2005 and collects data on tree diversity and growth as well as soil properties. The results of this monitoring program will be analysed over the next few years. The IWS has been conducted every two years since 2001 and includes data collection at approximately 900 waypoints. Data collected include red crab burrow distribution and abundance and distribution of crazy ant supercolonies. Data are also collected on the occupancy (distribution and presence) of other native and invasive species. The Biodiversity Monitoring Program (DNP 2008b) collected baseline data prior to the construction of the IDC, including Abbott's booby nesting sites adjacent to the centre. Surveys have also been conducted of disturbed sites to identify areas of weeds requiring treatment.

5.4 Communication

To assist in residents and visitors appreciating the values of and impact of threats to the Island's biodiversity, a number of community and visitor education programs are conducted:

- activities for the annual Bird Week which are coordinated by the Christmas Island Tourism Association
- presentations on national park conservation programs for residents and visiting cruise ships
- production of information such as brochures and maps that record the number of robber crabs killed by vehicles
- education activities at the school for example by CINP staff and WA Fisheries
- education activities provided by visiting researchers and scientists
- commercial tour activities conducted by individual tour operators.

5.5 Marine conservation

The Territories Administration has service delivery arrangements with the WA Department of Fisheries that include marine pest monitoring and management of fishing, including educational and awareness-raising activities. Research and monitoring of coral reef condition, threats (e.g. disease and bleaching) and diversity, including studies of hybrid fauna, has been conducted by independent researchers. In 2009 a study to assess the conservation values of Commonwealth waters of Christmas and Cocos (Keeling) Island territories was completed (Brewer et al. 2009). This study may be used to help with potential marine protection planning in the future.

Volunteers, including 'Island Care', occasionally conduct beach clean ups of Greta Beach in order to protect green turtle nesting habitat. Another outcome of this program is increased awareness in the community regarding the impacts of marine debris on wildlife.

The various marine conservation actions described are not directly focused on the recovery of species identified under this plan, as they are aimed at the conservation and management of marine biodiversity and resources. However, marine conservation actions may contribute to conserving species covered by this plan, such as seabirds, that rely on both terrestrial and marine environments.

Part 6—Objectives and actions

6.1 Objectives

The long-term vision for the natural environment of Christmas Island is:
Resilient ecosystems with self-sustaining populations of native species

The vision is only achievable through ensuring no further species decline to the point where they become threatened and eligible for listing as threatened species under the EPBC Act.

This plan has been designed to cover a 10-year timeframe and the plan's objectives have been developed to progress towards the long-term vision.

The biological objectives within the timeframe of this plan are to:

1. Maintain the ecological integrity of forest ecosystems.
2. Maintain or increase populations of significant species.
3. Maintain the ecological character of Ramsar wetlands.
4. Contribute to maintaining groundwater ecosystems.

The following underpinning objectives are essential in order to achieve the biological objectives. These are to:

5. Increase community and stakeholder understanding of, and engagement in, the recovery of ecosystems and native species.
6. Effectively coordinate and implement actions to address threatening processes and recover ecosystems and native species.



As recovery actions are implemented, progress in meeting the biological objectives will be assessed using performance criteria. The performance criteria and their relevance to each objective are described below.

Objective 1: Maintain the ecological integrity of forest ecosystems

This objective is focused on forest ecosystems that support significant species. In order to function as habitat these systems need to contain an appropriate assemblage of species and suitable structural elements and have low levels of threat (such as from invasive weeds and animals). The highest priority areas—most important for significant species—are previously uncleared/intact native vegetation and other habitats identified as being critical to the survival of significant species, and areas identified as a high priority for rehabilitation. Maintaining a large red crab population across the island is vital to shaping and maintaining the island's forests, and influences the survival of a range of native species.

Expected outcomes for this objective and measures to determine outcome achievement are:

Expected outcomes	Performance criteria	
1. Invasive animals and weeds do not threaten forest ecosystems	1	Crazy ant supercolonies cease to form
	2	Threat risk* of invasive weed species in previously uncleared/intact native forests/vegetation decreases
	3	No new high risk invasive animal or weed species (as identified in actions 2.3) become established
2. The structure and species composition of forest ecosystems is maintained	4	Red crab population numbers are maintained or increase when compared to the population number from the 2011 Island Wide Survey
	5	The number of Island Wide Survey sites at which red crabs are recorded is maintained compared to 2011 levels
3. Rehabilitated areas provide habitat for significant native species	6	High priority areas are rehabilitated with native flora that is self-sustaining 7–10 years after planting
	7	Red crab burrows are recorded in rehabilitated forest sites after five years and the number of burrows increases after 10 years

The main actions contributing towards achieving these outcomes are threat abatement (Actions 1, 2, 3).

Objective 2: Maintain or increase populations of significant native species

This objective addresses all significant species (as defined in Part 3.2 of this plan).

Maintaining the size of populations is relevant to many of the significant species and involves reducing declines, while *increasing* the size of populations is possible for only a small number of significant species in the wild and for captive populations.

For significant species that are rarely detected it is intended to capture as much information as possible and initiate necessary management. For significant species not known to be declining, it is intended to ensure that sufficient survey and monitoring is undertaken to detect any decline whilst there is time to initiate conservation measures.

Expected outcomes for this objective and measures to determine outcome achievement are:

Expected outcomes		Performance criteria
1. Populations of significant species are maintained, or declines slow and populations begin to recover	4	Red crab population numbers are maintained or increase when compared to the population number from the 2011 Island Wide Survey
	5	The number of Island Wide Survey sites at which red crabs are recorded is maintained compared to 2011 levels
	8	Occupancy levels of Abbott's booby at nesting sites is maintained or increases
	9	The population of the flying-fox is maintained
	10	The populations of each forest bird (emerald dove, white-eye, thrush and imperial pigeon) are maintained
	11	The population of the goshawk is maintained or increases
	12	The population of the hawk-owl is maintained
	13	The population of the Christmas Island frigatebird is maintained or increases
	14	The population of the golden bosun is maintained
	15	The population of the giant gecko is maintained
	16	For each threatened fern (<i>Asplenium listeri</i> , <i>Tectaria devexa</i> var. <i>minor</i> and <i>Pneumatopteris truncata</i>) the number of known populations is increased within five years and recovery actions initiated for all new populations
	17	The population of robber crabs is maintained
2. Captive populations contribute to the conservation of significant species	18	Captive populations of reptile species are increased to a size that ensures maintenance of genetic diversity and to the extent they can be re-introduced into the wild in the future
	19	Threatened native reptile species are recorded in the wild and/or trial releases of species bred in captivity occurs in 10 years
3. Management is initiated where necessary, where rarely recorded species are detected	20	If the shrew, pipistrelle, Christmas Island blind snake, forest skink or coastal skink are detected, conservation measures are implemented
4. Declines in native species are detected early enough to implement conservation measures	21	Any declines** in native species are detected and conservation measures initiated

The main actions contributing towards achieving these outcomes are threat abatement (Actions 1, 2, 3), captive breeding (Action 4) and monitoring and survey (Action 5).

Objective 3: Maintain the ecological character of Ramsar wetlands

A separate objective for Ramsar wetlands emphasizes their importance to the environmental values of Christmas Island and as habitat for significant species. The ecological character of each Ramsar wetland is the combination of the ecosystem components, processes and benefits/services that characterise the wetland, as defined under the EPBC Act and Ramsar Convention (see Part 3 of this plan).

Expected outcomes for this objective and measures to determine outcome achievement are:

Expected outcomes		Performance criteria
1. The Dales and Hosnies Spring continue to support ecologically characteristic native fauna and flora species	22	Mangroves at Hosnies Spring are retained at a density of at least 10 trees per 100 square metres (trees greater than 2.5 cm diameter at breast height) and seedlings and saplings are present
	23	Extent of Tahitian chestnuts at The Dales does not decline
	24	Blue, robber and red crabs remain present throughout the year and utilise the site for breeding migration and/or spawning
2. The Dales and Hosnies Spring maintain their hydrological characteristics	25	The First, Hugh's and Anderson Dale retain surface water connection to the sea
	26	Hosnies Spring has no loss of permanent water and retains a surface water area of greater than 0.3 hectares

The main actions contributing towards achieving these outcomes are threat abatement (Actions 1, 2, 3).

Objective 4: Contribute to maintaining groundwater ecosystems

As there is currently limited knowledge of groundwater ecosystems this objective is based on the possible contribution the actions can make within 10 years.

Expected outcome for this objective and measures to determine outcome achievement are:

Expected outcome	Performance criteria	
1. Understanding of ground water ecosystems is increased and human impacts are minimised	27	Groundwater flow rate and water quality baselines are established
	28	Understanding of groundwater systems is increased and management initiated

The main actions contributing towards achieving this outcome are threat abatement (Action 3) and monitoring and survey (Action 5).

NOTES ON PERFORMANCE CRITERIA:

- Any measures of change must be statistically significant and will take into account seasonal and other natural fluctuations.
- Given the limited quantitative data on population sizes and decline rates for most species, the expected outcomes for each species (slow decline of, maintain, or increase total population) have been selected based on expert knowledge of the species (including estimated current declines, extent to which threats can be abated, and potential rates of increase if all recovery actions are implemented and successful).

- Targets for proportional changes in populations have not been set. In many cases, ecologically acceptable population indicators, baselines and percentage targets will need to be determined by those with appropriate scientific expertise, as part of the recovery program. Population trend data (e.g. based on occupancy measures) will be used for most species as actual population numbers are difficult to measure.
- Threat risk of invasive weeds (*) to be measured by appropriate risk assessment that can take into account the distribution and abundance of a range of weed species.
- Potential future declines (**) cannot be estimated and the significance of any particular declines detected will need to be assessed by those with appropriate scientific expertise, as part of the recovery program.

6.2 Recommended actions

This section provides the overarching recovery actions required to achieve the plan's objectives. All actions that are currently considered essential to meet these objectives and assess progress towards the objectives have been included within the plan. However, relative priorities for implementation have been assigned (see Part 7 of this plan for details).

The strategy used to develop the plan's actions includes:

- assessing the conservation status and trend for major biodiversity attributes (i.e. significant taxa and ecologically significant ecosystems—forests, wetlands, groundwater and subterranean systems)
- identifying and assessing the primary risks to and threats affecting these attributes
- controlling these threats to a sufficient extent to allow for recovery of, or prevent the decline of, these attributes
- monitoring trends for all these attributes in a manner sufficient to evaluate the effectiveness of management interventions
- if threats leading to threatened species declines:
 - are not known—the likelihood of determining and mitigating threats
 - are not likely to be mitigated for some time—the feasibility and effectiveness of implementing interventionist programs, such as captive breeding, that have the long-term aim of conserving species in the wild.

Where information was available these steps have been followed, with the relevant information used to determine recovery actions (e.g. action to control crazy ants). Where information was not available, actions have been included to follow these steps and determine future actions.

Many actions identify broad activities but not the specific methods to be applied. This enables actions to be adaptive in character to ensure capacity to respond to uncertainty and change over the 10-year life of the plan.

The conduct and timing of many of the actions will be based on the availability of resources which will be allocated according to implementation priorities (see Part 7 of this plan). These priorities will be regularly reviewed and reported on by the recovery team (Action 9.4).

The individual species profiles in Appendix K provide specific management actions for the 26 Christmas Island species identified by this plan as significant; these management actions combine to form the basis of the broader integrated island-wide recovery requirements listed below. Action 7 (*Manage and analyse data*) Action 8 (*Communicate with and engage the community and other stakeholders*) and Action 9 (*Coordinate biodiversity conservation plan implementation*) are underpinning actions which are essential in order to achieve both the underpinning and the biological objectives of this plan.

Action 1	Continue threat abatement actions to address major threats
Action 1.1	<p>Control and reduce the impacts of crazy ants</p> <p>Priority 1 Action: based on the impacts of crazy ants on Christmas Island's red crabs and forest ecosystems and a number of significant species across the island. This is reflected in the listing of <i>Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (Anoplolepis gracilipes) on Christmas Island, Indian Ocean</i> as a key threatening process under the EPBC Act and as identified by the Expert Working Group (2010).</p> <p>1.1.1 Ground or aerially bait crazy ant supercolonies with Fipronil bait until other effective alternative control methods are developed.</p> <p>1.1.2 Continue to research and monitor the impacts of crazy ants on the island's biodiversity. This will include the Island Wide Survey (Action 5.1) and other studies to, particularly, gain a better understanding of poorly understood impacts, such as the density of crazy ants that prevents effective red crab recruitment.</p> <p>1.1.3 Research and trial alternative low off-target impact methods for controlling and reducing the impacts of crazy ants:</p> <ul style="list-style-type: none"> • give priority to the biological control of scale insects, as a means of indirectly controlling crazy ants • investigate additional control methods/baits, delivery systems and strategies, such as integrated methods using attractants like pheromones with other control methods/delivery systems, such as bait stations • investigate other measures to reduce supercolony formation and the control of crazy ants at sub supercolony densities <p>1.1.4 Assess the environmental risks of implementing any new/alternative crazy ant control methods that may be considered.</p> <p>1.1.5 Subject to the results of the research, trials and risk assessments conducted in tasks 1.1.3 and 1.1.4, implement and monitor the effectiveness of new/alternative crazy ant control methods.</p> <p>1.1.6 Assess and monitor the off target/environmental impacts of crazy ant control, including the use of Fipronil bait and any new/alternative control methods. Use this information to adaptively assess any environmental risks and to inform crazy ant control methods.</p> <p>1.1.7 Continue to seek and utilise scientific advice to inform crazy ant control.</p> <p>1.1.8 Compile research, monitoring and other relevant information on the biology, ecology, impacts and management of crazy ants. Use this information to review and, if needed, adapt control actions.</p>
Action 1.2	<p>Control and reduce the impacts of cats and rats</p> <p>Priority 1 Action: based on the impact or potential impact of cats and rats on a number of significant species across the island. This is reflected by the national <i>Threat abatement plan for predation by feral cats</i> (DEWHA 2008) and the report of the Expert Working Group (2010) which identifies several of Christmas Island's native species as being vulnerable to feral cat and rat predation.</p> <p>1.2.1 Continue to monitor compliance with local cat ownership by-laws.</p> <p>1.2.2 Eradicate feral and stray cats across the island. The program will begin in light industrial, tip and settled areas, including the Immigration Detention Centre and settled areas including the nesting colony of the silver bosun and habitats for significant species. This will include adopting strategies to minimise any off-target impacts including from toxin use and changes to prey abundance.</p> <p>1.2.3 Conduct targeted rat control in priority locations, especially ground-nesting seabird colonies.</p>

	<p>1.2.4 Determine the ecological effects of and need for eradicating rats across the island. Major considerations will include determining:</p> <ul style="list-style-type: none"> the types and extent of impacts rats have on significant species the affects that feral and stray cat eradication may have on the rat population and how any increases in rats may affect significant species the role played by land crabs in limiting the rat population. <p>1.2.5 If rat control across the island is determined necessary, assess the feasibility of and determine methods for controlling or eradicating rats across the island and implement programs if feasible. This will include assessing and adopting strategies to minimise any off-target impacts from control methods (including from chemical baits) as well as assessing the likelihood of maintaining the island rat-free if eradication were to be achieved.</p> <p>1.2.6 Adaptively trial cat and rat control methods.</p> <p>1.2.7 Use the monitoring data from Action 5 to evaluate the effectiveness of control programs and adapt them as necessary. Effectiveness measures include low off-target impacts; cat and rat population levels; and post-control recovery of significant species.</p>
<p>Action 1.3</p>	<p><i>Reduce vehicle impacts on significant species, particularly red crabs during their annual breeding migration</i></p> <p>Priority 1 Action: due to the keystone species role that red crabs have in the island's forest ecosystems and the level of community support and expectation for the protection of land crabs.</p>
	<p>1.3.1 Temporarily close or manage roads in and outside the national park that contain high densities of migrating red crabs. This will include but may not be limited to The Dales, Blowholes, Greta Beach, Gaze, Murray and Lily Beach roads and the Cove.</p> <p>1.3.2 Maintain existing and, if needed, install additional red crab crossings on roads that are not closed during the migration and that intersect major migration routes.</p> <p>1.3.3 Implement other road management measures to reduce robber and red crab mortality and potential bird mortality and disturbance, including driver education, setting and enforcing appropriate speed limits and through more effective road design, if and when roads are developed and/or upgraded.</p>
	<p>1.3.4 Support community efforts to mitigate the impacts of vehicles on land crabs, such as increased awareness through signs.</p> <p>1.3.5 Monitor crab deaths as a result of vehicles.</p> <p>1.3.6 Monitor deaths of forest birds particularly the goshawk and emerald dove and implement mitigation measures if vehicle deaths are identified as a threat (see 1.3.3).</p> <p>Other communication and awareness-raising activities will occur as part of Action 8.</p>
<p>Action 1.4</p>	<p><i>Continue to assess the environmental impacts of proposals in accordance with relevant legislation</i></p> <p>Priority 1 Action: as further loss of or disturbance to habitat, particularly previously uncleared primary rainforest, has the potential to further impact on critical habitat for threatened species.</p>
	<p>1.4.1 Assess the environmental impacts of proposed actions on significant species and their habitats in accordance with the referral and assessment processes under the EPBC Act, as well as other relevant legislation, including any applied Western Australian legislation.</p> <p>1.4.2 Avoid or minimise removal of previously uncleared and protected vegetation (as described under Schedule 12 of the EPBC Regulations) through, for example, strategic placement of infrastructure on cleared sites or sites with secondary vegetation regrowth.</p>

Action 2	Reduce the likelihood of new invasive species threats
Action 2.1	<p>Reduce the likelihood of new invasive species entering Christmas Island</p> <p>Priority 1 Action: new invasive species could have catastrophic effects on the island's biodiversity, as outlined by the Expert Working Group (2010).</p> <p>2.1.1 Implement actions to reduce the possibility of entry of high risk invasive species, including extending existing biosecurity measures to address high risk pathways and species.</p> <p>2.1.2 Prepare a biosecurity risk assessment for Christmas Island which examines the adequacy of existing procedures and requirements to minimise the risk of further introductions of invasive species, including species that may be a threat to human health.</p> <p>2.1.3 Monitor likely invasive species entry pathways (including the airport, cargo unloading areas and seaport/marine areas and surrounding areas) to detect any new high risk invasive species (plant, animal, disease, pathogen or parasite).</p> <p>2.1.4 Assess (using monitoring data from Task 2.1.3 and Action 5) the effectiveness of biosecurity strategies and adapt strategies as required.</p>
Action 2.2	<p>Rapidly eradicate new invasive species that enter Christmas Island</p> <p>Priority 1 Action: new invasive species could have catastrophic effects on the island's biodiversity, as outlined by the Expert Working Group (2010).</p> <p>2.2.1 Develop strategies to rapidly eradicate/respond to new invasive species that may be detected. This will include strategies for high risk invasive species with a high likelihood of entry, as well as strategies to reduce threats from high risk entry vectors.</p> <p>2.2.2 If new invasive species are detected, implement strategies to rapidly eradicate them before they can establish. This will include but not be limited to species not assessed and approved for import, racing/homing pigeons and Weeds of National Significance.</p> <p>2.2.3 Assess (using monitoring data from Action 5) the effectiveness of eradication strategies and adapt strategies as required.</p>
Action 2.3	<p>Assess risk of threat from invasive animals, diseases and pathogens</p> <p>Priority 2 Action: increased impacts from invasive species could have catastrophic effects on the island's biodiversity, as outlined by the Expert Working Group (2010).</p> <p>2.3.1 Conduct risk assessments on invasive animals, diseases and pathogens.</p> <p>2.3.2 Conduct weed risk assessments. Assessments will consider known highly invasive species and sleeper species present on the island, and their potential impacts on conservation assets (particularly significant species and their habitats).</p> <p>Assessments under tasks 2.3.1 and 2.3.2 will consider known highly invasive species not currently present on island that may have the potential to enter and sleeper species present on the island, and their potential impacts on conservation assets (including significant species). The risk assessment will include distribution and abundance.</p>
Action 3	Implement secondary threat abatement actions
Action 3.1	<p>Manage weeds</p> <p>3.1.1 Control high risk weeds (identified in Action 2.3) that can be feasibly controlled. Currently identified high risk weeds are Siam weed and weed species that have or may be likely to invade shaded/intact rainforests, such as <i>Clausena excavata</i>. This will include adopting strategies to minimise any off-target impacts.</p> <p>3.1.2 Based on weed risk assessments and other relevant information, review and as needed update the Weed Management Plan 2010–2015.</p>

Action 3.2	<i>Assess and manage the impacts of recreational activities</i>
	<p>3.2.1 Assess the impacts (using monitoring data from Action 5) of visitors and recreational activities on significant species and their habitat.</p> <p>3.2.2 If required, implement strategies to minimise visitor and recreational impacts on natural environments. This may include installation of facilities and infrastructure, management of visitor access at sensitive sites or preparation of educational guidelines as part of communication activities (Action 8).</p>
Action 3.3	<i>Rehabilitate previously mined areas of high conservation potential</i>
	<p>3.3.1 Continue to implement the Christmas Island Minesite to Forest Rehabilitation program as agreed between DNP and Territories Administration and in accordance with and subject to the mine lease conditions. The program will focus on high priority areas that can be cost effectively rehabilitated, especially rehabilitation of areas of the central plateau located adjacent to Abbott's booby habitat (and including red crab and forest bird habitat) and is based on the methods detailed in Part 5 of this plan and in the long-term rehabilitation plan.</p>
Action 3.4	<i>Assess and manage the impacts of newly identified threatening processes</i>
	<p>3.4.1 Assess the level of risk (based on monitoring and survey Action 5 and research Action 6) of newly identified threatening processes. Priority threatening processes/invasive species related to this action include wolf snake, giant centipede and giant African land snail.</p> <p>3.4.2 If the risks/impacts (actual or potential) of a threatening process are considered unacceptable, investigate and adaptively research and trial management programs to address threatening processes.</p>
Action 3.5	<i>Monitor and manage use of subterranean groundwater</i>
	<p>3.5.1 Map or otherwise quantify the island's baseline groundwater resources, capacity and flow.</p> <p>3.5.2 Develop a sustainable groundwater use plan for the island that includes assessing and monitoring groundwater habitat values and threats.</p> <p>3.5.3 Minimise the risks of polluting groundwater resources, including by effectively managing toxic materials/wastes that could leach into and contaminate groundwater.</p> <p>3.5.4 Prepare agreements between Territories Administration, DNP and WA Department of Water to help monitor, regulate and sustainably manage groundwater use.</p>
Action 4	<i>Develop and implement targeted recovery programs for declining significant species</i>
Action 4.1	<i>Maintain and adaptively develop conservation programs, including captive breeding program, for terrestrial reptiles under threat of extinction in the wild</i>
	<p>Priority 1 Action: as there is an imminent risk of extinction in the wild.</p> <p>4.1.1 Continue to develop and implement the captive breeding program for native reptiles. The program will aim to provide insurance populations to avoid their extinction in the wild and to breed enough genetically diverse individuals to enable the adaptive re-establishment of wild populations. It will include significant species that can be feasibly caught and bred in captivity, particularly the blue-tailed skink and Lister's gecko and, if needed, the giant gecko.</p> <p>4.1.2 Develop and implement adaptive programs to trial the reintroduction of captive-bred reptiles into the wild and to monitor their status, if and when threats (particularly those covered by Actions 1.1, 1.2 and 3.4) are sufficiently mitigated.</p>

Action 4.2 <i>Establish ex situ cultivation for significant flora species where needed and feasible</i>
<p>4.2.1 Prepare decision support systems to determine if and when to establish <i>ex-situ</i> cultivation for:</p> <ul style="list-style-type: none"> • Christmas Island spleenwort—include reintroduction to areas including, but not restricted to, the east coast terrace cliff tops • the fern <i>Pneumatopteris truncata</i> • the fern <i>Tectaria devexa</i> var. <i>minor</i> • mangrove species at Hosnies Spring. <p>This will include the targets and thresholds determined under Action 9.2 and seeking advice regarding the feasibility of <i>ex situ</i> cultivation for the fern <i>Pneumatopteris truncata</i>, mangrove species at Hosnies Spring and any other native flora species detected as being in decline.</p> <p>4.2.2 If a decision is made to cultivate a species, conduct cultivation trials; manage <i>ex situ</i> population/s; propagate and translocate plants; and monitor and manage planted population/s in their natural habitat.</p>
Action 4.3 <i>Assess the need for and feasibility of captive breeding for other species and implement programs where feasible</i>
<p>4.3.1 Seek advice regarding the need for and feasibility and requirements of a captive management program for the flying-fox. If a decision is made under Action 9.2 that management intervention is required, implement a captive management program in tandem with threat research and threat abatement actions covered elsewhere in the plan.</p> <p>4.3.2 If the Christmas Island shrew is found:</p> <ul style="list-style-type: none"> • implement Action 5.2 (conduct survey to locate population) • seek immediate scientific advice on the feasibility of a captive breeding/management program and implement if feasible. <p>4.3.3 If the Christmas Island pipistrelle is found:</p> <ul style="list-style-type: none"> • implement Action 5.2 (conduct survey to locate population) • seek immediate scientific advice on the feasibility of a captive breeding/management program and implement if feasible. <p>4.3.4 If a decline in other native species is detected and a decision is made under Action 9.2 that management intervention is required:</p> <ul style="list-style-type: none"> • immediately seek scientific advice on the feasibility of a captive breeding program, in tandem with modifying threat research and threat abatement actions covered elsewhere in the plan • if feasible implement a captive breeding program, with the ultimate aim of re-introducing the species to the wild.
Action 4.4 <i>Re-establish red crabs in forests</i>
<p>4.4.1 Re-establish red crabs in forests from which they have been eliminated by crazy ants, as a means of helping to assist in the recovery of forest ecosystems.</p> <p>4.4.2 Monitor the results of red crab re-establishment.</p>
Action 4.5 <i>Develop and implement additional programs to recover declining significant species</i>
<p>4.5.1 Implement appropriate threat management or other programs where a significant species has declined to a threshold determined under Action 9.2 and a decision has been made to intervene, including where a species is rediscovered. Appropriate management could include captive breeding or management or other <i>ex situ</i> conservation programs, in addition to developing or modifying threat research and threat abatement actions covered elsewhere in the plan.</p>

Action 5 Monitor and survey species and their habitats	
Action 5.1	Implement island-wide ecosystem monitoring <p>Priority 1 Action: as this is a key activity to detect changes in populations of select significant species.</p> <p>5.1.1 Adaptively develop and periodically undertake the Island Wide Survey (IWS). This program is primarily aimed at mapping and monitoring crazy ant supercolonies, including to assess the success of crazy ant control programs, as well as mapping and monitoring red crab burrow abundance and distribution trends.</p> <p>The IWS will also:</p> <ul style="list-style-type: none"> • continue to monitor Abbott’s booby nesting occupancy, flying-fox, forest birds (white-eye, imperial pigeon, emerald dove, thrush and goshawk presence and distribution) • monitor invasive plant and animal species, including cats, rats, Siam weed and <i>Clausena excavata</i> (monitoring of Siam weed will include confirmation of whether control programs have been successful) • collect data on opportunistic sightings of significant species, including native reptiles, Christmas Island pipistrelle and shrew.
Action 5.2	Monitor and survey other significant species <p>Priority 1 Action: as this is a key activity to detect changes in populations of other significant species.</p> <p>5.2.1 Develop and implement monitoring programs for significant fauna species not effectively monitored by the IWS. This will include determining and monitoring threats (e.g. invasive species) impacting or likely to impact on the ecological integrity of ecosystems. Monitoring which will be incorporated in these programs includes but need not be limited to:</p> <ul style="list-style-type: none"> • flying-fox populations including trends, camps and demographics • Christmas Island hawk-owl distribution and population trends • Christmas Island goshawk population trends and recruitment • Abbott’s booby breeding success, population demographics and population trends • Christmas Island frigatebird site occupation and population trends • golden bosun population trends • population trends for forest bird species • targeted surveys to test for the presence and/or persistence of native wild or (where applicable) reintroduced terrestrial reptiles • if the Christmas Island pipistrelle or shrew is located, conducted targeted surveys to determine population extent and habitat • population trends for all other significant species. <p>5.2.2 If there are indications (e.g. through opportunistic records during other monitoring) that native species previously thought to be stable are in decline, develop and implement a targeted monitoring program for those species.</p>

<p>Action 5.3 <i>Monitor the annual red crab migration</i></p> <p>Priority 1 Action: as this is a key activity to detect how well the red crab population is recovering following crazy ant control.</p>	<p>5.3.1 Develop a program to monitor the annual red crab migration.</p> <p>5.3.2 Monitor the patterns, distribution and size of the red crab migration. Methods will include monitoring of the return of red crabs from the sea as well as the spatial pattern and intensity of the migration.</p>
<p>Action 5.4 <i>Monitor and survey forest and wetland habitats</i></p> <p>Priority 1 Action: as this is a key activity to detect changes in forest and wetland ecosystems.</p>	<p>5.4.1 Survey and map the vegetation of Christmas Island (using where applicable remote sensing techniques and if needed ground-truthing). This will include accurately mapping:</p> <ul style="list-style-type: none"> • total vegetation cover and detailed vegetation types • habitat critical to survival of significant species as determined under Action 7.1. <p>5.4.2 Monitor vegetation changes over time using mapping data and via surveys.</p> <p>5.4.3 Monitor the ecological character of Ramsar wetlands at least every five years. This will include monitoring:</p> <ul style="list-style-type: none"> • extent of Tahitian chestnut at The Dales • monitor density of mangrove trees and presence of seedlings and saplings at Hosnies Spring • water connection to sea at First, Hugh's and Anderson Dales • surface water area and seasonal duration at Hosnies Spring • blue, red and robber crab presence and migration and/or spawning activity at The Dales and Hosnies Spring.
<p>Action 5.5 <i>Conduct targeted surveys of significant plant species</i></p>	<p>5.5.1 In order to determine environmental factors affecting distribution, and if needed to determine population size, conduct targeted surveys of known occurrences of:</p> <ul style="list-style-type: none"> • Christmas Island spleenwort • the fern <i>Pneumatopteris truncata</i> • the fern <i>Tectaria devexa</i> var. <i>minor</i> • mangroves at Hosnies Spring. <p>5.5.2 Conduct targeted surveys for additional populations of other significant plant species, with those listed as threatened as highest priority, in sites identified through Action 7.1.</p>

Action 6	Conduct research to inform management of significant species and habitat
Action 6.1	Research threatening processes likely to be impacting significant species
	<p>Priority 1 Action: invasive species are the major threat to the island's biodiversity, yet reasons for the decline of some species are not known (as outlined by the Expert Working Group 2010).</p>
	<p>6.1.1 Conduct research on the impacts of threats which may be or are affecting significant species. If impacts are identified, research threat mitigation methods (as required) for significant species (see also Action 3.4). High priority invasive species for which research which has been identified include:</p> <ul style="list-style-type: none"> • rats • cats • giant centipedes • wolf snakes • flowerpot snakes • introduced ants (see Action 1.1 for crazy ants) • giant African land snails and other exotic land snails
	<ul style="list-style-type: none"> • introduced bees • pathogens, diseases and parasites • chemical use. <p>6.1.2 For significant species that are or may be under threat of decline and where threatening processes are not well understood, research potentially threatening processes.</p>
Action 6.2	Research the biology and ecology of significant species
	<p>6.2.1 Where necessary for the conservation of species in decline (as based on population monitoring) conduct research on the biology (including, if/as needed, behavioural and taxonomic studies) and ecology of significant species. Current priority research which has been identified includes:</p> <ul style="list-style-type: none"> • native terrestrial reptiles, including the giant gecko, Christmas Island blind snake and Lister's gecko • Christmas Island frigatebird at-sea feeding ecology • Christmas Island goshawk foraging, nesting and breeding behaviour and habitat preferences as well as taxonomic distinctiveness • Christmas Island hawk-owl foraging, nesting and breeding behaviour and habitat preferences • Christmas Island spleenwort • the fern <i>Pneumatopteris truncata</i> ecology and habitat requirements • the fern <i>Tectaria devexa</i> var. <i>minor</i> • Christmas Island flying-fox ecological and biological studies to inform recovery actions • golden bosun particularly critical nesting habitat • robber crabs • at-sea distribution of Abbott's booby • at-sea lifecycle of red crabs and how this influences the return of red crabs migrating back to land • blue crab reproduction and juvenile dispersal.

Action 6.3 <i>Research poorly known species</i>	
<p>6.3.1 In order to determine future conservation requirements, conduct research on species diversity and ecology of:</p> <ul style="list-style-type: none"> • poorly studied endemic plant species, especially those with small populations (see Appendix C) • non-endemic plant species of possible conservation concern (see Appendix E) • cave dwelling including groundwater fauna • selected priority poorly studied land crab species, especially endemic species with small populations (see Appendix H) • other endemic invertebrates. 	
Action 7 <i>Manage and analyse data</i>	
<p>Action 7.1 <i>Analyse monitoring, survey and research data in order to determine future conservation requirements</i></p> <p>Priority 1 Action: as future conservation efforts will not be as effective without assessment of collated data.</p>	
<p>7.1.1 Analyse data collected from Actions 1 to 6 and existing information in a timely manner. This will include:</p> <ul style="list-style-type: none"> • analysing IWS data • assessing and using monitoring results to help inform management actions, such as managing crazy ants and traffic impacts (Action 1) • identifying sites for targeted surveys (Action 5) • identifying and describing areas of high conservation value. This will include sites with populations of endemic plant species, major red crab migration routes and habitats critical for the survival of threatened and other significant species. <p>These analyses will contribute to Action 9.4.</p>	
<p>Action 7.2 <i>Effectively manage data</i></p> <p>Priority 1 Action: as knowledge to inform conservation management is the key to effectively protecting significant species and the island's ecosystems.</p>	
<p>7.2.1 Document knowledge of long-term island residents in relation to significant ecosystem and species changes observed over time, including the red crab migration; and changes in the distribution and abundance of significant and other species, including invasive species.</p> <p>7.2.2 Develop, maintain and, as needed, update systems to record, store and analyse data, including GIS. Data derived from Actions 3, 5 and 6 will contribute to this task.</p> <p>7.2.3 Store and enable easy access to research papers and other relevant natural resource management documents and reports.</p>	
Action 8 <i>Communicate with and engage the community and other relevant stakeholders</i>	
<p>Action 8.1 <i>Develop and implement communication and awareness raising programs</i></p> <p>Priority 1 Action: as the success of this plan is largely dependent on informed and supportive stakeholders and an engaged public.</p>	
<p>8.1.1 Develop educational and awareness raising programs which include information about significant species' status, values, and threats, as well as recovery activities and outcomes. This will include but not be limited to:</p> <ul style="list-style-type: none"> • information about cat and rat control (Action 1), crazy ant control (Action 1) and weed control programs (Action 3) 	

- information about existing legislation such as cat by-laws, clearing regulations, protection of native species and requirements for approvals of actions under the EPBC Act and Regulations
- information on vehicle impacts on red and robber crabs, road closures and promotion of impact reduction measures (e.g. car pooling and re-timing of works/events and travel)
- ways to become involved in recovery activities
- threatened species, including updates on progress of their recovery
- information on minimising visitor and recreational impacts on significant species, if required (Acton 3.2)
- the value of wetlands, including the Ramsar Convention Program of Communication, Education, Participation and Awareness tools.

A range of communication methods will be used, such as identification guides, *The Islander* and school-based activities and will take account of the cultural backgrounds of residents.

8.1.2 Publish a booklet on recovery of the island's species based on the biodiversity conservation plan.

Action 8.2 Promote research partnerships

8.2.1 Provide logistical and/or in-kind support for relevant research studies.

8.2.2 Promote research findings and opportunities widely.

8.2.3 Build on existing research partnerships (Part 5 of this plan) and develop new research partnerships.

Action 9 Coordinate biodiversity conservation plan implementation

Action 9.1 Establish and maintain a recovery team

Priority 1 Action: as implementation requires a whole of island approach a team representing island wide responsibilities and relevant scientific expertise is essential.

9.1.1 Establish a recovery team with appropriate community, scientific and stakeholder representation within the first year of this plan coming into force.

The team will be required to undertake the following tasks:

- integrate and guide the implementation and monitoring of this plan, particularly for island-wide projects
- pursue collaborative funding opportunities, particularly for island-wide projects
- facilitate effective off and on island information-sharing and communication
- review, consider and advise on management priorities and scheduling
- provide regular updates to stakeholders, including the community, on progress in implementing the plan
- guide the review of the biodiversity conservation plan in its fifth year of operation.

<p>Action 9.2 <i>Determine target and threshold criteria for management intervention</i></p> <p>Priority 1 Action: as this is critical to our understanding of when to undertake particular actions to prevent species extinctions.</p>	<p>9.2.1 Use risk management frameworks to assess threats to significant species as an ongoing means of adjusting recovery priorities.</p> <p>9.2.2 Determine appropriate population measures, baselines and targets/criteria for significant species where required.</p> <p>9.2.3 Investigate population viability for significant species and determine thresholds for potential intervention.</p> <p>9.2.4 Establish a framework to guide implementation of relevant actions from this plan and, in particular, to determine when and how to respond if a species declines to its threshold for potential intervention.</p> <p>These tasks will involve experts with relevant expertise on each species and priorities for implementation to be determined under Action 9.1. Species more likely to require intervention (e.g. the flying-fox) are the highest priority.</p>
<p>Action 9.3 <i>Prepare a business case for funding the implementation of this plan</i></p> <p>Priority 1 Action: as additional targeted resources are critical to further halt the decline, and begin the recovery, of significant species.</p>	<p>9.3.1 Prepare a whole-of-government business case(s) outlining funds required for implementing this plan beyond existing resources (see Part 7 of this plan). This should also include investigation of private sector and non-government organisation resourcing and funding.</p>
<p>Action 9.4 <i>Monitor and review the implementation of this plan</i></p> <p>Priority 1 Action: so management efforts and resources continue to be targeted in the most effective ways to meet the plan's objectives.</p>	<p>9.4.1 Monitor, report on and evaluate the status of the implementation of this plan annually, including a review of future priorities.</p> <p>9.4.2 Where needed, seek independent scientific and other specialist advice for adaptively developing and implementing this plan. This may include adjusting existing actions or new actions where monitoring has detected significant declines in native species.</p> <p>9.4.3 Undertake an independent review of this plan after four years. The review should consider if the plan has been implemented effectively and efficiently; outcomes achieved from the implementation of the actions; whether the objectives have been met; and if plan priorities and actions are still appropriate or need to be revised.</p> <p>9.4.4 Ensure the actions from this plan and any subsequent reviews are incorporated in future park management plans or other on-island environmental management plans as appropriate.</p>

6.3 Management practices

Management practices and measures to address potential threats other than those contained in the plan have been developed and are being implemented through the CINP management plan; weed and predator management strategies; forest rehabilitation strategies; and quarantine operation procedures.

When using chemicals (e.g. for weed control) Material Safety Data Sheets must be followed to avoid spray drift and other off-target impacts and to ensure chemicals are used in a safe and appropriate manner.

Management practices associated with activities such as the development and maintenance of infrastructure (e.g. roads, new commercial buildings and visitor facilities) should be conducted in ways to avoid significant impacts on native species. Box 1 provides guidance for considering and minimising the impacts of proposed activities and actions but does not replace assessments processes under the EPBC Act (or any other assessments required under any relevant applied WA legislation) as these processes apply regardless of this plan (see Part 1.5 of this plan for details).

Box 1: Guideline for considering and minimising the impacts of proposed activities and actions

These guidelines and practices should be considered to help minimise the potential impacts of actions on Christmas Island's native species and their habitat.

Factors to consider when assessing and/or undertaking a proposed action or activity include but are not limited to:

- biosecurity and quarantine threats
- threats to terrestrial/forest, coastal/marine, wetland and groundwater/subterranean ecosystems, including impacts on the extent and quality of previously uncleared rainforest vegetation
- threats to significant species or their habitats
- threats to protected species listed under Schedule 12 of the EPBC Regulations 2000, including red and robber crabs
- incremental and compounding impacts that may not be immediate
- the capacity of ecosystems to sustain natural processes
- the capacity of the natural environment to meet the needs and aspirations of future generations, for example in relation to water use and fishing activities.

Subject to the assessment and approval processes under the EPBC Act and the nature and scope of a proposed action or activity, management practices or measures should be adopted to avoid, minimise or mitigate impacts of the action or activity on native species and their habitats. These practices and measures should consider at least one of the following:

- alternative low impact proposals or actions such as the use of previously disturbed sites
- avoiding disturbance of sensitive areas such as seabird nesting habitats, previously uncleared rainforest and high density red crab habitat and migration routes
- design measures such as red crab road underpasses, water efficiency designs, minimising impacts of linear infrastructure and effective waste management
- timing of works and activities, for example to avoid impacts on red crabs by not conducting major works or major events during their annual migration and/or at times of the day when red crab activity is at its highest
- work practice or activity impact mitigation, such as the retention of native vegetation on building sites or temporary road closures during the annual red crab migration.

Part 7—Implementation

7.1 Priorities

Determining priorities includes determining priority areas for action to take place; and determining priorities for implementation of recovery actions.

Priority areas

All of Christmas Island's natural areas are of high conservation value. Nonetheless, some areas or ecosystems are considered, through formal protection under the EPBC Act or EPBC Regulations and/or from scientific research and other studies, to be particularly significant. At this point in time the highest priority areas are considered to be:

Relatively intact and previously uncleared forest ecosystems and habitats

While all previously uncleared areas of native vegetation are considered to be of significance, evergreen tall closed forest (as described in Table 5), particularly on the central plateau, is of particular importance as it provides habitat for several endemic and threatened species, including habitat critical for the Abbott's booby. Uncleared rainforest vegetation also provides habitat for the endangered Christmas Island frigatebird and Christmas Island flying fox, as well as important habitat for red crabs. Areas of high red crab densities may change over time due to several factors, including recovery from, or as a result of, crazy ant impacts, and are generally located in areas of uncleared rainforest vegetation. While migration routes may be broadly defined, the intensity and patterns of the red crab migration around the island may vary each year. Consequently, important actions of this plan are to continue to map areas of high crab densities, through the Island Wide Survey, and further research the red crab migration routes.

The Dales and Hosnies Spring declared Ramsar wetlands

While there are other wetlands on the island, The Dales and Hosnies Spring are considered the most significant. This is because they are listed as wetlands of international importance under the Ramsar Convention on wetlands due to their unique ecological characteristics (see Part 3.1.2 of this plan). These wetlands also play a broader role in the ecology of the island, for example as critical and drought/refuge habitat for species such as forest birds, blue crabs and mangrove species (at Hosnies Spring).

Subterranean, cave and groundwater ecosystems

The island's subterranean systems provide habitat for several endemic invertebrate species and contain one of only two anchialine habitats known in the southern hemisphere. While many cave sites are known, subterranean and groundwater ecosystems and species remain poorly defined and surveyed. As the island's groundwater systems provide water for human uses, their sustainable management is important for both conservation and human use purposes.

Christmas Island National Park

The spatial definition of the park may be arbitrary in ecological terms, however, Christmas Island National Park's status as a Commonwealth reserve under the EPBC Act, which protects representative examples of the island's rainforest ecosystems (as well as the island's two Ramsar wetlands) and habitat for significant species, makes the park a priority area.

Prioritisation of recovery actions

Prioritising recovery actions for implementation was based on the following principles:

1. The use of evidence from scientifically sound research and monitoring programs and advice should guide the adaptive implementation and monitoring of management actions/responses. This includes incorporation of relevant priorities identified by the Expert Working Group (2010).
2. Ongoing assessments and prioritisation of threats to native species should use a risk management framework and recognise the feasibility of addressing threats.
3. The impacts and risks of not implementing particular recovery actions (based on the above point) should be identified.
4. The likelihood of actions addressing ecosystem or multiple species threats and objectives should be assessed.
5. The costs, benefits and effectiveness of implementing proposed recovery actions should be identified.
6. The level of or ability to gain stakeholder, community and organisational support, including technical and financial support, as well as community expectations that action should be taken (e.g. in relation to protection of red and robber crabs from traffic impacts), particularly for actions requiring long-term island-wide responses should be taken into account.

The results of the threat risk assessment, including explanatory notes, are shown in Appendix I. This assessment has resulted in prioritisation of the actions, as shown in Table 9, to abate the 'major risk threats' being given the highest priority rating. As all recovery actions are considered essential to meeting the objectives of this plan, the priorities are relative to other recovery actions only. In future these priorities may change depending on the results of recovery actions, changes to circumstances, and changes in knowledge, including through ongoing threat assessments.

7.2 Implementation stakeholders

The DNP assisted by Parks Australia (a division of the Department of the Environment) is the major agency with responsibilities for biodiversity conservation on Christmas Island. Christmas Island National Park is managed by the DNP and covers approximately 63 per cent of Christmas Island; as such the DNP (with, where applicable, relevant Commonwealth agencies) will have a major role in the implementation of this plan's actions. However, implementation of several of the actions, for instance, invasive species control, protection of land crabs from traffic impacts and the sustainable use and management of groundwater, may require responses over different land tenures and the collaboration and/or cooperation of a number of relevant organisations and agencies. These organisations and agencies may include, but are not be limited to, the Territories Administration; SOCI; DIBP; CIP; the Department of Agriculture; and off-island organisations such as research organisations.

Previous relationships and collaboration will be continued under this plan. While one of the roles of the recovery team is to determine implementation of priorities and to work with the delivery partners to establish responsibilities for implementing certain actions, a number of agencies have already identified they will have a role in specific actions.

DIBP has identified a role in:

- contributing communication and engagement planning skills to the recovery team
- continuing to support the feral cat management program through providing in-kind support
- contributing resources and staff time to education programs for residents and visitors.

Territories Administration has identified a role in:

- any changes to speed limits required to protect crabs during migration
- potential for a partnership to map and understand the groundwater system.

The Commonwealth, under s269 of the EPBC Act, must implement a recovery plan to the extent to which it applies to Commonwealth areas. This plan does not bind and there is no obligation on individuals, businesses or other organisations, including SOCI, to contribute resources or funds to implement this plan. However, it is hoped that this plan will help maintain or enhance opportunities for collaboration in regard to supporting the implementation of priority recovery actions, particularly those needing island-wide responses.

The recovery team will have a role in guiding the plan's collaborative implementation (as described under Action 9.1). The recovery team will have appropriate community, scientific and stakeholder representation. Membership may change over the life of the plan, and specific expertise may be called on to provide advice on specific issues.

7.3 Timing and costs

The estimated total cost of the biodiversity conservation plan is \$58.865m over 10 years. Table 9 provides a breakdown of the estimated costs, including which actions are currently funded, including through the annual budget of the DNP for management of Christmas Island National Park.

The costs are based on a mix of estimates including the cost of conducting similar actions over the last few years; projections based on the historical cost of conducting the same on-going operations; and more detailed costings of particular actions. The more detailed cost estimates include:

- cat and rat control costs which are broadly based on the *Proposed management plan for cats and rats on Christmas Island* (Algar & Johnston 2010)
- crazy ant control costs which are based on a proportion of funding allocated to crazy ant control over the period 2011–12 to 2015–16 (noting that this funding also supports monitoring of crazy ant impacts and other invasive species control work)
- mining site rehabilitation costs which are based on the per hectare funding modelling from the *Christmas Island Minesite to Forest Rehabilitation Plan 2012–2020* (DNP 2012g).

Implementing the actions identified in the plan is subject to budgetary and other constraints affecting the key stakeholders, particularly the Commonwealth. Given the length of the biodiversity conservation plan and external factors impacting funding it is not practicable to provide a year-by-year budget.

Recovery Action 9.3 includes developing a business case which will detail funding required for implementation of this plan.

7.4 Plan review

The plan will be implemented over a ten year period and a review to determine whether variation is required will be conducted in the fifth year (Action 9.4). The review should be guided by the Christmas Island recovery team. This review is not intended to replace the ongoing need for adaptive management approaches, for instance when new information arises from research studies that will inform management decisions, priorities and actions. The recovery team will guide annual assessments of the status and success of the implementation of this plan.

Table 9: Estimated cost and current priority of recovery actions

ACTIONS ^(a)	Total cost (\$) over 10 years EXISTING FUNDING	Total cost (\$) over 10 years ADDITIONAL FUNDING	Total cost (\$) over 10 years TOTAL FUNDING	Action Priority ^(b)
Action 1 Continue threat abatement actions to address major threats				
1.1 <i>Control and reduce the impacts of crazy ants</i>	4,000,000	3,500,000	7,500,000	1
1.2 <i>Control and reduce the impacts of cats and rats</i>	500,000	4,500,000	5,000,000	1
1.3 <i>Reduce vehicle impacts on significant species, particularly red crabs during their annual migration</i>	1,500,000	1,000,000	2,500,000	1
1.4 <i>Continue to assess the environmental impacts of proposals in accordance with relevant legislation</i>	n/a ^(c)	n/a ^(c)	n/a ^(c)	1
Action 2 Reduce the likelihood of new invasive species threats				
2.1 <i>Reduce the likelihood of new invasive species entering Christmas Island</i>	3,500,000	3,500,000	7,000,000	1
2.2 <i>Rapidly eradicate new invasive species that enter Christmas Island</i>	200,000	800,000	1,000,000	1
2.3 <i>Assess risk of threat from invasive animals, diseases and pathogens</i>	100,000	500,000	600,000	1
Action 3 Implement secondary threat abatement actions				
3.1 <i>Manage weeds</i>	750,000	1,500,000	2,250,000	2
3.2 <i>Assess and manage the impacts of recreational activities</i>	500,000	500,000	1,000,000	2
3.3 <i>Rehabilitate previously mined areas of high conservation potential</i>	13,600,000 ^(d)	0	13,600,000 ^(d)	2
3.4 <i>Assess and manage the impacts of newly identified threatening processes</i>	500,000	1,500,000	2,000,000	2
3.5 <i>Monitor and manage use of subterranean groundwater</i>	0	350,000	350,000	3
Action 4 Develop and implement targeted recovery programs for declining significant species				
4.1 <i>Maintain and adaptively develop conservation programs, including captive breeding, for terrestrial reptiles under threat of extinction in the wild</i>	600,000	1,400,000	2,000,000	1
4.2 <i>Establish ex situ cultivation for significant flora species where needed and feasible</i>	20,000	200,000	220,000	3
4.3 <i>Assess the need for and feasibility of captive breeding for other species and implement programs where feasible</i>	0	2,000,000	2,000,000	2
4.4 <i>Re-establish red crabs in forests</i>	0	200,000	200,000	3
4.5 <i>Develop and implement additional programs to recover declining significant species</i>	500,000	1,000,000	1,500,000	2

ACTIONS ^(a)	Total cost (\$) over 10 years EXISTING FUNDING	Total cost (\$) over 10 years ADDITIONAL FUNDING	Total cost (\$) over 10 years TOTAL FUNDING	Action Priority ^(b)
Action 5 Monitor and survey species and their habitats				
5.1 <i>Implement island-wide ecosystem monitoring</i>	1,000,000	1,000,000	2,000,000	1
5.2 <i>Monitor and survey other significant species</i>	800,000	1,200,000	2,000,000	1
5.3 <i>Monitor the annual red crab migration</i>	200,000	300,000	500,000	1
5.4 <i>Monitor and survey forest and wetland habitats</i>	200,000	800,000	1,000,000	1
5.5 <i>Conduct targeted surveys of significant plant species</i>	100,000	200,000	300,000	2
Action 6 Conduct research to inform management of significant species and habitat				
6.1 <i>Research threatening processes likely to be impacting significant species</i>	250,000	750,000	1,000,000	1
6.2 <i>Research the biology and ecology of significant species</i>	400,000	700,000	1,100,000	2
6.3 <i>Research poorly known species</i>	100,000	400,000	500,000	3
Action 7 Manage and analyse data				
7.1 <i>Analyse monitoring, survey and research data in order to determine future conservation requirements</i>	200,000	200,000	400,000	1
7.2 <i>Effectively manage data</i>	100,000	100,000	200,000	1
Action 8 Communicate with and engage the community and other relevant stakeholders				
8.1 <i>Develop and implement communication and awareness raising programs</i>	100,000	150,000	250,000	1
8.2 <i>Promote research partnerships</i>	50,000	50,000	100,000	2
Action 9 Coordinate biodiversity conservation plan implementation				
9.1 <i>Establish and maintain a recovery team</i>	0	500,000	500,000	1
9.2 <i>Determine target and threshold criteria for management intervention</i>	0	200,000	200,000	1
9.3 <i>Prepare a business case for funding the implementation of this plan</i>	0	20,000	20,000	1
9.4 <i>Monitor and review the implementation of this plan</i>	0	75,000	75,000	1
TOTAL COST OF PLAN OVER 10 YEARS:	29,770,000	29,095,000	58,865,000	

(a) All actions are considered essential to achieve the objectives. Estimated costs of actions are based on a mix of estimates including the cost of conducting similar actions over the last few years; projections based on the historical cost of conducting the same on-going operations; and more detailed costings of particular actions. The costs of actions have been estimated individually and the total amount does not reflect efficiency savings that would result from integrated management approaches such as for invasive species management.

(b) Priority levels are relative only to other actions within the plan and reallocation of funds will be subject to priorities, as described in Part 7.1 of this plan.

(c) Not applicable as environmental assessment processes under the EPBC Act (or other relevant legislation) apply regardless of this biodiversity conservation plan so are not considered an additional cost associated with the plan.

(d) Amount subject to amount of conservation levy payable under the mine lease.

7.5 Social and economic benefits and impacts

Implementing this biodiversity conservation plan is expected to have positive social and economic consequences for the Christmas Island, Australian and international communities, through the recovery of threatened species and avoiding further loss of native species.

Significant adverse social or economic impacts are not expected as a result of implementation, but during preparation of the plan some stakeholders raised concerns that the implementation of the plan may impact on existing and future development activities on the island. However, on further consultation these stakeholders did not identify any specific actions in the plan that were of concern and that could result in such an outcome.

Although the information in this biodiversity conservation plan may be used to help assess the impacts of proposals that may trigger the assessment and approval provisions under the EPBC Act, proponents (organisations and individuals) are required to comply with the provisions of the EPBC Act regardless of whether a recovery plan is in place or not. In addition, the biodiversity conservation plan does not affect the operation of activities that are undertaken consistent with an existing approval under the EPBC Act or are subject to exemptions under the EPBC Act, including activities undertaken consistent with a 'prior authorisation' or that constitute a 'continuing use' (see Part 1.5 of this plan for more detail). The information collated in this plan was sourced from existing documents and reports, including the nine existing recovery plans for Christmas Island's species and the Expert Working Group report, and the collation of this information may help make environmental assessment and approval considerations more transparent for the Christmas Island community and the broader public.

Anticipated social and economic impacts from the implementation of this plan's actions are considered minimal. Further changes to use of the road network to enhance protection of native species, particularly red crabs during their migration, may lead to slightly increased travel times for residents and visitors. This already occurs during red crab migration and generally has wide community and organisational support. If increased quarantine and bio-security efforts are applied, there may be inconvenience and delays to residents and visitors, especially with regard to shipping of goods. However, there would also be potential benefits. For instance, the likelihood of the entry of species that may impact on human health, such as mosquitoes carrying dengue fever and malaria, could be reduced.

Anticipated social and economic benefits are detailed below, and include:

- more efficient and effective coordination of recovery efforts
- nature-based tourism and recreational benefits
- environmental management and research
- ecosystem services and products.

7.5.1 More efficient and effective coordination of recovery efforts

This plan addresses threats to significant species of Christmas Island including red crabs. Incorporating single species and ecosystem-wide recovery actions into one plan will assist with the effective coordination of recovery actions, such as invasive species control, and the efficient and effective use of available resources and funding.

Monitoring the plan's implementation, and the ongoing review of priorities, will enable the recovery team and delivery partners to ensure available resources are used to gain the most conservation benefit. Through identifying a number of priority actions to manage the principal threats to a number of significant species and their habitats, this plan enables the most efficient and effective use of available resources. This is one of the key benefits of having a single island wide biodiversity conservation plan rather than up to 17 separate plans for the listed taxa.

As noted under Part 7.2, several collaborative and cross-tenure recovery programs were operating during the preparation of this plan. This demonstrates the benefits of agencies and stakeholders working in a collaborative fashion to achieve recovery outcomes. The continuation of this approach may have broader positive benefits and contribute to maintaining a collaborative approach between agencies in other areas of their work on Christmas Island. As outlined in Part 5.1 of this plan, the cat and rat management program is one example of where this is successfully working. Such partnerships will be important for securing funding in the future.

7.5.2 Sustainable tourism and recreational benefits

Nature-based tourism refers to tourism opportunities and experiences which are based on ecologically sustainable visitation (Tourism WA 2006) to natural areas and which foster environmental and cultural understanding, appreciation and conservation (Ecotourism Australia 2012). The term nature-based tourism is often interchanged with ecotourism. Sustainable tourism is another term often used and it refers to the maintaining a balance between tourism and conservation. In 2009, 64 per cent of international visitors to Australia participated in nature-based tourism, with significantly longer lengths of stay per trip compared to visitors who did not participate in nature activities (Tourism Australia 2009).

The uniqueness of Christmas Island's natural heritage and its current and future potential to support nature-based tourism and development is widely recognised. For example, the Christmas Island Tourism Association (CITA) states 'Christmas Island is one of nature's most impressive feats, an island full of natural wonders: from the unique annual red crab migration to rare and unusual birds'. Similarly, 'with a proper plan, tourism and other natural industries that rely on natural attractions of the island that may be established' (Zekulich 2008). Furthermore, the Commonwealth Parliament's *Inquiry into the changing economic environment in the Indian Ocean Territories* in 2010 recommended that Christmas Island stakeholders 'examine ways to diversify the local economy with a focus on developing tourism'. Likewise, the 2018 Plan considered the further development of tourism, with an emphasis on low-impact, high-yield tourism, to be one of several vital aspects for the island's social and economic sustainability.

Christmas Island currently attracts a relatively small number of nature-based tourists but because of the island's natural and cultural attractions, there is potential for numbers to increase. In recent years there have been a number of significant nature-based tourism and conservation-focused events on Christmas Island. These include the annual Bird Week and the Underwater Festival, organised by CITA; the Indian Ocean Seabird Conference in 2008; and educational activities, such as annual visits by international schools, hosted by the Christmas Island District High School. It is estimated that in 2002 tourism contributed \$3–5 million to the Christmas Island economy (Planning for People 2008).

The 2010 inquiry into the changing economic environment (Joint Standing Committee on the National Capital and External Territories 2010) acknowledged a number of challenges but found that tourism could provide a new economic driver on Christmas Island, 'spurring complementary industries and moving the economy towards greater sustainability'.

Tourism Australia defines a number of markets for international visitors to Australia, and Christmas Island's unique species and their habitats are ideally placed to target the experience seeker market (Planning for People 2008).

Experience seekers:

- are highly interested in travel for travel's sake—it is a big part of their life
- look for inspiration; research extensively; take all their needs and wants into consideration; and often know where they are going next—there are so many destinations geared for them
- are intrigued by stories of exotic places, people, lifestyle, histories and environment
- yearn for ways to involve themselves in experiences with exotic places and people's lifestyles and histories
- recognise the role of communications and mass media but tune into personally relevant information.

The key, however, to having a nature-based tourism product is having an environment that is sufficiently preserved and unique (CIP 2010). Consequently, achieving the vision of this plan by preserving and recovering the island's unique native species will be fundamental to maintaining the island's natural visitor attractions. This will in turn play a part in supporting nature-based sustainable tourism on Christmas Island.

7.5.3 Environmental management, research and education

The 2018 Plan considered economic diversification as being vital to the sustainability of the Christmas Island, and that there was a need to investigate the establishment of centre/s for international education and scientific research, as these were some of several industries that the community would embrace.

At the time of preparing this plan the Christmas Island District High School and a local tour company, had facilitated several international school visits over a number of years. These visits had a large environmental educational focus centred on the island's natural features and native species, including red crabs. In addition, each year several researchers visit Christmas Island to conduct environmental research, such as on species that are unique (endemic) to Christmas Island. These activities have the potential to expand and promote the island's natural values, whilst helping support the island's economy. As with nature-based tourism, environmental research and educational activities rely on preservation of the island's natural environment.

Furthermore, the information gained through environmental management and research activities associated with this plan may contribute information that may be valuable for other conservation managers, both in Australia and internationally.

7.5.4 Ecosystem services and products

Christmas Island's ecosystems provide a number of services and products that are used by and benefit the Christmas Island community and visitors. These include storage and filtration of the island's water supply; regulation of the local climate; nature-based recreational activities; and provision of fish habitat, enabling fish to be caught for human consumption. If the island's ecosystems become degraded, these products and services may no longer be available or may be of diminished quantity or quality. Implementing some recovery actions, for example the sustainable management of groundwater and the control of crazy ants, will help ensure that some ecosystem products and services can continue to be sustainably provided in the future.

7.6 Affected interests

The interests listed below may be affected by the plan's implementation as they own or manage relatively large areas of land (or may otherwise influence the way land is managed). Consequently, these parties may be affected by and/or have a role in the implementation of recovery actions, for instance, invasive species control and environmental monitoring, which may need to occur across different land tenures. The major affected interests are:

- Administrator of Indian Ocean Territories
- Director of National Parks, Department of the Environment
- Territories Administration
- Department of Immigration and Border Protection
- Shire of Christmas Island
- Department of Agriculture
- Christmas Island Phosphates.

As Commonwealth agencies, the Australian Federal Police (AFP), Australian Customs and Border Protection Service (ACBPS) and Royal Australian Navy (RAN) may be affected by this plan. However, because they do not directly own and/or manage land areas, their role in relation to implementing or being affected by this plan is likely to be minimal. Their roles may include the AFP enforcing vehicle speed limits as part of their ongoing duties (which may help reduce crab deaths) and the RAN and ACBPS promptly disposing of suspected illegal entry vessels (SIEVs) that carry asylum seekers to Christmas Island's waters (in order to minimise the risks of biosecurity threats).

There are a number of relevant WA government agencies, such as, but not limited to, the Department of Parks and Wildlife and Department of Fisheries, that provide services under service delivery agreements with Territories Administration. WA agencies are unlikely to be directly affected by this plan but the plan may be used to help guide the types of environmental services that are conducted under relevant service delivery agreements, for example in relation to invasive species control.

There are also a number of non-government organisations, businesses and individual land/house owners on Christmas Island. Non-Commonwealth government organisations and individuals are not bound by or obliged to implement this plan, but may choose to support the implementation of recovery actions. Consequentially, it is not anticipated that they will be negatively affected by this plan. Social and economic effects are considered to be minimal and are described in Part 7.5 of this plan.

7.7 International agreements

Australia is a signatory to a number of international agreements relevant to this biodiversity conservation plan. This plan is consistent with Australia's international responsibilities under these agreements, and implementation of the plan will help meet these obligations. Appendix B describes the international agreements which relate to species on Christmas Island.

Glossary and acronyms

In this plan:

.....
Administrator means the Commonwealth Administrator of the Indian Ocean Territories
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.....
AFMA means the Australian Fisheries Management Authority
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.....
Anchialine means a subterranean water body with connections to the ocean
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.....
BMP or **Biodiversity Monitoring Program** means the 2003–2007 biodiversity monitoring programme funded by the Department of Finance and Deregulation and carried out by the Director of National Parks
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.....
Bonn means the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
.....

.....
CAMBA means the Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment
.....

.....
CIMFR or **rainforest rehabilitation program** means the Christmas Island Minesite to Forest Rehabilitation Program
.....

.....
CINP or **Christmas Island National Park** means the area declared as a national park by that name under the *National Parks and Wildlife Conservation Act 1975* and continued under the EPBC Act by the *Environmental Reform (Consequential Provisions) Act 1999*
.....

.....
CIP means Christmas Island Phosphates, also known as Phosphate Resources Limited (PRL)
.....

.....
CITA means the Christmas Island Tourism Association
.....

.....
CITES means the Convention on International Trade in Endangered Species of Wild Fauna and Flora
.....

.....
Crazy ant/s means the yellow crazy ant (*Anoplolepis gracilipes*)
.....

.....
CSIRO means the Commonwealth Scientific and Industrial Research Organisation
.....

.....
DAFWA means the Western Australian Department of Agriculture and Food
.....

.....
DIBP means the Australian Government Department of Immigration and Border Protection
.....

.....
DNP or **Director** means the Director of National Parks under s.514A of the EPBC Act, and includes Parks Australia and any person to whom the Director has delegated powers and functions under the EPBC Act in relation to Christmas Island National Park
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.....
Department means the Australian Government Department of the Environment or such other department or agency that succeeds the functions of the Department
.....

.....
ECD or **Ecological Character Description** means descriptions of Ramsar wetlands
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.....
Ecological community means an assemblage of interdependent plant and animal species interacting with one another in a particular area
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.....
Ecological integrity is “the ability of an ecological system to support and maintain a community of organisms that has a species composition, diversity, and functional organization comparable to those of natural habitats within a region. An ecological system has integrity, or a species population is viable, when its dominant ecological characteristics (e.g. elements of composition, structure, function, and ecological processes) occur within their natural ranges of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions.” (Parrish et al. 2003)
.....

.....
Ecosystem means an ecological community together with the physical non-living environment interacting as a functional unit
.....

EDCG means Economic Development Consultative Group

Endemic means native plant and animal species that have a restricted geographical distribution and, for the purposes of this plan, species that are only found on Christmas Island and nowhere else in the world

EPBC Act means the *Environment Protection and Biodiversity Conservation Act 1999*, including Regulations under the Act, and includes reference to any Act amending, repealing or replacing the EPBC Act

EPBC Regulations means the Environment Protection and Biodiversity Conservation Regulations 2000 and includes reference to any Regulations amending, repealing or replacing the EPBC Regulations

EWG means the Christmas Island Expert Working Group established to advise the Minister on conservation of biodiversity on Christmas Island

Exotic species means species not native to Christmas Island

Ghost forests are forest from which the resident Red Crabs have been eliminated by the direct impact of yellow crazy ants

High risk invasive species means invasive species that has been identified through a risk assessment process as having an impact on a significant species

IDC means the Immigration Detention Centre at North West Point on Christmas Island

Introduced species means species (plant, animal, disease, pathogen or parasite) not native to Christmas Island

Invasive species means exotic introduced species (plant, animal, disease, pathogen or parasite) that threatens native flora and fauna

Island or the island means the Territory of Christmas Island located in the Indian Ocean unless otherwise stated

IUCN means the International Union for Conservation of Nature

IWS means the 'Island Wide Survey' monitoring program, as described in Part 5.9

JAMBA means the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment

Keystone species means those native species whose removal or substantial decline would result in major changes to ecosystem structure and function

Landscape means an area of land composed of interacting ecosystems that are repeated in a similar form throughout an area and include living and non-living natural aspects as well as human influenced or made aspects

Minister means the Minister administering the EPBC Act

MOU means Memorandum of Understanding

Native species means species which occur on Christmas Island but may also naturally occur at other locations

Nature-based tourism means tourism opportunities and experiences which are based on ecologically sustainable visitation to natural areas and which foster environmental and cultural understanding, appreciation and conservation

Park or the national park means Christmas Island National Park

Parks Australia means that part of the Department that assists the Director of National Parks in performing the Director's functions under the EPBC Act

PRL means Phosphate Resources Limited, also known as Christmas Island Phosphates (CIP)

Ramsar means the Convention on Wetlands of International Importance (Ramsar Convention)

.....
Recovery plan, the plan or this plan means the Christmas Island Biodiversity Conservation Plan unless otherwise stated

.....
ROKAMBA means the Agreement between the Government of Australia and the Government of the Republic of Korea for the Protection of Migratory Birds and their Environment

.....
SOCI means the Shire of Christmas Island

.....
Stygofauna means subterranean fauna living in freshwater-filled voids

.....
Supercolony means an area of high density crazy ants comprised of multi queen colonies that is determined based on density of crazy ants that result in red crab mortality. A supercolony is determined using a standardised density monitoring method

.....
Territories Administration means the Australian Government department with responsibility for administering the Christmas Island Act. At the time of preparing this plan that agency is the Department of Infrastructure and Regional Development

.....
WA means Western Australia

.....
Working Group means the Christmas Island Recovery Plan Working Group

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Appendix A—How the recovery plan addresses the Government response to the recommendations of the Expert Working Group

Recommendations to protect the integrity of Christmas Island ecosystems from further unwanted introductions, prevent additional detrimental changes to the landscape and establish better environmental governance and management frameworks for the island

Expert Working Group Recommendation	Australian Government Response	How Addressed in Recovery Plan
Recommendation 1: (High priority) Biosecurity management on Christmas Island be upgraded urgently to a standard commensurate with the Island biodiversity values using Chevron Australia's Barrow Island Quarantine Management System as a model (see sections 3.3.4, 4.2, 4.5.4 and 4.6).	Enhancement of biosecurity management supported in principle, subject to availability of additional resources	Addressed by actions 2.1 and 2.2
Recommendation 2: (High priority) The governance of Christmas Island be modified so that environmental governance, including matters of biological protection, conservation management and quarantine, is brought under a single authority with both the power and the resources to be effective (see sections 4.2, 4.3.1 and 4.6).	Not supported	Not addressed (not appropriate)
Recommendation 3: (High priority) The pressures on the environment posed by the increasing use of the Island as an Immigration Detention Centre and the continuation of mining be recognised and minimised or adequately managed through new governance arrangements, with biodiversity conservation being the highest priority. This must include much better management of the roads between the Settlement and the IDC to greatly reduce the high level crab deaths due to vehicles (sections 3.2, 3.3.4, 4.5.7 and 4.11).	Supported in part Better management of roads between the Immigration Detention Centre and settlement is supported however major changes to governance arrangements not required and not supported	Addressed in part by action 1.3

Expert Working Group Recommendation	Australian Government Response	How Addressed in Recovery Plan
<p>Recommendation 4: (High priority) The utilisation and management of surface and subterranean water and coastal marine waters be addressed as part of improved island governance (section 4.5.7).</p> <p>In practice this recommendation should include the following:</p> <ol style="list-style-type: none"> 1. Urgent completion of a Service Delivery Agreement between the Attorney General's Department and the Western Australian Department of Water so that the water supply on Christmas Island can be properly regulated. 2. Proclamation of Christmas Island as a water reserve under relevant WA legislation and development of a Water Resource Management Plan ensuring that water allocation is dependent on a licence with suitable conditions issued by the Department of Water in consultation with the authority proposed in Recommendation 2. Water supply to be permitted only where it is sustainable for both human use and environmental needs. 3. Development of a groundwater model for Christmas Island and installation of new monitoring bores as required to ensure model calibration and the sustainability of water use. 4. Sharing of costs associated with implementation of the above recommendations between the Commonwealth government and the WA Water Corporation. 	Supported in principle, subject to availability of additional resources and further detailed consideration of appropriateness of proposed actions	Addressed by action 3.5
<p>Recommendation 5: Priority (High priority) Environmental management of the island, including quarantine, research, restoration, environmental approvals and associated compliance, be improved through a single line budget, an appropriate level of funding and management accountability supported by a scientific advisory system and an appropriate research facility (section 4.3.1, 4.5.3 and section 6).</p>	Not supported	Not addressed (not appropriate)
<p>Recommendation 6: Priority (High priority) Where commercial leases or other commercial regulatory instruments exist or are proposed, their negotiation should include additional resources to research and manage areas or matters of high conservation importance (sections 4.5.6 and section 6 lesson 5).</p>	Supported	Not addressed (out of scope)
<p>Recommendation 7: (High priority) A science management strategy be developed for Christmas Island as a whole and the management lessons identified elsewhere in this report become part of this process and a Christmas Island Conservation Research Centre be established (sections 4.3.1, 4.5.3 and 4.13).</p>	Supported in principle, subject to availability of additional resources	Not specifically addressed (out of scope) but addressed generally by actions 7.1. and 7.2; and key research and monitoring priorities being identified

Expert Working Group recommendations for management of the island's ecological processes so as to prevent further loss of biodiversity

Expert Working Group Recommendation	Australian Government Response	How Addressed in Recovery Plan
Recommendation 8: (High priority) In the absence of any alternative, baiting Yellow Crazy Ant supercolonies with Fipronil continues as a short-term control measure, but with greatly enhanced monitoring of its non-target effects (sections 4.4 and 4.5.3).	Supported	Addressed by actions 1.1 and 5.1
Recommendation 9: (High priority) The initial steps taken already to explore biological control of the introduced scale insects be accelerated and biological control trials be started as soon as possible (sections 4.4, 4.5.3, 4.11.1). In addition helicopter bait delivery trials be conducted over larger areas of the island with the aim of preventing rapid re-establishment of Yellow Crazy Ant supercolonies. These and other initiatives should be implemented within an adaptive management and integrated pest control framework (sections 4.4 and 4.11.1).	Supported, subject to the development of new baits	Addressed by action 1.1
Recommendation 10: (High priority) Monitoring of biodiversity condition and trends be continued but with a high priority for continuous improvement and adaptive management that is informed by the independent scientific advisory system of Recommendations 5 and 7 (sections 4.3.2, 4.13).	Supported subject to availability of additional resources	Addressed by actions 5.1 to 5.5
Recommendation 11: (Medium to High priority) Threats to the island's subterranean fauna and marine ecosystems be assessed and appropriate processes developed to address them (section 4.14).	Supported in principle, subject to availability of additional resources	Addressed in part by actions 3.5 and 6.3 (marine element out of scope)
Recommendation 12: (High priority) A comprehensive review that builds on this report be commissioned to determine gaps that must be filled in our understanding of the biology and population ecology of Red Crabs. Subsequently commissioned research needs to focus on informing adaptive management that concentrates on crab population enhancement and reestablishment in areas from which they have been eliminated (sections 4.4, 4.9.2 and 4.11.1).	Supported in principle, subject to availability of additional resources	Addressed in general terms by action 6.2
Recommendation 13: (Medium priority) Red Crabs be re-introduced experimentally to ghost forests (section 4.4).	Supported in principle, subject to availability of additional resources	Addressed by action 4.4
Recommendation 14: (High priority) Robber Crabs be given a high conservation priority and a study of their population ecology and key threats be undertaken as soon as possible (section 4.11.2).	Supported in principle, subject to availability of additional resources	Addressed in general terms by action 6.2
Recommendation 15: (High priority) Eradication of Black Rats and Feral Cats from Christmas Island be carried out as soon as possible in a coordinated project and research into rat eradication commence as soon as possible (sections 4.5.2.2 and 4.9.2).	Supported in principle, subject to availability of additional resources	Addressed by action 1.2

Expert Working Group Recommendation	Australian Government Response	How Addressed in Recovery Plan
Recommendation 16: (High Priority) A comprehensive program of invertebrate biodiversity research be undertaken resolved to a high taxonomic level and that the definitive collection of Christmas Island invertebrates be housed in a recognised public fauna collection with only non-critical voucher specimens retained on Christmas Island (sect 4.13).	Supported in principle, subject to availability of additional resources	Addressed in general terms by action 6.3
Recommendation 17: (Medium priority) Potential 'sleeper' species of both exotic plants and animals be identified and those species identified as being a high threat to the island's biodiversity be eradicated (section 4.5.1).	Supported in principle, subject to availability of additional resources	Addressed by actions 2.3, 3.1 and 5.4
Recommendation 18: (High priority) Sampling take place to establish baseline levels of prevalence of pathogens, disease and parasites in selected endemic animals and plants (section 4.5.4).	Supported (completed)	Addressed in part by action 6.1
Recommendation 19: (High priority) Sampling take place to establish disease (including parasite) levels in exotic plants and animals now present on Christmas Island (specifically including Black Rats, Feral Cats, Dogs, Tree Sparrows, Java Sparrows, House Geckos, Wolf Snakes and Giant African Land Snails) (section 4.5.4).	Supported (completed)	Addressed in part by action 6.1
Recommendation 20: (Medium priority) A program of regular and robust monitoring of these pathogen levels be developed (section 4.5.4) and Recommendation 21: (Medium priority) The development of a response protocol and framework associated with the monitoring program be undertaken (section 4.5.4).	Supported in principle	Addressed in part by action 6.1

Expert Working Group recommendations for management actions that can be taken immediately to prevent or slow biodiversity loss

Expert Working Group Recommendation	Australian Government Response	How Addressed in Recovery Plan
Recommendation 22 (High priority) A program for checking for the presence of the Pipistrelle be continued for the next two years, with a response protocol in place for implementation should a detection occur (Section 4.7).	Supported (being implemented)	Addressed by action 5.2
Recommendation 23 (High priority) All proposals for land clearance and resource extraction on the island be subject to rigorous assessment and amendment where necessary to prevent significant impact on Island biodiversity. Where land clearance and resource extraction is approved associated conditions should be locally monitored and enforced (section 4.5.6).	Supported	Not addressed (out of scope)
Recommendation 24: (High priority) The costs / benefits and need for a flying fox captive breeding program be considered, for establishment, if recommended, by December 2010 (section 4.10).	Supported in principle (longer timeframe required)	Addressed by actions 4.3 and 9.2
Recommendation 25: (High priority) Appropriate monitoring and targeted research be conducted to identify major threatening processes for the endemic flying fox (Section 4.10).	Supported in principle, subject to availability of existing resources	Addressed by actions 5.2 and 6.2
Recommendation 26: (High priority) Measures be implemented immediately to exclude Cats from Red-tailed Tropicbird nesting areas along the Settlement shoreline (section 4.9.2).	Supported, subject to availability of additional resources above those already committed	Addressed by action 1.2
Recommendation 27: (High priority) The recently established captive breeding program for the Blue-tailed Skink, Lister's Gecko and Forest Skink be continued (section 4.8).	Supported (being implemented)	Addressed by action 4.1
Recommendation 28: (High priority) Appropriate monitoring and/or targeted research be conducted to identify major threatening processes for endemic reptiles (section 4.8).	Supported, subject to availability of additional resources	Addressed by action 5.2
Recommendation 29: (High priority) Fundamental investigations continue and be augmented by adaptive management and aspects of Integrated Pest Control experimental work to develop cost-effective methods to break the scale insect—Yellow Crazy Ant mutualistic dependence (sections 4.4 and 4.5.3).	Supported	Addressed in general terms by action 1.1
Recommendation 30: (High priority) “Christmas Island and its surrounding seas” be considered for listing as a threatened ecological community under the Environment Protection and Biodiversity Conservation Act (section 5.1).	Not supported	Not addressed (not appropriate)
Recommendation 31: (High priority) An appropriate community communications program relating to the recovery of Christmas Island biodiversity and re-establishing key ecological relationships be planned and executed (sections 4.3.1 and 5.2).	Supported	Addressed by action 8.1

Findings with wider applicability

Expert Working Group Recommendation	Australian Government Response	How Addressed in Recovery Plan
<p>Recommendation 32: (High priority for DSEWPAC as a whole)</p> <p>National recognition (and concomitant resourcing) of Australia's iconic islands, many of which have extraordinary conservation values and a high susceptibility to biodiversity loss.</p> <p>Long continuity in conservation management, with appropriate monitoring and adaptive capacity.</p> <p>Development and implementation of a management prioritisation framework.</p> <p>More systematic and streamlined processes for identification and review of threatening processes and lists of threatened species, including those in conservation reserves.</p> <p>The application of suitable conditions on developments to create additional resources to manage areas or matters of high biodiversity conservation importance.</p> <p>Development and maintenance of a secure funding stream for the conservation management of all biodiversity aspects of Parks Australia reserves.</p> <p>Development and maintenance of robust, integrated monitoring programs for Parks Australia reserves, including for threatened species, ecosystem health and other matters of particular conservation significance, the provision of annual reports on such monitoring and using monitoring as a basis for ongoing adaptive management.</p> <p>Improved monitoring and stronger incorporation of adaptive management into Recovery Plans.</p> <p>Development of explicit response protocols for intervention in recovery planning, including the option of precautionary establishment of captive breeding populations.</p> <p>Establishment of conservation reserves is a useful step towards biodiversity conservation, but must be accompanied by appropriate management for biodiversity conservation outcomes; this must include direct assessment of threats (especially by introduced biota), biodiversity condition and trends, and of management effectiveness.</p>	<p>Addressed in part via the aims of Australian Government strategies and programs</p>	<p>Not specifically addressed (largely out of scope) however recommended actions concerning recovery plans and recovery planning noted and taken into account (e.g. via action 9.2)</p>

Appendix B—International Agreements relating to species on Christmas Island

Convention on Wetlands of International Importance (Ramsar Convention)

The Ramsar Convention is an international agreement which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The convention aims to stop the world from losing wetlands and to conserve, through wise use and management, those that remain. There are now more than 150 contracting parties to the convention throughout the world.

Sites are selected for the List of Wetlands of International Importance under the Ramsar Convention because of ecological, botanical, zoological, limnological or hydrological importance. The Hosnies Spring site was listed in 1990 and The Dales was listed in 2002. Ecological Character Descriptions are available for both The Dales (Butcher and Hale 2010) and Hosnies Spring (Hale and Butcher 2010).

Wetlands included in the List of Wetlands of International Importance under the Ramsar Convention are considered ‘declared Ramsar wetlands’ under the EPBC Act. Australian Ramsar management principles are prescribed by the EPBC Regulations.

<http://www.ramsar.org/>

China–Australia Migratory Bird Agreement (CAMBA)

CAMBA provides for China and Australia to cooperate in the protection of migratory birds listed in the annex to the agreement and of their environment, and requires each country to take appropriate measures to preserve and enhance the environment of migratory bird species listed under the agreement.

<http://www.environment.gov.au/biodiversity/migratory/waterbirds/bilateral.html>

Japan–Australia Migratory Bird Agreement (JAMBA)

JAMBA provides for Japan and Australia to cooperate in taking measures for the management and protection of migratory birds, birds in danger of extinction, and the management and protection of their environments, and requires each country to take appropriate measures to preserve and enhance the environment of birds protected under the provisions of the agreement.

<http://www.environment.gov.au/biodiversity/migratory/waterbirds/bilateral.html>

Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)

ROKAMBA provides for the Republic of Korea and Australia to cooperate in taking measures for the management and protection of migratory birds and their habitat by providing a forum for the exchange of information, support for training activities and collaboration on migratory bird research and monitoring activities.

<http://www.environment.gov.au/biodiversity/migratory/waterbirds/bilateral.html>

Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

The Bonn Convention aims to conserve terrestrial, marine and avian migratory species throughout their range. Parties to this convention work together to conserve migratory species and their habitat.

<http://www.cms.int/>

Species that are listed under the above migratory agreements and conventions are listed Migratory species the EPBC Act. Migratory species of Christmas Island are listed in Appendix D.

Convention on Biological Diversity

Australia ratified the Convention on Biological Diversity on 18 June 1993 and the Convention came into force in December 1993. The Convention's objectives are:

- the conservation of the world's biological diversity
- to promote the sustainable use of the components of biological diversity
- to provide for the fair and equitable sharing of benefits from the utilisation of genetic resources, including providing appropriate access to genetic resources and the appropriate transfer of relevant technologies taking into account all rights over those resources and technologies, and by appropriate funding.

Appendix C—Endemic vascular plants of Christmas Island

Species Name	Common Name	Abundance	Distribution
<i>Abutilon listeri</i>	lantern flower	common	coastal fringe and shore terraces
<i>Arenga listeri</i>	Christmas Island palm	abundant	most habitats; plateau and terraces
<i>Asplenium listeri</i>	Christmas Island spleenwort	rare	limestone rocks and cliffs in marginal forest
<i>Asystasia alba</i>	a herb	rare	coastal fringe and terrace forest
<i>Brachypeza archytas</i>	Ridley's orchid	abundant	terrace forest
<i>Colubrina pedunculata</i>	a shrub	common	terrace vegetation
<i>Dendrocnide peltata</i> var. <i>murrayana</i>	stinging tree	rare	tops of inland cliffs
<i>Dicliptera maclearii</i>	a herb	rare	lower terraces marginal forest
<i>Flickingeria nativitatis</i>	an epiphytic orchid	uncommon	evergreen tall closed forest, plateau
<i>Grewia insularis</i>	a tree	uncommon	terrace forest
<i>Hoya aldrichii</i>	hoya vine	abundant	forest canopy, plateau
<i>Illigera elegans</i>	a vine	rare	marginal forest
<i>Ischaemum nativitatis</i>	Christmas Island duck-beak	common	pinnacles behind sea cliffs
<i>Pandanus christmatensis</i>	pandanus, screw-pine	abundant	tops of shore and inland cliffs
<i>Pandanus elatus</i>	pandanus, screw-pine	abundant	forest understorey, plateau and terraces
<i>Peperomia rossi</i> ^(a)	an epiphytic herb	unknown	unknown
<i>Phreatia listeri</i>	an epiphytic orchid	abundant	tall plateau forest canopy
<i>Zeuxine exilis</i> ^(b)	Ridley's ground orchid	unknown	unknown

(a) Not collected since first recorded in 1900, possibly extinct

(b) Rediscovered in 2009 after not being collected since first recorded in 1904

Sources: Commonwealth of Australia 1993; Holmes & Holmes 2002; Parks Australia unpub. data

Appendix D—EPBC Act listed Christmas Island flora and fauna

Species Name	Common Name	EPBC Act Lists		
		Status ^(a)	Migratory	Marine
VASCULAR PLANTS				
<i>Asplenium listeri</i>	Christmas Island spleenwort	CE		
<i>Pneumatopteris truncata</i>	a fern	CE		
<i>Tectaria devexa</i> var. <i>minor</i>	a fern	EN		
MAMMALS				
<i>Crocidura trichura</i>	Christmas Island shrew	EN		
<i>Pipistrellus murrayi</i>	Christmas Island pipistrelle	CE		
<i>Pteropus melanotus natalis</i>	Christmas Island flying-fox	CE		
<i>Rattus macleari</i>	Maclear’s rat	EX		
<i>Rattus nativitatis</i>	bulldog rat	EX		
REPTILES				
<i>Chelonia mydas</i>	green turtle	VU	X	X
<i>Cryptoblepharus egeriae</i>	blue-tailed skink	CE		
<i>Cyrtodactylus sadleiri</i>	giant gecko	EN		
<i>Emoia nativitatis</i>	forest skink	CE		
<i>Eretmochelys imbricata</i>	hawksbill turtle	VU	X	X
<i>Lepidodactylus listeri</i>	Lister’s gecko	CE		
<i>Ramphotyphlops exocoeti</i>	Christmas Island blind snake	VU		
FISHES				
<i>Rhincodon typus</i>	whale shark	VU	X	
BIRDS (excludes vagrant species)				
<i>Accipiter hiogaster natalis</i>	Christmas Island goshawk	EN		X
<i>Actitis hypoleucos</i>	common sandpiper		X	X
<i>Anous stolidus</i>	common noddy		X	X
<i>Apus pacificus</i>	fork-tailed swiftlet		X	X
<i>Ardea alba</i>	great egret		X	X
<i>Arenaria interpres</i>	ruddy turnstone		X	X
<i>Bulweria bulwerii</i>	Bulwer’s petrel			X
<i>Chalcophaps indica natalis</i>	emerald dove (Christmas Island)	EN		
<i>Charadrius leschenaultii</i>	greater sand plover		X	X
<i>Charadrius veredus</i>	oriental plover		X	X
<i>Chlidonias hybrida</i>	whiskered tern			X
<i>Cuculus saturatus</i>	oriental cuckoo		X	X
<i>Egretta sacra</i>	eastern reef egret		X	X
<i>Falco cenchroides</i>	Australian kestrel			X
<i>Fregata andrewsi</i>	Christmas Island frigatebird	VU	X	X
<i>Fregata ariel</i>	lesser frigatebird		X	X

Species Name	Common Name	EPBC Act Lists		
		Status ^(a)	Migratory	Marine
BIRDS (excludes vagrant species)				
<i>Fregata minor</i>	great frigatebird		X	X
<i>Gallinago stenura</i>	pin-tailed snipe		X	X
<i>Hirundo rustica</i>	barn swallow		X	X
<i>Motacilla cinerea</i>	grey wagtail		X	X
<i>Motacilla flava</i>	yellow wagtail		X	X
<i>Ninox natalis</i>	Christmas Island hawk-owl	VU		
<i>Papasula abbotti</i>	Abbott's booby	EN	X	X
<i>Phaethon lepturus fulvus</i>	golden bosun, white-tailed tropicbird		X	X
<i>Phaethon rubricauda</i>	silver bosun, red-tailed tropicbird			X
<i>Stiltia isabella</i>	Australian pratincole			X
<i>Sula leucogaster</i>	brown booby		X	X
<i>Sula sula</i>	red-footed booby		X	X
<i>Tringa glareola</i>	wood sandpiper			X
<i>Tringa nebularia</i>	greenshank			X
<i>Pluvialis fulva</i>	Pacific golden plover		X	X
<i>Turdus poliocephalus erythropleurus</i>	Christmas Island thrush	EN		

(a) EX = extinct; CE = critically endangered; EN = endangered; VU = vulnerable

Appendix E—Non-endemic vascular plants of Christmas Island of possible conservation concern

Species Name	Common Name	Christmas Is Abundance	Christmas Is Distribution	Other Distribution
<i>Abelmoschus manihot tetraphyllus</i>	a shrub	rare	clearings, forest edges	Sumatra, Philippines
<i>Amaracarpus pubescens</i>	a shrub	rare	evergreen tall closed forest	South-east Asia, New Guinea
<i>Balanophora abbreviata</i>	a herb	rare	parasitic on roots of host trees in evergreen tall closed forest on plateau	Madagascar, Africa, Malesia, Philippines, New Guinea, Pacific
<i>Blumea balsamifera</i>	camphor bush	occasional	plateau in secondary growth	South east Asia
<i>Blumea lanceolaria</i>	a herb	rare	clearings and marginal forest	India, China, south-east Asia
<i>Cinnamomum iners</i>	wild cinnamon	rare	clearings, forest edges	India, south east Asia
<i>Cleome gynandra</i>	an annual herb	rare	disturbed areas	Africa, Asia
<i>Commicarpus chinensis</i> ssp. <i>chinensis</i>	a subshrub	rare	rock ledges at North West Point	India, China, south-east Asia, southern Africa
<i>Cycas rumphii</i>	cycad	rare	cliff lines and shore terrace	Malesia, Philippines, Pacific
<i>Cynometra ramiflora</i>	wrinklepod mangrove	rare	a single stand in evergreen tall closed forest south of Ross Hill	India, south-east Asia, Pacific
<i>Didymoplexis pallens</i>	an orchid	one record only	evergreen tall closed forest	India, south-east Asia, Polynesia, north Australia
<i>Eria retusa</i>	an epiphytic orchid	common	evergreen tall closed forest on plateau	Java
<i>Ficus saxophila</i>	a fig tree	frequent	terraces and cliffs island-wide	South-east Asia, Philippines, Java
<i>Hibiscus vitifolius</i>	a herb	two records only	shore terrace	Old World tropics
<i>Jacquemontia paniculata</i>	a twining herb	rare	disturbed sites	Madagascar, Africa, Asia, Malesia
<i>Leptochilus decurrens</i>	a fern	rare	evergreen tall closed forest on plateau	South-east Asia
<i>Leucas zeylanica</i>	a herb	rare	disturbed sites, forest margins	South-east Asia
<i>Lycianthes biflora</i>	a herb	unknown	clearings, rainforest edges	India, Asia, Malesia
<i>Momordica charantia</i>	an annual climber	unknown	disturbed sites, forest margins	Asia, Africa, Malesia, north Australia
<i>Mucuna pruriens</i>	velvet bean	occasional	disturbed sites, forest margins	Madagascar, Africa, Asia

Species Name	Common Name	Christmas Is Abundance	Christmas Is Distribution	Other Distribution
<i>Muellerargia timorensis</i>	a climber	rare	semi-deciduous closed forest	Malesia, north Australia
<i>Peperomia laevifolia</i>	an epiphytic herb	unknown	evergreen tall closed forest on plateau	Java, Sumatra, Borneo, Philippines, New Guinea
<i>Phlegmariurus phlegmaria</i>	common tassel fern	rare	evergreen tall closed forest on plateau	South-east Asia, north Australia, Polynesia
<i>Pteridrys symmatica</i>	a fern	common	evergreen tall closed forest on plateau	Sri Lanka, India, south-east Asia, Philippines
<i>Remusatia vivipara</i>	an epiphytic herb	one record only	evergreen tall closed forest	Old World tropics
<i>Selaginella alutacia</i>	a fern-ally	one record only	limestone rocks near the shore	South-east Asia, Sumatra, Java
<i>Setaria clivalis</i>	a grass	one record only	near Flying Fish Cove	Malesia
<i>Spermacoce mauritiana</i>	an annual herb	rare	clearings, rainforest edges	Pantropical
<i>Spondias cytherea</i>	great hog plum	rare	semi-deciduous closed forest, only known from two natural sites	South-east Asia
<i>Strongylodon lucidus</i>	a climbing shrub	rare	plateau in semi-deciduous closed forest	Madagascar, Sri Lanka, Malesia, north-east Australia, Pacific
<i>Taeniophyllum hasseltii</i>	an epiphytic orchid	uncommon	evergreen tall closed forest on plateau	Malesia
<i>Tectaria dissecta</i>	a fern	uncommon	plateau and upper terraces	Taiwan, Philippines, Borneo, Java, New Guinea, Pacific
<i>Thelasis capitata</i>	an epiphytic orchid	uncommon	evergreen tall closed forest on plateau	Java, Sumatra, Sabah
<i>Thrixspermum carinatifolium</i>	an epiphytic orchid	abundant	evergreen tall closed forest on plateau	Malaya, Java, Sumatra
<i>Triphasia trifolia</i>	limeberry	rare	scree slope in marginal forest, only known from one site	South east Asia, Malesia
<i>Triumfetta suffruticosa</i>	a shrub	occasional	clearings and rainforest edges	Malay Islands, Polynesia
<i>Vitis flexuosa</i>	a climber	rare	disturbed or scrubby vegetation	India, China, Philippines, south-east Asia, Java
<i>Zehneria mucronata</i> ^(a)	a vine	unknown	shrubby margins or forest	North Australia

(a) Christmas Island population formerly considered to be endemic (as *Z. alba*)

Sources: Commonwealth of Australia 1993; Holmes & Holmes 2002; Parks Australia unpub. data

Appendix F—Birds of Christmas Island

Species Name	Common Name	Status	Abundance
RESIDENT FOREST BIRDS AND SHOREBIRDS			
<i>Accipiter hiogaster natalis</i>	Christmas Island goshawk	endemic	uncommon
<i>Amaurornis phoenicurus</i>	white-breasted water-hen	self-introduced	uncommon
<i>Chalcophaps indica natalis</i>	emerald dove (Christmas Island)	endemic	common
<i>Collocalia linchi natalis</i>	Christmas Island swiftlet, glossy swiftlet	endemic	abundant
<i>Ducula whartoni</i>	Christmas Island imperial pigeon	endemic	common
<i>Egretta novaehollandiae</i>	white-faced heron	self-introduced	rare
<i>Egretta sacra</i>	eastern reef egret	native	rare
<i>Falco cenchroides</i>	Australian kestrel	self-introduced	common
<i>Gallus gallus</i>	feral fowl	introduced	common
<i>Ninox natalis</i>	Christmas Island hawk-owl	endemic	uncommon
<i>Lonchura oryzivora</i>	java sparrow	introduced	uncommon
<i>Passer montanus</i>	tree sparrow	self-introduced	common
<i>Turdus poliocephalus erythropleurus</i>	Christmas Island thrush	endemic	common
<i>Zosterops natalis</i>	Christmas Island white-eye	endemic	abundant
BREEDING SEABIRDS			
<i>Anous stolidus</i>	common noddy	native	common
<i>Fregata andrewsi</i>	Christmas Island frigatebird	endemic	uncommon
<i>Fregata ariel</i>	lesser frigatebird	native	rare
<i>Fregata minor</i>	great frigatebird	native	common
<i>Papasula abbotti</i>	Abbott's booby	endemic	uncommon
<i>Phaethon lepturus fulvus</i>	golden bosun	endemic	common
<i>Phaethon rubricauda</i>	silver bosun	native	common
<i>Sula leucogaster</i>	brown booby	native	common
<i>Sula sula</i>	red-footed booby	native	common
REGULAR MIGRANTS AND OCCASIONAL VISITORS^(a)			
<i>Actitis hypoleucos</i>	common sandpiper	regular migrant	
<i>Apus pacificus</i>	fork-tailed swiftlet	regular visitor	
<i>Ardea alba</i>	great egret	occasional visitor	
<i>Arenaria interpres</i>	ruddy turnstone	regular migrant	
<i>Bulweria bulwerii</i>	bulwer's petrel	occasional visitor	
<i>Charadrius leschenaultii</i>	greater sand plover	rare migrant	
<i>Charadrius veredus</i>	oriental plover	rare migrant	
<i>Chlidonias hybrida</i>	whiskered tern	occasional visitor	
<i>Cuculus saturatus</i>	oriental cuckoo	rare migrant	
<i>Gallinago stenura</i>	pin-tailed snipe	occasional visitor	
<i>Glareola maldivarum</i>	oriental pratincole	rare migrant	
<i>Gorsachius melanolophus</i>	Malay night-heron	occasional visitor	
<i>Hirundo rustica</i>	barn swallow	common migrant	
<i>Motacilla cinerea</i>	grey wagtail	common migrant	
<i>Motacilla flava</i>	yellow wagtail	common migrant	
<i>Pluvialis fulva</i>	Pacific golden plover	regular migrant	
<i>Stiltia isabella</i>	Australian pratincole	occasional visitor	
<i>Tringa glareola</i>	wood sandpiper	rare migrant	
<i>Tringa nebularia</i>	greenshank	rare migrant	

(a) excludes vagrant species

Sources: Johnstone & Darnell 2004; Parks Australia unpub. data

Appendix G—Terrestrial mammals and reptiles of Christmas Island

Species Name	Common Name	Status	Abundance
MAMMALS			
<i>Crocidura trichura</i>	Christmas Island shrew	endemic	presumed extinct
<i>Felis catus</i>	feral cat	introduced	common
<i>Mus musculus</i>	house mouse	introduced	common
<i>Pipistrellus murrayi</i>	Christmas Island pipistrelle	endemic	presumed extinct
<i>Pteropus melanotus natalis</i>	Christmas Island flying-fox	endemic	declining
<i>Rattus macleari</i>	Maclear's rat	endemic	extinct
<i>Rattus nativitatis</i>	bulldog rat	endemic	extinct
<i>Rattus rattus</i>	black rat	introduced	common
REPTILES			
<i>Cryptoblepharus egeriae</i>	blue-tailed skink	endemic	possibly extinct in the wild ^(a)
<i>Cyrtodactylus sadleiri</i>	giant gecko	endemic	rare, declining
<i>Emoia atrocostata</i>	coastal skink	native	possibly extinct
<i>Emoia nativitatis</i>	forest skink	endemic	possibly extinct in the wild
<i>Gehyra mutilata</i>	Pacific gecko	introduced	common
<i>Hemidactylus frenatus</i>	Asian house gecko	introduced	common
<i>Lepidodactylus listeri</i>	Lister's gecko	endemic	very rare, declining ^(a)
<i>Lycodon aulicus</i>	wolf snake	introduced	abundant
<i>Lygosoma bowringii</i>	grass skink	introduced	common
<i>Ramphotyphlops braminus</i>	flowerpot snake	introduced	common
<i>Ramphotyphlops exocoeti</i>	Christmas Island blind snake	endemic	very rare, declining

(a) captive breeding populations maintained on-island and off-island

Sources: Cogger & Sadlier 2000; Parks Australia unpub. data

Appendix H—Land and shoreline crabs of Christmas Island

Species Name	Common Name	Status	Abundance and Distribution
<i>Birgus latro</i>	robber crab	native	common, widespread, arboreal and terrestrial
<i>Chiromantes garfunkel</i>	Christmas Island yellow-eyed crab	endemic	common, crevices high in seacliffs beyond tidal or salt spray, around coast
<i>Coenobita brevipennis</i>	purple hermit crab	native	common, beaches and shore terraces
<i>Coenobita perlatus</i>	red hermit crab	native	common, rubble beaches
<i>Coenobita rugosus</i>	tawny hermit crab	native	common, beaches and shore terraces
<i>Cyclograpsus integer</i>	sandy rubble crab	native	rare, restricted to rubble buried in sand at Greta and Ethel beaches
<i>Discoplax celeste</i>	Christmas Island blue crab	endemic	uncommon, moist areas with water seepages
<i>Discoplax</i> aff. <i>hirtipes</i>	orange-legged crab	native	uncommon, drier karstic environments
<i>Discoplax rotunda</i>	rugose land crab	native	rare, shore terrace near The Blowholes
<i>Epigrapsus politus</i>	brown crab	native	rare, beach sand/rubble boundary on forest soil, usually under rocks
<i>Gecarcoidea humei</i>	purple land crab	native	rare, distributed island-wide
<i>Gecarcoidea lalandii</i>	purple crab	native	rare, distributed island-wide
<i>Gecarcoidea natalis</i>	red crab	endemic ^(a)	abundant but declined due to impact of crazy ants, distributed island-wide
<i>Geograpsus crinipes</i>	yellow nipper	native	uncommon, lower terraces, seacliff and beaches
<i>Geograpsus grayi</i>	little nipper	native	common, distributed from shore terrace to plateau
<i>Geograpsus stormi</i>	red nipper	native	rare, under shoreline rocks and in crevices on the seacliff near water
<i>Grapsus tenuicrustatus</i>	grapsus crab	native	common all around coastline
<i>Karstama jacksoni</i>	Jackson's crab	endemic	rare, cool moist areas on lower terraces, in caves
<i>Labuanium vitatum</i>	white-striped crab	native	uncommon, terraces above Greta Beach, The Dales and West White Beach
<i>Metasesarma obesum</i>	mottled crab	native	rare, leaf litter above beaches
<i>Ocypode ceratophthalmus</i>	horn-eyed ghost crab	native	common, sandy beaches
<i>Ocypode cordimanus</i>	smooth-handed ghost crab	native	common, sandy beaches
<i>Ocypode kuhlii</i>	ghost crab	native	Rare, Greta Beach
<i>Ocypode sinensis</i>	Chinese ghost crab	native	Greta Beach
<i>Ocypode</i> sp.	horn-eyed ghost crab	native	sandy beaches
<i>Orcovita hicksi</i>	Hick's cave crab	endemic	unknown but restricted to anchialine cave systems
<i>Orcovita orchardorum</i>	Orchard's cave crab	endemic	unknown, less common than <i>O. hicksi</i> , currently known only from Runaway, Whip and Freshwater caves

(a) A very small, likely introduced population occurs on North Keeling Island

Sources: Hicks et al.1990; Orchard 2012, Ng & Davie 2012; Ng & Davie 2013

Appendix I—Threat risk assessment

During the development of this plan an analysis of the consequences of threats to significant Christmas Island species was attempted. This incorporated estimates of the intensity of the impact and extent of threatening processes potentially affecting each significant species. In many instances, the threats were found to be poorly understood for most species, with comments for each species ranging from the worst case ‘no reliable information on threats’ to, at best, ‘some threats understood’.

The main conclusion from this process is that there is currently insufficient information, on both the impacts and likelihood of consequences of threats, to support a detailed rigorous threat risk analysis. An action to use a risk management framework to assess threats (Action 9.2) is therefore included in this plan, along with collecting data (Actions 1, 2, 3, 5 and 6) for use in a more detailed rigorous assessment. This is reflected in Sections 6.2 (Recommended Actions) and 7.1 (Priorities) which identify the need for an adaptive and risk management approach in relation to action prioritisation.

For the preparation of this plan, a simple process was used to identify major threats. This was based on the pervasiveness of a threat (number of significant species known or potentially affected) and impacts to species essential to the ecosystem (known threat to species considered as important in maintaining the island’s ecosystem). Threats were classed as a ‘major risk’ to the biodiversity of Christmas Island if they met one (or both) of the following criteria:

1. A known or potential threat to more than five significant species (as defined in Part 3.2 of this plan).
2. A known threat to at least one species with a keystone role (as described in Part 3.2 of this plan).

This basic assessment does not take into account confounding factors, such as:

- the relative degree of impact of threats on species
- the potential for single threats to have multiple impacts (e.g. both predation and habitat change due to crazy ants)
- the interplay between threats (e.g. crazy ants changing forest dynamics and increasing potential for weed invasion)
- threats to other native species, in particular poorly known species (plants of possible conservation concern; freshwater, subterranean and terrestrial invertebrates)
- the varied conservation status of species
- the future risk from threats such as climate change, and existing introduced species which are currently not thought to be affecting significant species.

Threats identified as having major risk and the criteria they meet are:

- crazy ants (criteria 1 and 2)
- introduction of new terrestrial invasive species (criterion 1)
- cats (criteria 1 and 2)
- rats (criterion 1)
- habitat disturbance and loss (criterion 1)
- traffic-induced mortality (criterion 2).

Processes which are not considered threats or for which abatement actions are currently beyond the scope of this plan are not included. These comprise:

- processes with minimal consequences and/or highly unlikely, such as overfishing and hunting within the Territory of Christmas Island (see Part 4.3 of this plan)
- threats or potential threats currently beyond the Australian terrestrial range of threatened species, such as habitat clearing and hunting of Christmas Island frigatebirds and Abbott's booby in nearby countries
- marine threats which may affect terrestrial species, as this plan is restricted to terrestrial areas.

Appendix J—Review of existing recovery plans

SPECIES: CHRISTMAS ISLAND SHREW (*Crocidura trichura*)

Overall comment			
Except for clarification of its taxonomy and opportunistic but non-target monitoring, the recovery plan was not/could not be specifically implemented as the species is likely to be extinct			
Objectives			
<ol style="list-style-type: none"> 1. To clarify the taxonomic status from existing museum specimens. 2. To assess the current status and distribution through targeted surveys. 3. To control the abundance and spread of the crazy ant 4. To establish captive breeding populations from any extant populations, pending mitigation of all potential threats. 5. To effectively protect and manage any extant populations 6. To identify habitat critical to survival, including shelter, breeding and foraging habitat. 7. To determine threatening processes affecting the species. 8. To develop and implement a community awareness program to assist in the location of previously undetected populations. 			
Recovery criteria			
<ol style="list-style-type: none"> 1. Taxonomic status of the Christmas Island Shrew resolved. 2. Current conservation status and distribution determined. 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. 4. Captive breeding populations established with the aim of reintroduction once potential threat control has been achieved. 5. Any identified extant populations protected and population numbers increase. 6. Habitat critical to survival investigated and determined. 7. Threatening processes determined, and actions taken to control them. 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. 			
No.	Actions	Action status comments	Status Recommendations
1	Investigate the taxonomic status of the shrew	In 2009 the Australian Museum conducted a study for DEWHA on the taxonomy of the Christmas Island shrew. Based on available evidence the study suggested the CI shrew should be regarded as a distinct species. The study also confirmed that the shrew specimens collected on Christmas Island in 1985 were authentic Christmas Island shrews and represent the same taxon last collected in 1899.	Complete No further action recommended.

2	Investigate current status and distribution	No specific surveys were conducted. However, the Island Wide Survey has been conducted every two years since 2001 with approx. 900 waypoints surveyed. In addition intensive reptile and other biodiversity surveys have been conducted by Park staff. Although shrews were not specifically targeted, no shrews were sighted during these surveys and targeted surveys are unlikely to be more efficient at detecting this species. There have been no recent reports of reliable sightings from individuals/residents.	Not started	Ensure IWS and any other ecosystem wide monitoring programs use methods suitable for detecting the species.
3	Develop wildlife management program for potential habitat outside the Christmas Island National Park	A specific plan was not prepared. However, the Christmas Island regional recovery plan will cover this requirement.	Started	Include habitat management outside National Park in regional recovery plan.
4	Control abundance and spread of crazy ant	Management of crazy ants is ongoing and includes aerial baiting to reduce numbers in supercolonies, monitoring to assess success of and need for baiting, assessing off-target impacts, and research into alternative control methods.	Ongoing	Continue crazy ant management.
5	Implement community awareness program	No specific community awareness program has been conducted.	Not started	Consider publishing booklet of threatened species.
6	Establish captive breeding population	Could not be considered as shrew had not been sighted since 1985.	Not started	Consider if population/s are found and it is feasible and appropriate.
7	Effective management of populations	Could not be considered as shrew had not been sighted since 1985.	Not started	In absence of detectable population, continue to focus on ecosystem and broader species threat abatement activities (e.g. crazy ant and cat and rat management).
8	Identify and describe critical habitat	This was not progressed beyond what was stated in the recovery plan: "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. If the shrew is found to be extant, identifying habitat requirements critical to survival is recommended".	Not started	Further define habitat if/when population/s are found.
9	Identify threatening processes	No specific studies were conducted. However, invasive species threats (particularly, disease, crazy ants and cats and rats) as well as previous habitat losses are likely to be a threat. Crazy ant, cat and rat management has occurred and needs to continue.	Not started	If/when population/s are found, the highest priority actions are surveys to determine population extent and habitat, and potentially captive breeding. If these actions occur, potential threats may be investigated.

SPECIES: CHRISTMAS ISLAND PIPISTRELLE (*Pipistrellus murrayi*)

Overall comment: Many of the actions were started and some were completed. However, these this did not prevent the rapid decline and likely extinction of the pipistrelle. However, captive breeding was likely to be the only action that could have prevented its likely extinction, but may not have resulted in release of populations back in the wild.

Objectives:

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

1. The current status of the population and distribution trends in the species are determined.
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.
3. The impact of the Common Wolf Snake on roosting bats is determined and management actions established to reduce such impacts where they occur.
4. The impact of the Nankeen Kestrel on pipistrelles is determined and management actions established to reduce such impacts where they occur.
5. Primary foraging habitat is identified away from forest ecotones and roadways.
6. The diet of the species is determined in both the wet and dry season and compared to prey availability.
7. Taxonomic status of the Christmas Island Pipistrelle is resolved.
8. All supercolonies of the Yellow Crazy Ant are eliminated and ongoing management undertaken to ensure no subsequent re-infestation.
9. Protection of known or potential habitat is increased outside the Christmas Island National Park.
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.
11. Guidelines have been established and implemented to reduce vehicle related mortality.
12. The conservation status of the species has been reviewed.

No.	Actions	Action status comments	Status	Recommendations
1	Assess population and distribution trends in the Christmas Island Pipistrelle and establish long-term monitoring programs	Significant monitoring was conducted by Park staff, external researchers and by consultant(s) engaged by Christmas Island Phosphates using Anabat detectors and other methods (e.g. night vision goggles). The results of this monitoring showed that the pipistrelle had contracted to a few sites on the western part of the island. However, in 2009 an extensive monitoring program was conducted by members of the Australasian Bat Society as part of an attempted captive breeding program. Despite considerable efforts no bats were caught and only one was detected. The pipistrelle is likely to now be extinct.	Complete	Pipistrelle monitoring to be incorporated into island wide ecosystem monitoring.
2	Determine roosting requirements, investigating seasonal and distributional differences	Potential roost trees were searched for, including an intensive survey in 2009. Due to several factors, including low population numbers, roosting requirements could not be determined.	Started	If population/s are found, the highest priority actions are: surveys to determine population extent and habitat; and potential captive breeding. This may include identifying roosting requirements.
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	Wolf snakes were detected on or near known roost trees or within the western end of the island. However, there was no evidence to show that it had a role in the decline of the pipistrelle.	Partially complete	If population/s are found and the highest priority actions occur, potential threats may be investigated.
4	Determine the impact of the nankeen kestrel, and if found to prey on pipistrelles, develop management actions to reduce the impact	Studies by Lumsden (et al.) in 2007 found that the nankeen kestrel largely preyed on large grasshoppers but they were found in pipistrelle foraging areas near the start of the Winifred Beach track. Due to seasonal prey availability and the low density of pipistrelles in 2007 it is hard to conclusively determine what impact the nankeen kestrel may have had on the decline of the pipistrelle. However, its impact is considered to have been insignificant.	Complete	No further action
5	Identify primary foraging sites away from ecotones and roads	Surveys (by Lumsden, Richards and Parks Australia) showed that the pipistrelle continued to contract to the west of the island until its last detection in 2009. However, these surveys were aimed at detecting pipistrelles, not specifically at identifying foraging sites away from ecotones and roads.	Partially complete	If population/s are found, the highest priority actions include surveys to determine habitat. This may include identifying foraging sites.
6	Investigate dietary specialisation as a contributing factor to the current status of Christmas Island Pipistrelle)	In 2007 Lumsden et al. recommended that further investigations be carried out to determine if the pipistrelle was an opportunistic or specialised feeder. Although inconclusive Lumsden's analysis of the spatial and temporal distributions of crazy ant supercolonies and the pattern of decline in the pipistrelle did not correlate. Richards (2008) hypothesised a link between prey availability, influenced by crazy ants, and pipistrelle decline.	Started	No further action

No.	Actions	Action status comments	Status	Recommendations
7	Clarify the taxonomic status of the Christmas Island pipistrelle	An examination was carried out by the Australian Biological Resources Study in 2009, which determined that the pipistrelle is a discrete and endemic species.	Complete	No further action
8	Continue active management for the control of Yellow Crazy Ant supercolonies	Management of crazy ants is ongoing and includes aerial baiting to reduce numbers in supercolonies, monitoring to assess success of and need for baiting, assessing off-target impacts, and research into alternative control methods.	Ongoing	Continue crazy ant management program.
9	Increased protection of known and potential habitat outside the National Park	No additional protection of potential habitat was initiated. During the life of the recovery plan the distribution of the pipistrelle contracted to the western end of the island and was mostly detected in the national park. However, some calls were detected outside of the Park along the Winifred Beach track (which intersects mine fields 25 and 26). A survey of mine fields was also conducted by Richards in 2008, although no calls were detected.	Not started	Progress if species is detected in an area outside the National Park which requires additional protection.
10	Assess the impact of phosphate stockpile removal on the Christmas Island Pipistrelle	Pipistrelle surveys were conducted by Christmas Island Phosphates before the removal of stockpiles at fields on the north west of the island.	Complete	No further action
11	Guidelines to reduce vehicle-related mortality	No guidelines were prepared. However, due to the rapid decline of the pipistrelle vehicle impacts were not considered to be a factor in their decline.	Not started	No further action
12	Review the conservation status of the species	When the recovery plan was prepared in 2004 the pipistrelle was listed under the EPBC Act as endangered but was assessed and listed under the EPBC Act as critically endangered in 2006.	Complete	No further action

SPECIES: ABBOTT'S BOOBY (*Papasula abbotti*)

Overall comment: Many recovery actions were started/partially completed. Anecdotally it appears that the Abbott's booby populations may slowly be recovering but existing monitoring data do not provide a basis for drawing conclusions about the status of the Abbott's booby. Furthermore, if recovery is occurring it is difficult to attribute this to any specific recovery actions.

Protect, restore and enhance the breeding habitat of Abbott's booby				
Objective 1				
Recovery Criteria 1.1				
Recovery Criteria 1.2	<ul style="list-style-type: none">Removal of stockpiles proceeds in accordance with the CINPMP.Breeding habitat is not compromised by removal of stockpiles.			
	<ul style="list-style-type: none">Mining fields rehabilitated in accordance with priorities in CINPMP.Extent to which mining fields are rehabilitated.			
	<ul style="list-style-type: none">Breeding success and survival of Abbott's booby nesting adjacent to mining fields increased to levels observed in good (non-turbulent) habitat.			
	<ul style="list-style-type: none">Extent to which the actions and priorities of the CI weed management are implemented.			
	<ul style="list-style-type: none">Habitat critical to survival is mapped			
Recovery Criteria 1.3				
Recovery Criteria 1.4				
No.	Actions	Action status comments	Status	Recommendations
1.1	Manage the removal/mining of phosphate stockpiles in and adjacent to the Park in accordance with the mining lease and <i>Third Christmas Island National Park Management Plan</i> , to ensure this activity does not have a significant environmental impact on breeding habitat.	No stockpiles were removed from Christmas Island National Park. Stockpiles outside of the park were removed in accordance with lease conditions.	Complete	Continue compliance monitoring through existing regulatory processes.
1.2	Implement the Christmas Island Rainforest Rehabilitation Program, giving priorities for to mining fields detailed in Table 2 of the <i>Third Christmas Island National Park Management Plan</i> (page 94) with consideration of land tenure and long term success of the rehabilitation.	With over 25% of the island cleared since settlement and most of this area being located on the plateau and former rainforest, not all sites are likely to be able to be rehabilitated. However, this action is considered Partially Complete as rehabilitation occurred to the extent possible with the current available financial and physical resources (e.g. soil).	Partially complete	Continue the rainforest rehabilitation program subject to continued annual funding allocations as per the rehabilitation program plan.

No.	Actions	Action status comments	Status	Recommendations
1.3	Continue to implement the Christmas Island weed management strategy.	A weed management plan 2005–2009 has been prepared and was updated in 2010 (for 2010–2015). Weed management occurred in the fields planted as part of the Christmas Island Mine-site to Forest Rehabilitation Program (CIMFR). This involved pre-planting clearing of weeds and follow up weed management in planted fields. Since 2006 a minimum of 250 hectares of weed control work was also conducted on other sites, primarily in plateau areas. Parthenium weed has been detected on Christmas Island and is being managed under a Service Delivery Agreement between the Territories Administration and WA DEC. However, except for weed management work associated with the CIMFR program it is difficult to determine the benefits of weed control work in terms of Abbott's booby recovery.	Partially complete	Continue weed management.
1.4	Accurately map critical breeding habitat inside and outside the Park. The wind turbulence model (Action 7) will help to determine and assess potential breeding habitat.	This action was not conducted and is not considered necessary. Existing knowledge of nesting requirements, as well as the IWS, aerial surveys and remote sensing data, combined with GIS mapping, provide a means of mapping critical habitat.	Not started	No further action
Objective 2				
Manage any threats posed by the crazy ant to ecosystem function in areas of infestation				
Recovery Criteria 2.1				
<ul style="list-style-type: none"> Control program is maintained at, or increased above, current (2002) levels. Crazy ants reduced to a level where ecosystem function is re-established in affected areas. Crazy ant control has no negative impact on Abbott's booby. 				
No.	Actions	Action status comments	Status	Recommendations
2.1	Continue control of crazy ants as a high priority action to preserve ecosystem integrity and hence protect breeding habitat.	Management of crazy ants is ongoing and includes aerial baiting to reduce numbers in supercolonies, monitoring to assess success of and need for baiting, assessing off-target impacts, and research into alternative control methods.	Ongoing	Continue crazy ant management.
Objective 3				
Ensure activities associated with construction and operation of Immigration Reception and Processing Centre do not impede recovery				
Recovery Criteria 3.1				
<ul style="list-style-type: none"> Removal of vegetation on site is minimised. Wherever possible, revegetation is undertaken on parts of the site. Development of the Centre is contained within the site. Breeding success and survival of Abbott's booby nesting adjacent to the Centre is not reduced. 				
Recovery Criteria 3.2				
<ul style="list-style-type: none"> Wind-shear effects on nests along Murray's Road are not increased. Breeding success and survival of Abbott's booby nesting along Murray's Road is not reduced. 				
Recovery Criteria 3.3				
<ul style="list-style-type: none"> Breeding success and survival of boobies nesting adjacent to the Centre is not reduced as a result of routine operation of the facility. 				
Recovery Criteria 3.4				
<ul style="list-style-type: none"> Monitoring program is established, preferably one that is integrated with the regular monitoring program (objective 7). 				

No.	Actions	Action status comments	Status	Recommendations
3.1	<p>Closely supervise construction of the IRPC to ensure environmental impacts are minimised, in particular, design and siting of the Centre to minimise:</p> <ul style="list-style-type: none"> wind-turbulence effects on adjacent Abbott's booby nests; and removal of revegetation within the designated site. 	<p>The building of the IRPC was considered a matter of national interest and was not subject to referral and assessment processes under the EPBC Act. However, as part of the construction of the IRPC, DOFA funded the Christmas Island Biodiversity Monitoring Program which included monitoring of Abbott's booby nesting sites adjacent to the IRPC. The monitoring did not detect any measurable change in the density and distribution of nest sites in the vicinity of the IRPC between 2004–2006 and no strong indication of any movement of nesting sites away from the IRPC. This is likely to have been because no clearing of tall evergreen rainforest (i.e. Abbott's booby nesting habitat) for the IRPC's construction occurred.</p>	Complete	No further action
3.2	<p>Closely supervise road upgrading and infrastructure construction along Murray's Road during development of the IRPC, to ensure environmental impacts are minimised. In particular:</p> <ul style="list-style-type: none"> rainforest clearing should be minimised if not prevented; waste treatment and other services should be laid close together on the same side of the road; minor road re-alignments should be considered to prevent destruction of nesting trees. 	<p>It is difficult to determine if impacts were minimised or avoided. Transect surveys along Murray Road may indicate a slight decrease in Abbott's booby numbers, which may be due to increased road dust and noise since the opening of the IRPC. However, more studies would need to be done in order to draw any conclusions as there is no clear baseline for comparisons.</p>	Partially complete	Assess any future road upgrades in accordance with the assessment processes identified in the EPBC Act.
3.3	<p>The day-to-day operational activities of the IRPC are managed to ensure that environmental impacts are minimised. In particular, breeding of Abbott's booby pairs nesting adjacent to the site should not be compromised by the Centre's operational activities.</p>	<p>Covers were placed on the lights of the IRPC but no other related measures, including monitoring, have been adopted as part of the on-going operation of the IRPC. However, any impacts are considered to be low or minimal when compared to other threats so this action is not considered necessary unless the centre expands considerably.</p>	Started	No further action
3.4	<p>Establish and implement a monitoring program for construction and operational activities of the IRPC which:</p> <ul style="list-style-type: none"> establishes baseline data; and rapidly detects any adverse impacts on Abbott's booby (both short and long-term). 	<p>Some baseline data was collected as part of the DoFA funded Biodiversity Monitoring Program. However, no other specific measures, including specific IRPC site monitoring, are adopted as part of the on-going operation of the IRPC.</p>	Started	See previous action

Objective 4		Ensure activities associated with the construction and operation of the Asia Pacific Space Centre do not impede recovery		
Recovery Criteria 4.1		<ul style="list-style-type: none"> Monitoring program is established, preferably one that contributes to the regular monitoring program (objective 7). 		
Recovery Criteria 4.2		<ul style="list-style-type: none"> APSC activities suspended if an adverse impact identified. APSC activities not resumed until the adverse situation has been rectified and Abbott's booby conservation assured. 		
No.	Actions	Action status comments	Status	Recommendations
4.1	Establish a monitoring program of construction and operational activities of the APSC which: <ul style="list-style-type: none"> collects baseline data for at least 3 years prior to the first launch; and detects any significant impacts on Abbott's booby. 	Not applicable as the APSC did not get off the ground	Not applicable	No further action
4.2	If a significant impact is detected, any satellite launch regime should be suspended immediately and a review conducted. Any detrimental activity should not re-commence until the cause of the impact has been rectified.	Not applicable as the APSC did not get off the ground	Not applicable	No further action
Objective 5		Identify feeding habitat of adults and juveniles and develop appropriate management responses to any threats identified		
Recovery Criteria 5.1		<ul style="list-style-type: none"> Satellite telemetry studies completed. Marine habitat critical to survival (if any), and potential threats to this habitat, identified. 		
No.	Actions	Action status comments	Status	Recommendations
5.1	Investigate at-sea distribution of Abbott's booby through the use of satellite telemetry to: <ul style="list-style-type: none"> determine foraging range and potential overlap with threatening processes e.g., fishing and hunting. Studies need to resolve at-sea range both spatially and temporally and account for sex, age class, season and breeding status; resolve/define marine habitat critical to survival. 	Monitoring has been conducted as part of a 2007 NHT funded project 'Investigation of the Foraging Ecology of the Endangered Abbott's booby' conducted in collaboration with Hamburg University. The results showed that Abbott's booby travel as far away as 550 km from Christmas Island and can cover 2200 km in a single journey and that they dominantly travel to the north, south and west.	Started	Investigate the at-sea distribution of Abbott's booby, including to detect any seasonal variation in foraging journeys, and ensure results are used during management of these areas.

Objective 6		Establish a population monitoring program		
Recovery Criteria 6.1		<ul style="list-style-type: none"> Techniques for monitoring developed and trailed. 		
Recovery Criteria 6.2		<ul style="list-style-type: none"> A regular monitoring program is implemented within two years. Results of the monitoring program are reported immediately to assist in management and recovery. Results of the monitoring program used to evaluate and guide CIRRP. 		
No.	Actions	Action status comments	Status	Recommendations
6.1	Develop and trial sampling techniques for use in monitoring program.	Methods for monitoring population demographics are established and being used. Ground survey methods through the Island Wide Survey are also being used and aerial surveys have also been used.	Complete	As needed further refine methods during future monitoring programs.
6.2	Develop and implement a cost-effective monitoring program for Abbott's booby to: <ul style="list-style-type: none"> detect changes in population with high precision; monitor effectiveness of mine site rehabilitation on adjacent nesting Abbott's boobies to ascertain whether population size, distribution and breeding success are increased; estimate total population size with low to medium precision; and where possible, allow monitoring of other potential threats, such as from APSC and IRPC. 	In 2009 an aerial survey was conducted. However, the methods may need to be refined as population trends/counts are difficult to determine. Data collected needs to be analysed and correlated with ground surveys as it is difficult to estimate a population size from these surveys.	Started	Continue to monitor Abbott's booby. Analyse data already collected and correlate with ground surveys.
6.3	Upgrade existing monitoring data and ensure that the coding system is documented.	This action was not completed.	Not started	Ensure monitoring data and is effectively managed in GIS and other data systems.

Objective 7		Develop a wind turbulence model to guide and evaluate the CIRRP in restoration of Abbott's booby breeding habitat		
Recovery Criteria 7.1		<ul style="list-style-type: none"> Refined wind turbulence model for Abbott's booby breeding habitat developed. Effectiveness of existing mine rehabilitation in improving habitat assessed. Rehabilitation priorities and prescriptions of CIRRP are re-evaluated. 		
No.	Actions	Action status comments	Status	Recommendations
7.1	Appraise effectiveness of mine site rehabilitation in ameliorating wind turbulence upwind of breeding sites through use of GIS and computer modelling. Use model to determine at what stage wind turbulence upwind of clearings is ameliorated to an extent that breeding success and survival of Abbott's booby is not compromised, and to improve guidelines for rehabilitation, including stockpile removal, in consultation with DOTARS and PRL.	The model was not completed. However, it is not clear what the value of the model will be in terms of influencing rehabilitation works, as rehabilitation is already targeted at rainforest adjoining evergreen tall closed forest. Monitoring actual nesting sites adjacent to areas that have been rehabilitated is likely to be a more effective measure of rehabilitation success in the long-term, once revegetation is old enough.	Not started	No further action in short term. Monitor nesting sites in areas adjacent to revegetated areas to measure success of rehabilitation in long-term.
Objective 8		Monitor and assess the likely impact of developing fisheries in the Christmas Island area		
Recovery Criteria 8.1		<ul style="list-style-type: none"> As necessary, assessment of risk and development of preventative procedures. 		
No.	Actions	Action status comments	Status	Recommendations
8.1	In the event of a fishery developing in the area, ensure observer coverage to identify whether by catch is occurring; develop appropriate measures to eliminate any problem.	Currently there are no large scale commercial fisheries within the Territory of Christmas Island or surrounding Australian waters. This action is also relevant to a number of other seabird species.	Not applicable	If a fishery is considered, advise AFMA and other relevant agencies of potential fishing impacts on Abbott's booby (and other seabirds).
Objective 9		Assess and revise the Recovery Plan as necessary		
Recovery Criteria 9.1		<ul style="list-style-type: none"> Recovery Team formed and plan implemented. 		
Recovery Criteria 9.2		<ul style="list-style-type: none"> Consistency across National and International threatened species lists. 		
No.	Actions	Action status comments	Status	Recommendations
9.1	Form Recovery Team and implement Recovery Plan. Team should include experts and stakeholder representatives and communicate via email and telephone conferencing.	A recovery team was not formed. However, a working group has been developed to assist with the preparation of the Christmas Island regional recovery plan and a recovery team is proposed for the plan's implementation.	Started	Develop and maintain a recovery team.
9.2	Prepare and submit nomination to TSSC for listing as Critically Endangered.	A nomination was not prepared. However, as the population numbers are unclear it may be difficult to assess the Abbott's booby as being critically endangered.	Not started	No further action

SPECIES: CHRISTMAS ISLAND FRIGATEBIRD (*Fregata andrewsi*)

Overall comment: Some recovery actions were started or partially completed. However, existing monitoring data do not provide a basis for drawing conclusions about the status of the Christmas Island frigatebird populations and other than habitat disturbance, likely threats are not known.

Objective 1		Maximising extent of occurrence and total population size.		
Recovery Criteria		<ul style="list-style-type: none"> Breeding distribution of Christmas Island frigatebirds maintained or increased on Stokes (1988) levels. Total population size not significantly less than 1620 breeding pairs. Protection of all habitat critical to survival of the Christmas Island frigatebird. 		
No.	Action	Action status comments	Status	Recommendations
1	Develop techniques to monitor the total breeding population size.	Monitoring techniques were developed and used as part of the Biodiversity Monitoring Program (BMP) to determine population trends and site occupation. However, there are limitations using these methods for locating other breeding colonies.	Complete	Continue to use and adapt methods to detect population trends and site occupation/colonies.
2	Monitor the total breeding population size.	Monitoring was conducted as part of the BMP (indicating that there were an estimated 100 breeding pairs near the phosphate dryers in 2005); genetic work is being initiated by Hamburg University and an opportunistic aerial survey was conducted in 2009. These may assist with monitoring the trends in the breeding population size but it may be difficult to determine a total population size. A total population estimate is not currently available.	Partially complete	Continue to monitor population trends.
3	Monitor and/or assist the recovery of the Dryers breeding colony.	Surveys in 2005 estimated 100 breeding pairs near the phosphate dryer's colony and surveys conducted in 2011 appear to indicate the colony and moved west of the initial site.	Partially complete	Monitor frigatebird colony at the Dryers area as part of monitoring known colonies.
4	Development and implementation of a wildlife management plan for frigatebird habitat outside the national park.	The Christmas Island regional recovery plan will incorporate actions for conserving the Christmas Island frigatebird.	Started	Include relevant actions in the regional recovery plan.
5	Ensure protection of habitat critical to survival outside the national park.	The crazy ant management program includes off-park area. However, threats such as weeds are not being managed and other threats are not fully understood. However, actions that may impact on its habitat require assessment under the EPBC Act.	Started	Continue to assess the impacts of proposed actions in accordance with the EPBC Act.
				Continue to implement island-wide ecosystem recovery actions such as weed and crazy ant management.

Objective 2		Implementing threat abatement strategies.		
Recovery Criteria		<ul style="list-style-type: none"> Crazy Ants having an insignificant impact on Christmas Island frigatebirds. Maintenance of effective quarantine against the introduction of avian diseases 		
No.	Action	Action status comments	Status	Recommendations
6	Implement the Invasive Ants on Christmas Island Action Plan.	Management of crazy ants is ongoing and includes aerial baiting to reduce numbers in supercolonies; monitoring to assess success of and need for baiting, assessing off-target impacts, and research into alternative control methods.	Ongoing	Continue crazy ant management.
7	Maintenance [and regular review] of a quarantine barrier between Christmas Island and all other lands to minimise the risks of new avian diseases establishing on Christmas Island.	DAFF Biosecurity have been present on Christmas Island since 1994 and carry out their operations in accordance with the <i>Quarantine Act</i> . However, in 2009 the Minister for the Environment, Heritage and the Arts established an Expert Working Group (EWG) to advise the Minister on biodiversity conservation issues on Christmas Island. The EWG recommended quarantine management be upgraded to a standard consistent with the island's biodiversity values.	Partially complete	Increase/improve quarantine.
Objective 3		Increasing community involvement in and awareness of the Frigatebird.		
Recovery Criteria		<ul style="list-style-type: none"> Demonstrated increase in community awareness and support for habitat protection 		
No.	Action	Action status comments	Status	Recommendations
8	Conduct a community education program.	Several community education activities were conducted on Christmas Island's ecology and species but little was specifically focused on the frigatebird.	Not started	Consider publishing booklet of threatened species.
Objective 4		To implement the Recovery Plan through a Recovery Team.		
Recovery Criteria		Demonstrated successful operation of the Recovery Team over five years.		
No.	Action	Action status comments	Status	Recommendations
9	Establish a recovery team which meets regularly	A recovery team was not formed. However, a recovery working group has been developed to assist with the preparation of the Christmas Island regional recovery plan and a recovery team is proposed for the plan's implementation.	Partially complete	Develop and maintain a recovery team.
10	Carry out a major review of the recovery plan.	This audit provides the review.	Complete	No further action

SPECIES: CHRISTMAS ISLAND GOSHAWK (*Accipiter hiogaster natalis*)

Overall comment: Most recovery actions were complete, started or partially completed including establishing a monitoring program. However, existing monitoring data do not provide conclusions about their population status and likely threats.

Objective 1		Determine taxonomic status		
Recovery Criteria 1		<ul style="list-style-type: none"> Taxonomic position of Christmas Island goshawk clarified. 		
No.	Action	Action status comments	Status	Recommendations
1	Investigate the taxonomic status of the Christmas Island goshawk.	No taxonomic investigations were carried out.	Not started	Conduct taxonomic investigations.
Objective 2		Determine and maximise total population size and area of occupancy		
Recovery Criteria		<ul style="list-style-type: none"> Distribution of Christmas Island goshawks widespread on the island in all suitable habitats as demonstrated by population monitoring Density of Christmas Island goshawks increased as demonstrated by population monitoring Protection of all habitat critical outside the national park. A continuing increase in suitable habitat through implementation Christmas Island Rainforest Rehabilitation program. 		
2	Conduct detailed population survey.	In 2006–07 Holdsworth established a monitoring program; established a sightings database and conducted surveys. The goshawk was also monitored by Parks Australia in the 2009 Island Wide Survey and through the CIMFR program. A total population estimate is yet to be determined.	Partially complete	Analyse existing data and generate population figures for comparison with ongoing monitoring data.
3	On-going monitoring of the population.	Monitoring has been conducted over a number of years by Holdsworth and Parks Australia through the 2009 Island Wide Survey and the CIMFR program.	Partially complete	Continue monitoring population trends.
4	Develop and implement wildlife management plan outside the national park.	A regional recovery plan for Christmas Island is being prepared and will effectively be a wildlife management plan for a range of species inside and outside of the park.	Started	Complete the regional recovery plan.
5	Ensure protection of habitat critical outside the national park.	All new development proposals likely to have significant impact on matters of national significance must be referred under the EPBC Act. Threatening processes impacting on the goshawk are not conclusive, but are likely to be related to habitat loss and modification, weed impacts and invasive species.	Partially complete	Continue to assess the impacts of proposed actions in accordance with the EPBC Act. Continue to implement island wide ecosystem recovery actions such as weed and crazy ant management. Ensure consideration of impacts on the goshawk (e.g. prey relationships, toxin impacts) in any cat and rat management.

No.	Action	Action status comments	Status	Recommendations
6	Continue effective and long-term rainforest rehabilitation program managed by DOTARS & supported by PAN and the mining company.	Rehabilitation occurred to the extent possible with the current available financial and physical resources (e.g. soil). This activity will continue according to annual funding allocation.	Partially complete /ongoing	Continue the rainforest rehabilitation program.
Objective 3				
Recovery Criteria				
<ul style="list-style-type: none"> Crazy Ants have a negligible impact on Christmas Island goshawk Maintenance of effective quarantine against the introduction of all avian diseases 				
No.	Action	Action status comments	Status	Recommendations
7	Implement the Invasive Ants on Christmas Island Action Plan.	Management of crazy ants is ongoing and includes aerial baiting to reduce numbers in supercolonies, monitoring to assess success of and need for baiting, assessing off-target impacts, and research into alternative control methods.	Ongoing	Continue crazy ant management.
	Maintenance [and regular review] of a quarantine barrier between Christmas Island and all other lands which minimises the risks of new avian diseases establishing on Christmas Island.	DAFF Biosecurity have been present on Christmas Island since 1994 and carry out their operations in accordance with the <i>Quarantine Act</i> . However, in 2009 the Minister for the Environment, Heritage and the Arts established an Expert Working Group (EWG) to advise the Minister on biodiversity conservation issues on Christmas Island. The EWG recommended that quarantine management be upgraded to a standard consistent with the island's biodiversity values.	Partially complete	Increase/improve quarantine.
Objective 4				
Recovery Criteria				
<ul style="list-style-type: none"> Demonstrated increase in community awareness and support for habitat protection 				
No.	Action	Action status comments	Status	Recommendations
9	A community education program to raise awareness and interest in the conservation of Christmas Island goshawks.	The goshawk has been included as a feature bird species as part of the annual Bird Week program for seabird groups. No other specific programs for the goshawk have been implemented.	Partially complete	Consider publishing booklet on recovery of the island's species.
Objective 5				
Recovery Criteria				
<ul style="list-style-type: none"> Demonstrated successful operation of the Recovery Team over five years 				
No.	Action	Action status comments	Status	Recommendations
10	Establish a recovery team which meets regularly.	A recovery team was not formed. However, a recovery working group has been developed to assist with the preparation of the Christmas Island regional recovery plan and a recovery team is proposed for the plan's implementation.	Started	Develop and maintain a recovery team.
11	Carry out a major review of the recovery plan	This audit provides the review.	Complete	No further action

SPECIES: CHRISTMAS ISLAND HAWK-OWL (*Ninox natalis*)

Overall comment Recovery actions were complete, started or partially completed but monitoring was limited and existing data do not enable conclusions about their population status and likely threats to be determined.				
Objective 1		Maintain (or increase) extent of occurrence and total population size at 1994–96 levels.		
Recovery Criteria		<ul style="list-style-type: none"> Total population size not less than 562 ± 105 occupied territories as measured by the monitoring program. Owls widespread on the island in all suitable habitats as measured by the monitoring program. Protection of all habitat critical to survival outside the national park. A continuing increase in suitable habitat through implementation of the Christmas Island Rainforest Rehabilitation program. 		
No.	Action	Action status comments	Status	Recommendations
1	Monitor the Christmas Island hawk-owl population every two years to detect any significant change in the distribution or abundance.	Limited/incomplete monitoring of Hawk-owls occurred as part of the Biodiversity Monitoring Program (BMP) and a program was further developed and implemented in 2010 after completion of the BMP. These surveys were repeated in 2012 and indicate that the population trend may be stable. Surveys were also conducted by Christmas Island Phosphates for the preparation of a supplementary impact assessment for their application for new mining leases.	Partially complete	Analyse existing monitoring data. Continue the monitoring program.
2	Develop and implement a wildlife management plan for hawk-owl habitat outside the national park.	A regional recovery plan for Christmas Island is being prepared and will effectively be a wildlife management plan for a range of species inside and outside of the park.	Started	Complete the regional recovery plan.
3	Ensure protection of habitat critical to survival outside the national park.	All new development proposals are subject to referral and assessment processes outline under the EPBC Act. However, threatening processes impacting on the Hawk-owl are not conclusive but are likely to be related to habitat loss and modification, weed impacts and invasive species.	Partially complete	Continue to assess the impacts of proposed actions in accordance with the EPBC Act.
4	Continue an effective and long-term rainforest rehabilitation program managed by DOTARS and supported by other government departments, PAN and the mining company.	Rehabilitation occurred to the extent possible with the current available financial and physical resources (e.g. soil).	Partially complete/ongoing	Continue the rainforest rehabilitation program

Objective 2		Implement threat abatement strategies		
Recovery Criteria		<ul style="list-style-type: none"> Crazy Ants having a negligible impact on Christmas Island hawk-owls populations. Maintenance of effective quarantine against the introduction of all avian diseases. 		
No.	Action	Action status comments	Status	Recommendations
5	Implement the Invasive Ants on Christmas Island Action Plan	Management of crazy ants is ongoing and includes aerial baiting to reduce numbers in supercolonies, monitoring to assess success of and need for baiting, assessing off-target impacts, and research into alternative control methods.	Ongoing	Continue crazy ant management.
6	Maintenance [and regular review] of a quarantine barrier between Christmas Island and all other lands which minimises the risks of new avian diseases establishing on Christmas Island.	DAFF Biosecurity have been present on Christmas Island since 1994 and carry out their operations in accordance with the <i>Quarantine Act</i> . However, in 2009 the Minister for the Environment, Heritage and the Arts established an Expert Working Group (EWG) to advise the Minister on biodiversity conservation issues on Christmas Island. The EWG recommended that quarantine management be upgraded to a standard consistent with the island's biodiversity values.	Partially complete	Increase/improve quarantine.
Objective 3		Increase community involvement in and awareness		
Recovery Criteria		<ul style="list-style-type: none"> Demonstrated increase in community awareness and support for habitat protection. 		
No.	Action	Action status comments	Status	Recommendations
7	Community education program to raise awareness and interest in conservation of Christmas Island hawk-owls.	No specific program for the Hawk-owl was implemented.	Started	Consider publishing booklet on recovery of the island's species.
Objective 4		Implement the Recovery Plan through a Recovery Team		
Recovery Criteria		<ul style="list-style-type: none"> Demonstrated successful operation of the Recovery Team over five years. 		
No.	Action	Action status comments	Status	Recommendations
8	Establish a recovery team which meets regularly.	A recovery team was not formed. However, a recovery working group has been developed to assist with the preparation of the Christmas Island regional recovery plan and a recovery team is proposed for the plan's implementation.	Started	Develop and maintain a recovery team.
9	Carry out a major review of the recovery plan.	This audit provides the review.	Complete	No further action

SPECIES: LISTER'S GECKO (*Lepidodactylus listeri*) and CHRISTMAS ISLAND BLIND SNAKE (*Ramphotyphlops exocoeti*)

Overall comment: Recovery actions were complete, started or partially completed. Intensive localised surveys were conducted for Lister's gecko leading to the rediscovery of the species and the Island Wide Survey resulted in the rediscovery of the CI blind snake. A captive breeding program, not identified in the original recovery plan, for native reptiles, including for Lister' gecko commenced in 2009. Investigation of likely threatening processes is being commenced, including disease and invasive species threats.

Objectives:

1. Find both species in the wild
2. Determine the likelihood that one or more potential threats are threatening the survival of the species
3. Continue present abatement strategies, or develop and implement new strategies, for potential threats such as crazy ants, predators, habitat fragmentation and unintended invasive species introductions (quarantine effectiveness).
4. Obtaining, following rediscovery of either or both species, sufficient knowledge of the biology and ecology of, and threats to, these species to guide an effective management program for increasing their numbers and spatial distribution.

Recovery Criteria:

1. Populations of both species are located within 2 years *or* surveys to locate both species continue (until species located) for the life of the Recovery Plan (5 years).
2. The possible role of the wolf snake, cats and black rats as threats, and potential for control programs, investigated.
3. Existing control program for the crazy ant maintained and/or improved within 2 years.
4. Quarantine regulations and protocols reviewed, and modified as necessary within 2 years.
5. Autecological studies are commissioned within 6 months of the rediscovery of either or both species.
6. Should populations of either species be rediscovered, then at the end of 5 years the current distribution, biology, demography (including estimates of population size) and ecology is sufficiently well documented as to enable development of a full recovery program, including identification and prioritisation of all threats, together with plans for their abatement.
7. Comprehensive information is compiled on both species to support reassessment of their conservation status under the EPBC Act after 2 years if the species are not located, or, if rediscovered, at the end of 5 years.

No.	Action	Action status comments	Status	Recommendations
1	Survey and monitor the endemic reptilian and other selected taxa of Christmas Island.	Considerable native reptile surveys have been conducted during the life of the recovery plan by Barker and Schultz (2008) and park staff surveys, including the Biodiversity Monitoring Program (BMP); Island Wide Surveys and targeted reptile-specific surveys. The results of these surveys were that Lister's gecko and the CI blind snake were rediscovered in 2009 (although only one blind snake was found) but that all six native reptile species were in serious decline. Recent surveys showed that all species (except for the blind snake and giant gecko) are restricted to Egeria Point.	Complete/ongoing	Continue to monitor native reptiles.
2	Until Lister's gecko and the CI blind snake are rediscovered, have annual searches for both species.	See above	Complete/ongoing	Continue to search for Lister's gecko and CI blind snake populations.

No.	Action	Action status comments	Status	Recommendations
3	Upon rediscovery of either or both species in the wild, conduct autecological studies to inform recovery actions.	Ecological studies, including disease threats, have been conducted or are being initiated in conjunction with: a captive breeding program for Lister's gecko and blue-tailed skink (with the aim of adaptively releasing them back into the wild) and monitoring to help determine threatening processes to inform recovery actions.	Started	Continue studies to investigate threatening processes. Continue the captive breeding program for Lister's gecko.
4	Identify the role of the introduced wolf snake as a potential threat to endemic reptiles.	The Biodiversity Monitoring Program (BMP) analysed prey data from the digestive tracts of wolf snakes. As cited by Shultz and Barker (2008) the BMP found reptiles comprised 96% of the diet by weight of 104 snakes examined. The predominant prey species were introduced species: the Asian wolf snake (37%, n=30), grass skink (30%, n=24), Asian house gecko (12%, n=10) and barking house gecko (11%, n=9). The blue-tailed skink comprised only a small dietary component (1%, n=1), but this is likely to be a reflection of the low relative abundance of this species compared to the more abundant introduced species. Although inconclusive this indicates wolf snakes are a threat to native reptiles but the level of threat is difficult to quantify. In 2010 the stomach contents of a wolf snake included blue-tailed skink.	Complete	Continue studies to investigate and if possible address threatening processes, including the wolf snake.
5	Review and maintain existing control program for crazy ants.	Management of crazy ants is ongoing and includes aerial baiting to reduce numbers in supercolonies, monitoring to assess success of and need for baiting, assessing off-target impacts, and research into alternative control methods.	Ongoing	Continue crazy ant management.
6	Identify the role of cats and rats as potential threats to endemic reptiles.	Previous cat gut content studies have shown cats predate on native reptiles. However, any current predation is likely to be low as reptile numbers are low. Due to the known and potential impacts of cats and rats on many Christmas Island species, the Shire of Christmas Island and Parks Australia coordinated the preparation of an island-wide cat and rat management plan (Algar and Johnston 2010). Implementation commenced in 2010 and is ongoing.	Started	Investigate impacts of rats on endemic reptiles. Continue to implement cat and as needed rat management.
7	Reassess conservation status in the absence of further records.	Species both detected in 2009. Nomination for revised status for Lister's gecko has been prepared.	Complete	No further action
8	Review quarantine protocols for all personnel and materiel entering Christmas Island.	DAFF Biosecurity have been present on Christmas Island since 1994 and carry out their operations in accordance with the <i>Quarantine Act</i> . However, in 2009 the Minister for the Environment, Heritage and the Arts established an Expert Working Group (EWG) to advise the Minister on biodiversity conservation issues on Christmas Island. The EWG recommended that quarantine management be upgraded to a standard consistent with the island's biodiversity values.	Partially complete	Increase/improve quarantine.

SPECIES: CHRISTMAS ISLAND SPLEENWORT (*Asplenium listeri*)

Overall comment: Few recovery actions were complete, started or partially completed. There is little understanding of its biology and ecology and threats (other than weeds and direct human impacts like vegetation clearance) or if its populations are increasing from a low population base as it may be a recently evolved species. Some proposed actions were difficult to link with recovery.

Objective 1		To abate and avert threats to the species		
Recovery Criteria 1		<ul style="list-style-type: none"> No population of the species is impacted by a threatening process. 		
No.	Action	Action status comments	Status	Recommendations
1.1	Keep locations of populations confidential.	Confidentiality of sites was maintained however on Christmas Island illegal collection of plants is considered rare or not to occur.	Complete	No further action
1.2	Monitor visitor pressure and impact on Gannet Hill population.	Although a detailed monitoring program is not in place monitoring of track conditions and visitor infrastructure indicates that visitor impacts and pressures are low.	Partially complete	Maintain monitoring of visitor pressure and impacts.
1.3	Ensure inclusion of <i>Asplenium listeri</i> in all guidelines and specifications for environmental assessment and standards, particularly along the east coast.	<i>Asplenium listeri</i> has been considered in environmental assessments.	Partially complete	Continue to assess the impacts of proposed actions in accordance with the EPBC Act.
1.4	Pursue national park status for the Ross Hill Gardens area and around South Point, and other areas related to populations of <i>Asplenium listeri</i> that are located within the term of this plan.	The Christmas Island National Park management plan indicates that there may be an opportunity to expand the area of the park. Any consideration of boundary changes would seek to extend the area of the park to include other areas of high conservation value and recently rehabilitated minfield, and possibly remove areas of low conservation value. Any boundary changes must be approved by both houses of Parliament and boundary extensions are beyond the scope of recovery plans.	Not started	No further action for recovery plan
1.5	Consider need for listing on the EPBC Register of Critical Habitat to strengthen legal protection, with update as new populations are located.	Need was considered and listing not pursued. Due to the existing level of protection under other provisions of the EPBC Act, there would be no additional conservation benefit from listing reptile habitat on the EPBC Register of Critical Habitat.	Complete	No further action
1.6	Expand content about <i>Asplenium listeri</i> (and other listed plant species) in future national park management plans with specific reference to recovery plans and relevant threat abatement plans (keeping precise locations confidential).	Reference to <i>Asplenium listeri</i> was included in Christmas Island National Park Management Plan. However, except for raising some awareness and for impact assessments, the recovery benefits of doing this may be limited.	Complete	No further action

No.	Action	Action status comments	Status	Recommendations
1.7	For the population at The Dales, and if a population is located at Hosnies Spring, update the relevant Ramsar Information Sheet and description of ecological character to ensure the most robust protective framework under the EPBC Act.	Ramsar Ecological Character Descriptions (ECD) for The Dales and Hosnies Spring were prepared in 2010. The Dales ECD refers to the CI spleenwort. While it is valuable documenting its presence at The Dales the impact on recovery is likely to be limited.	Complete	No further action
Objective 2				
To improve knowledge of factors in the restricted distribution of the species				
Recovery Criteria 2				
<ul style="list-style-type: none"> A comprehensive list of environmental factors (physical and biological) and/or a predictive model assist(s) location of additional populations. 				
No.	Action	Action status comments	Status	Recommendations
2.1	Survey all known occurrences of <i>Asplenium listeri</i> to compile a comprehensive list of environmental factors (physical and biological) and base data (including photographic) for population monitoring.	Surveys were conducted in 2002 by Holmes and Holmes but surveys have not been conducted in the life of the recovery plan. Environmental factors and base data for population monitoring have not been compiled.	Not started	Conduct population monitoring. Survey known sites to determine environmental factors affecting distribution.
2.2	Consider use of the above to develop predictive models to assist location of additional populations.	This action was not started .	Not started	Develop a model based on habitat survey results.
Objective 3				
To increase the number of known occurrences				
<ul style="list-style-type: none"> At least one additional population (or an enlarged population) of the species has been located in the wild. 				
Recovery Criteria 3				
No.	Action	Action status comments	Status	Recommendations
3.1	Survey potential habitat for more populations, with focus on the east coast, including Hosnies Spring (following a wet season).	Surveys were conducted in 2002 by Holmes and Holmes but surveys have not been conducted in the life of the recovery plan.	Not started	Conduct surveys of potential habitat.
3.2	Examine the need for and potential of <i>ex situ</i> cultivation.	The potential for <i>ex situ</i> has been examined and scientific advice indicates it is feasible. The need has not been examined.	Partially complete	Determine triggers for implementing <i>ex situ</i> cultivation, monitor populations and implement <i>ex situ</i> actions if required.
3.3	Examine potential for (re)introduction of <i>Asplenium listeri</i> into additional east coast terrace cliff-tops.	This has not been examined.	Not started	Investigate potential re-introduction areas if <i>ex situ</i> cultivation is triggered.

SPECIES: The fern *Tectaria devexa* (a)

Overall comment: Most recovery actions were complete, started or partially completed. There is little understanding of its biology and ecology and threats but exotic species and direct human impacts like vegetation clearance are proposed. Some proposed actions were difficult to link with recovery.

Note: specific objectives and actions referring to Queensland populations are not included.

Objective 1		To reduce the rate of decline in the species			
Recovery Criteria 1		<ul style="list-style-type: none">Monitoring demonstrates no net decline in populations.			
No.	Action	Action status comments	Status	Recommendations	
1.1	Quantify and monitor populations in the Rockhampton area and on Christmas Island.	Limited surveys at one site were conducted (2004–05 and 2009) by Parks Australia. These surveys found additional individuals to those surveyed by Holmes and Holmes in 2002.	Started	Conduct population monitoring surveys, including through the IWS.	
Objective 2		To increase the number and area of occurrences			
Recovery Criteria 2		<ul style="list-style-type: none">Systematic surveys to determine whether there are any additional populations have been completed.			
No.	Action	Action status comments	Status	Recommendations	
2.1	Survey potential habitat for more populations in the Rockhampton area and on Christmas Island.	Potential habitat not surveyed.	Not started	Conduct surveys of potential habitat.	
2.2	Encourage reporting of new localities to assist on-going review of conservation status.	Active encouragement did not occur.	Not started	Consider publishing booklet on recovery of the island's species. Encourage involvement in regional recovery plan actions.	
Objective 3		To abate and avert threats to the species			
Recovery Criteria 3		<ul style="list-style-type: none">No population of the species is significantly impacted by a threatening process.			
No.	Action	Action status comments	Status	Recommendations	
3.1	Maintain confidentiality for precise locations in the Rockhampton area (other than Capricorn Caves) and on Christmas Island.	Confidentiality of sites was maintained however on Christmas Island illegal collection of plants is considered rare or not to occur.	Complete	No further action	
3.5	Ensure inclusion of <i>Tectaria devexa</i> in all guidelines and specifications for environmental assessment and standards on Christmas Island, particularly on the central plateau.	<i>Tectaria devexa</i> has been considered in environmental assessments.	Partially complete	Continue to assess the impacts of proposed actions in accordance with the EPBC Act.	

No.	Action	Action status comments	Status	Recommendations
3.7	Objectively examine differences in specialist opinion regarding the extent to which canopy gaps may be important to <i>Tectaria devexa</i> on Christmas Island.	No examination was conducted. This action is no longer considered essential to recovery, given it is not focused on addressing conservation threats or is likely to trigger a management response.	Not started	No further action
3.8	Update The Dales Ramsar Information Sheet and description of ecological character to note the population of <i>Tectaria devexa</i> near Sydney's Dale.	The Ramsar Ecological Character Description for The Dales (prepared in 2010) refers to <i>Tectaria devexa</i> being within the site. However, the recovery benefits of doing this are likely to be limited.	Complete	No further action
3.10	Expand content about <i>Tectaria devexa</i> (and other listed plant species) in future Christmas Island National Park management plans in line with recovery plans and relevant threat abatement plans.	Reference to <i>Tectaria devexa</i> is included in the Christmas Island National Park Management Plan.	Complete	No further action

Actions 3.2–4.3 and 3.9 were not applicable for the Christmas Island population.

Objective 4 To improve knowledge of factors in the restricted distribution of the species				
Recovery Criteria 4				
No.	Action	Action status comments	Status	Recommendations
4.1	Investigate all known occurrences of <i>Tectaria devexa</i> to compile a comprehensive list of habitat requirements (physical and biological) to assist location of additional populations.	Limited surveys at one site were conducted (2004–05 and 2009) by Parks Australia. However these surveys did not assess habitat requirements.	Not started	Survey known sites to determine environmental factors affecting distribution.
Objective 5 To develop capability for enrichment planting or reintroduction of the species				
Recovery Criteria 5				
5.1	Examine the need for, and potential risks of, <i>ex situ</i> cultivation of both varieties.	The species (var. <i>devexa</i>) has been cultivated <i>ex situ</i> as a precaution against extinction in the wild in the Rockhampton area. The potential for <i>ex situ</i> cultivation of var. <i>minor</i> has been examined and scientific advice indicates it is feasible. The need and risks have not been examined.	Partially complete	Determine triggers for implementing <i>ex situ</i> cultivation, monitor populations and implement <i>ex situ</i> actions if required.

Action 5.2 was not applicable for the Christmas Island population.

Objective 6 To improve community awareness of the species and its conservation status				
Recovery Criteria 6				

The action included under this objective was not applicable for the Christmas Island population.

- (a) The *Tectaria devexa* recovery plan will remain in place under the EPBC Act, as it covers the Queensland population of this species

Appendix K—Species profiles

The following profiles provide information on species identified as significant (see Part 3.2 of this plan for definition).

The action numbers identified in the species profiles refer to the integrated actions described in Part 6 of this plan. The actions which are essential in order to achieve both the underpinning and biological objectives of this plan—Action 7 *Manage and analyse data*, Action 8 *Communicate with and engage the community and other stakeholders* and Action 9 *Coordinate biodiversity conservation plan implementation*—are not included within species profiles as these actions are relevant to all species.

Species		Page	Map
Vascular plants			
<i>Asplenium listeri</i>	Christmas Island spleenwort	138	1
<i>Bruguiera gymnorhiza</i> , <i>B. sexangula</i>	large-leafed and upriver orange mangroves	140	n.a.
<i>Pneumatopteris truncata</i>	a fern	141	2
<i>Tectaria devexa</i> var. <i>minor</i>	a fern	143	3
Seabirds			
<i>Fregata andrewsi</i>	Christmas Island frigatebird	145	4
<i>Papasula abbotti</i>	Abbott's booby	147	5
<i>Phaethon lepturus fulvus</i>	golden bosun (white-tailed tropicbird)	149	n.a.
Forest birds			
<i>Accipiter hiogaster natalis</i>	Christmas Island goshawk	150	6
<i>Chalcophaps indica natalis</i>	Christmas Island emerald dove	152	7
<i>Collocalia linchi natalis</i>	Christmas Island swiftlet	154	n.a.
<i>Ducula whartoni</i>	Christmas Island imperial pigeon	155	8
<i>Ninox natalis</i>	Christmas Island hawk-owl	157	9
<i>Turdus poliocephalus erythropleurus</i>	Christmas Island thrush	159	10
<i>Zosterops natalis</i>	Christmas Island white-eye	161	11
Mammals			
<i>Crocidura trichura</i>	Christmas Island shrew	163	12
<i>Pipistrellus murrayi</i>	Christmas Island pipistrelle	165	13
<i>Pteropus melanotus natalis</i>	Christmas Island flying-fox	167	14
Reptiles			
<i>Cryptoblepharus egeriae</i>	blue-tailed skink	169	15
<i>Cyrtodactylus sadleiri</i>	giant gecko	171	16
<i>Emoia atrocostata</i>	coastal skink	173	17
<i>Emoia nativitatis</i>	forest skink	175	18
<i>Lepidodactylus listeri</i>	Lister's gecko	177	19
<i>Ramphotyphlops exocoeti</i>	Christmas Island blind snake	179	20
Land crabs			
<i>Birgus latro</i>	robber crab	181	n.a.
<i>Discoplax celeste</i>	blue crab	182	21
<i>Gecarcoidea natalis</i>	red crab	184	22

Conservation Significance

Small rock-dwelling fern endemic to Christmas Island
EPBC Act Listing: Critically Endangered

Existing Conservation Measures

Monitoring through IWS and targeted surveys

Previous Recovery Plan

Butz 2004b

Distribution

Asplenium listeri is currently known from five separate sites across the island of which three are in the national park (Map 1). However, distribution is not well known and there is the possibility of undiscovered sites.

The sites are narrow cliff-top strips up to 15 m wide, between a very open aspect on the seaward side and a forest structure increasing up to 40 m high on the inland side (Reddell pers. comm. in Butz 2004b), situations which are well placed to interrupt and capture moist flow from south-easterly trade winds (Tranter pers. comm. in Butz 2004b).

Populations

There are five known populations, all restricted to Christmas Island. There is a further historical record from a site at Flying Fish Cove (Du Puy 1993a).

In 2002 a total of about 300 plants were recorded across the five known sites (Holmes & Holmes 2002). Sizes of populations are currently unknown, apart from a single estimate of 25–50 plants for one population (DNP unpub. data 2012).

All occurrences of the species, including any future populations found, are important populations, based on its endemic status, its highly restricted occurrence and the uncertainty surrounding the reasons for its rarity.

Habitat

A. listeri grows colonially on limestone rocks and cliffs in semi-deciduous closed forest, mainly beneath or near *Ficus microcarpa*, in partly shaded sites but sufficiently exposed for ventilation (Holmes & Holmes 2002).

Habitat critical to the survival of the species is:

- all limestone rock crevices in the vicinity of known occurrences (reflecting uncertainty regarding reasons for the extremely limited distribution of the species and potential threats to survival)
- tall vegetation on the inland side of cliff-tops with relatively open exposure to the coast.

Due to the uncertainty of current location information and limited knowledge on the ecology and specific habitat requirements, habitat critical to the survival of the species cannot be mapped.

Threats

The endemism, very small population size, fragmented distribution and lack of accurate location data for this species make it vulnerable to a wide range of threats and to changes in its habitat.

Threats include:

- removal or modification of habitat through vegetation clearing and disturbance e.g. road construction, developments or mining
- invasive species e.g. weeds, giant African land snails and crazy ants (which reduce numbers of red crabs which prey on snails)
- introduction of new invasive species
- climatic events, such as drought and cyclones, and climate change.

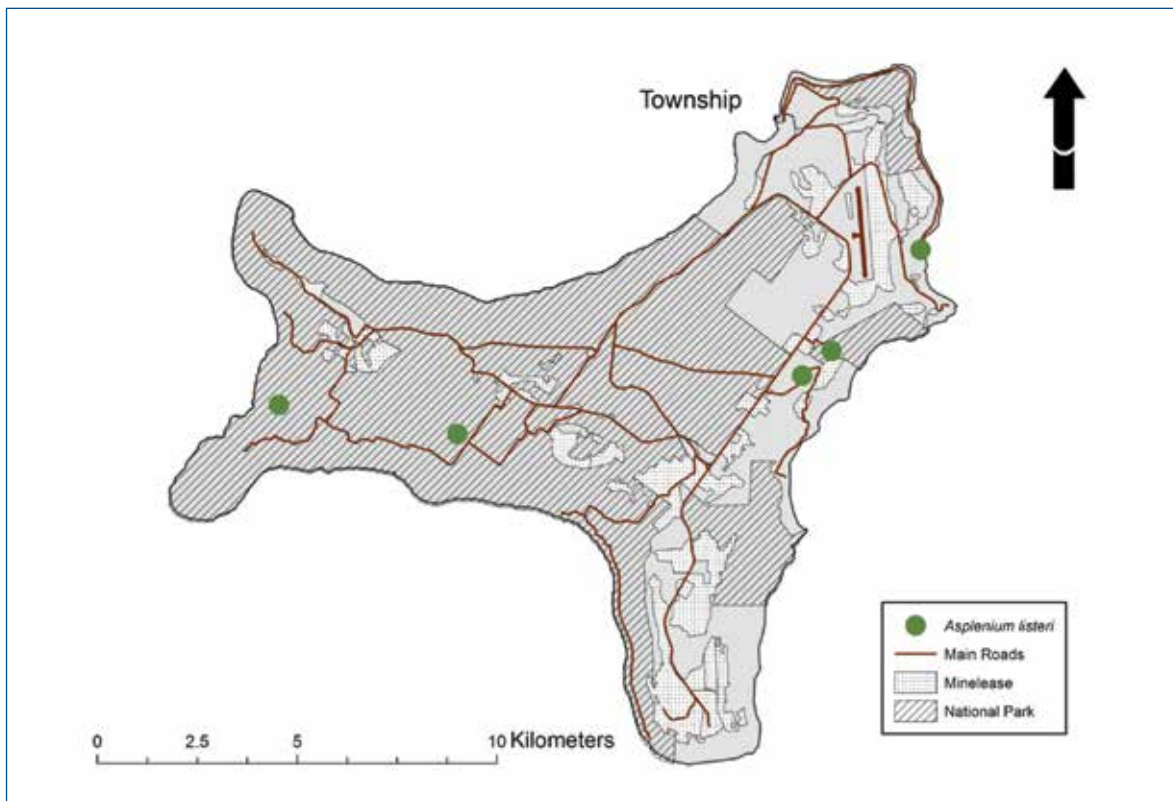
Most of these threats are widespread, occurring across the range of this species on Christmas Island. Vegetation disturbance through clearing is only a threat to populations located outside the national park.

Forest fires represent a potential threat if dry seasons become more severe as the climate changes.

Illegal collection is highly unlikely to occur so is not considered a threat.

Management Actions

- Conduct population surveys to determine sizes and locations, and collect additional habitat/site data, as well as targeted surveys for additional populations (Action 5.5).
- Monitor populations to detect any declines (including for possible *ex situ* action) (Action 5.2).
- Assess and identify physical and biological habitat requirements (Action 6.2).
- Monitor and avoid or mitigate threats and negative impacts to populations, including: invasive species, such as crazy ants (Action 1.1), weeds (Action 3.1) and giant African land snails (Action 3.4).
- Improve biosecurity to maintain effective quarantine against the introduction of invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Determine targets and thresholds for implementing *ex situ* cultivation (Action 9.2). Implement *ex situ* actions and investigate potential re-introduction areas if *ex situ* cultivation is triggered (Action 4.2).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).



Map 1: Known locations of *Asplenium listeri* on Christmas Island 2013 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

<i>Bruguiera gymnorhiza</i>	large-leafed orange mangrove
<i>Bruguiera sexangula</i>	upriver orange mangrove

Family RHIZOPHORACEAE

Conservation Significance

The dominant plant species and critical components for defining the ecological character of Hosnies Spring which is listed as a Wetland of International Importance under the Ramsar Convention (Hale & Butcher 2010).

The two species are treated together as they co-occur and are difficult to distinguish.

EPBC Act listing: none

Existing Conservation Measures

Not actively promoting visitor access to the site as board walks are not in place or proposed. No other specific conservation measures are currently in place

Hosnies Spring is a declared Ramsar wetland under the EPBC Act.

Distribution

On Christmas Island both species are restricted to the freshwater environment of Hosnies Spring which is located wholly within the national park (Figure 4).

Both species are widely distributed outside Christmas Island. *B. gymnorhiza* occurs in littoral mangrove forest from eastern Africa and south-east Asia through Malesia and New Guinea to northern Australia and the Pacific islands. *B. sexangula* is distributed from south-east Asia through Malesia to New Guinea, New Britain and northern Australia (Du Puy 1993b).

Populations

On Christmas Island these species only occur in the unusual freshwater mangrove stand at Hosnies Spring, which is on the north east coast of Christmas Island, located about 30 m above sea level and 120 m inland from the seaward cliff (see Figure 4).

Approximately 300 to 600 individuals of both species occur at this site, restricted to an area of about 0.33 hectares (Woodroffe 1988).

The single population is necessary for the long-term survival of both species on Christmas Island.

Habitat

Hosnies Spring (Figure 4) is near the base of the first inland cliff, where a junction between basalt and limestone rocks occurs at an altitude of about 15–25 m (Du Puy 1993b). The spring is habitat critical for both species.

The site is an example of a specific type of wetland unique to Christmas Island and perhaps unique worldwide. The mangroves are a relict population estimated to be 120,000 years old. They occur at an elevation not recorded anywhere else in the world.

Threats

There are no conceivable current threats (Holmes & Holmes 2002).

Potential threats, which may be exacerbated by small population size, include:

- stochastic events and landscape or habitat change such as cyclones and drought
- pervasive threats arising from changes to rainforest ecosystem dynamics from the introduced crazy ant and their interaction with the red crabs (may change the forest structure, floristic composition and dynamics and favour other invasive species including weeds and giant African land snails)
- crazy ant super colonies help develop or maintain heavy infestations of scale insects on foliage, with consequential increases in tree mortality
- competition from weeds
- changes to water flows and hydrology, for example from over extraction of groundwater
- visitor impacts on mangrove seedling regeneration.

Management Actions

- Conduct survey of mangrove community composition, extent, age classes and regeneration (Action 5.5) and density of mangrove trees and presence of seedlings and saplings (Action 5.4).
- Control and reduce the impacts of crazy ants (Action 1.1).
- Monitor and manage use of subterranean groundwater (Action 3.5).
- Control high risk weeds (Action 3.1).
- Monitor and minimise visitor impacts (Action 3.2)
- Determine targets and thresholds for implementing *ex situ* cultivation (Action 9.2) and implement relevant actions if *ex situ* cultivation is triggered (Action 4.2).

Conservation Significance

Only Australian occurrence is on Christmas Island
EPBC Act Listing: Critically Endangered

Existing Conservation Measures

Monitoring through targeted surveys

Previous Recovery Plan

This is the first recovery plan for this species

Distribution

The species has a fragmented distribution over Asia and Malesia (Du Puy 1993c). The Australian distribution is restricted to Christmas Island, where it is known from two localities on the south-west side of the island (Holmes & Holmes 2002; Du Puy 1993c) (Map 2). However, distribution is not well known and there is the possibility of undiscovered sites.

Populations

Two populations of this species were identified on Christmas Island in a survey in 2002 (Holmes & Holmes 2002). There are also two historical records, one with no precise locality and one from the Waterfall (Du Puy 1993c). Additional scattered occurrences have subsequently been located on former mining areas within the national park that have been rehabilitated (DNP unpub. data 2012).

A total of 45 plants divided between two small localities (Hugh's Dale and the Blowholes) was recorded in the 2002 survey. Current total population size is unknown however more than 100 plants have been identified within rehabilitated areas; the population at Hugh's Dale may be declining (DNP unpub. data 2012).

All occurrences of the species, including any future populations found, are important populations, based on its highly restricted occurrence and the uncertainty surrounding the reasons for its rarity.

Habitat

P. truncata grows in colonies on permanently moist sites in semi-deciduous closed forest (Figure 3) between 50 and 140 m elevation (Holmes & Holmes 2002; Du Puy 1993c).

Data on the habitat requirements of this species are insufficient to define and locate habitat critical to survival.

Threats

The very small known population size, fragmented distribution and lack of accurate location data make the species vulnerable to a wide range of threats and to changes in its habitat.

Threats include:

- removal or modification of habitat through vegetation clearing and disturbance e.g. road construction, developments or mining
- invasive species e.g. weeds, giant African land snails and crazy ants (which reduce numbers of red crabs which prey on snails)
- the introduction of new invasive species
- climatic events, such as drought and cyclones, and climate change.

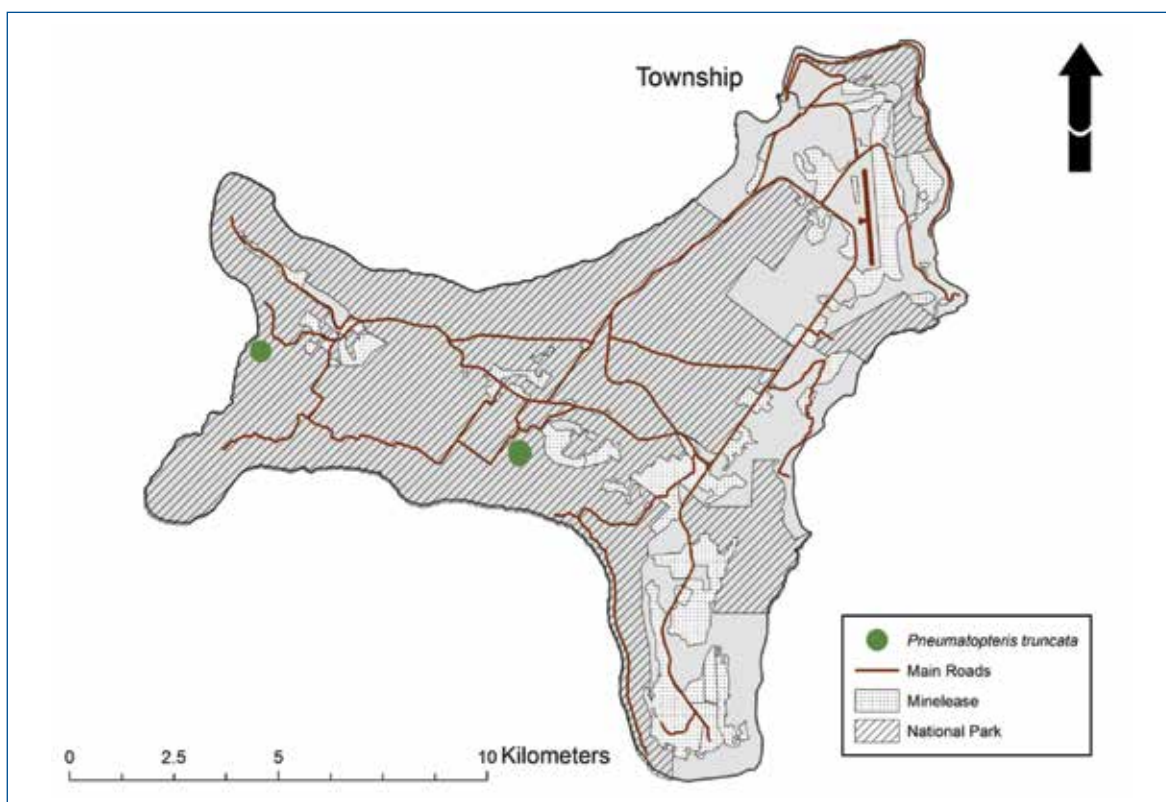
Most of these threats are widespread, occurring across the range of this species on Christmas Island. Vegetation disturbance through clearing is only a threat to populations located outside the national park.

Forest fires represent a potential threat if dry seasons become more severe as the climate changes.

Illegal collection is highly unlikely to occur and is not considered a threat.

Management Actions

- Conduct population surveys to determine size and location and collect additional habitat/site data as well as targeted surveys for additional populations (Action 5.5).
- Monitor populations to detect any declines (including for possible *ex situ* action) (Action 5.2).
- Assess and identify physical and biological habitat requirements (Action 6.2).
- Monitor and avoid or mitigate threats and negative impacts to populations, including invasive species, such as crazy ants (Action 1.1), weeds (Action 3.1) and giant African land snails (Action 3.4).
- Determine targets and thresholds for implementing *ex situ* cultivation (Action 9.2). Implement *ex situ* actions and investigate potential re-introduction areas if *ex situ* cultivation is triggered (Action 4.2).
- Improve biosecurity to maintain effective quarantine against the introduction of invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).



Map 2: Known locations of *Pneumatopteris truncata* on Christmas Island 2013 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Tectaria devexa* var. *minor**a fern****Family TECTARIACEAE****Conservation Significance**

EPBC Act Listing: Endangered (as part of *Tectaria devexa*)

Existing Conservation Measures

Monitoring through IWS and targeted surveys

Previous Recovery Plan

Butz 2004a (for *Tectaria devexa*)

Distribution

Tectaria devexa var. *minor* is found only on Christmas Island and Sri Lanka. *Tectaria devexa* var. *devexa* is known from southern Asia and central Queensland (Du Puy 1993d).

On Christmas Island *T. devexa* var. *minor* has a fragmented distribution on the plateau where it is currently known from nine locations (Du Puy 1993d; Holmes & Holmes 2002; Butz 2004a, DNP unpub. data 2012). Most known sites occur within the national park (Map 3). However, distribution is not well known and there is the possibility of undiscovered sites.

An historic record exists from a site that has since been developed (Du Puy 1993d).

Populations

The total number recorded on Christmas Island by Holmes & Holmes (2002) was just over 400 plants with 210 being confined to one locality, 170 to another and remaining plants distributed among small and scattered colonies. Recent decline has not been observed or inferred.

All occurrences of the species, including any future populations found, are important populations, based on its highly restricted occurrence and the uncertainty surrounding the reasons for its rarity.

Habitat

T. devexa var. *minor* grows in shaded positions in the evergreen tall closed forest on the plateau above 80 m elevation (Holmes & Holmes 2002), usually in areas of deep soil derived from limestone substrate, where it may be the only forest floor species (Du Puy 1993d). Records have been made of this species inhabiting drill line clearings (Butz 2004a) although subsequent searches highlighted there may have been confusion with the similar species *Tectaria dissecta* (Moloney pers. comm. 2012).

Data on the biophysical requirements of this species is insufficient to define, and identify the location and extent of, habitat critical to survival. Until this information is available, habitat critical to the survival of *T. devexa* var. *minor* is considered to include all areas within 50 m of the area occupied by the species.

Threats

The very small known population size, fragmented distribution and lack of accurate location data make the species vulnerable to a wide range of threats and to changes in its habitat.

Threats include:

- removal or modification of habitat through vegetation clearing (e.g. road construction, developments or mining)
- invasive species e.g. weeds, giant African land snails and crazy ants (which reduce numbers of red crabs which prey on snails)
- introduction of new invasive species
- climatic events, such as drought and cyclones, and climate change.

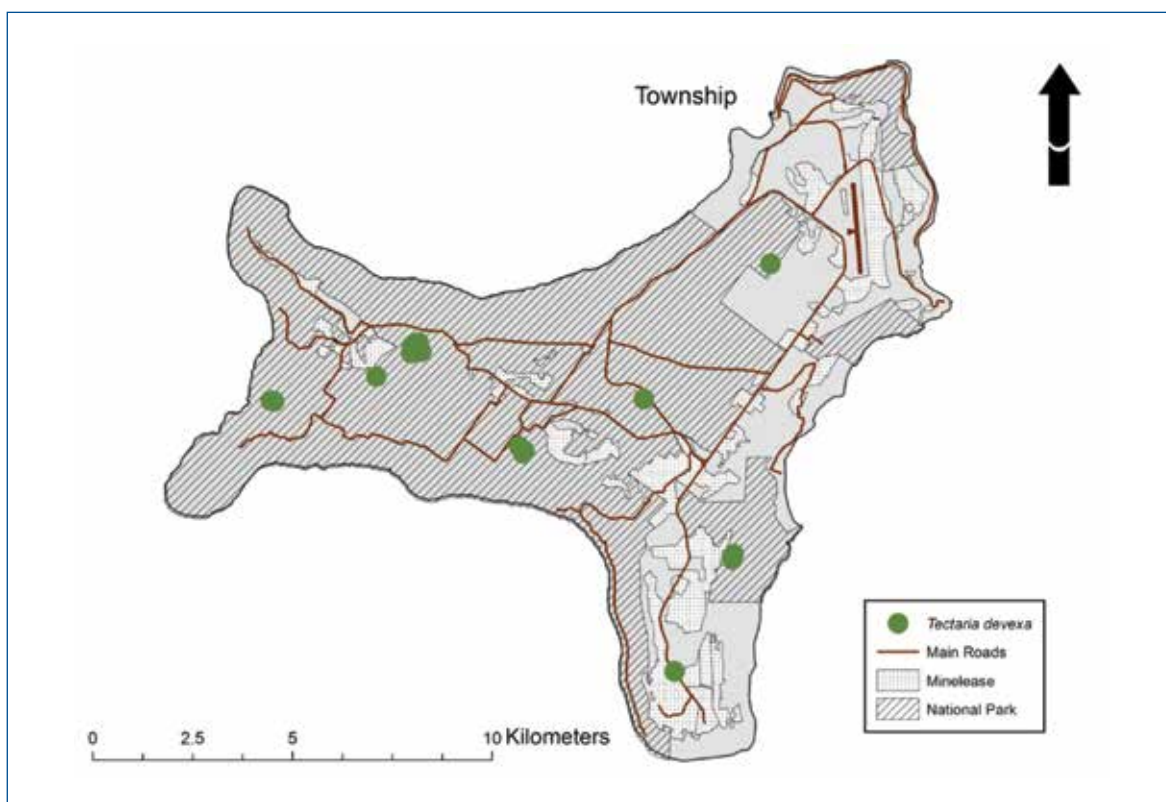
Most of these threats are widespread, occurring across the range of this species on Christmas Island. Vegetation disturbance through clearing is only a threat to populations located outside the national park.

Forest fires represent a potential threat if dry seasons become more severe as the climate changes.

Illegal collection is highly unlikely to occur so is not considered a threat.

Management Actions

- Conduct population surveys to determine sizes and locations, and collect additional habitat/site data, as well as targeted surveys for additional populations (Action 5.5).
- Monitor populations to detect any declines (including for possible *ex situ* action) (Action 5.2).
- Assess and identify physical and biological habitat requirements (Action 6.2).
- Monitor and avoid or mitigate threats and negative impacts to populations, including invasive species, such as crazy ants (Action 1.1), weeds (Action 3.1) and giant African land snails (Action 3.4).
- Improve biosecurity to maintain effective quarantine against the introduction of invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Determine targets and thresholds for implementing *ex situ* cultivation (Action 9.2). Implement *ex situ* actions and investigate potential re-introduction areas if *ex situ* cultivation is triggered (Action 4.2).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).



Map 3: Known locations of *Tectaria devexa* var. *minor* on Christmas Island 2013 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Fregata andrewsi**Christmas Island frigatebird****Family FREGATIDAE****Conservation Significance**

Breeds only on Christmas Island

EPBC Act Listing: Vulnerable (also marine and migratory)

IUCN Listing: Critically Endangered

Existing Conservation Measures

Monitoring of nesting success at known nesting colonies

Previous Recovery Plan

Hill & Dunn 2004

Distribution

The Christmas Island Frigatebird nests in a few small areas of terrace forests on the north-east of the island, located both in and outside the national park. James (2003) estimated the then four known breeding colonies to cover about 140 ha, a reduction from a previous report of 170 ha (Stokes 1988).

Breeding birds frequently forage hundreds and even thousands of kilometres over the Indian Ocean and throughout the Indo–Malay Archipelago. When not breeding the species ranges widely across the seas of south-east Asia to Indochina and south to northern Australia; its range to the west is less well known (Hill & Dunn 2004).

Populations

The total population size was estimated in 1984 as approximately 1620 pairs (Stokes 1984) and more recently was reported as 1100 breeding pairs (DNP 2008c). The current population size is unknown and, while it is not clear if the population has remained stable, decreased or increased, it is thought to be declining.

In 2004 there were four breeding colonies (Flying Fish Cove, Dryers, Golf Course and Cemetery with the latter two being within the national park—see Map 4). However, as at 2011 there is no longer a known colony at Flying Fish Cove (Garnett et al. 2011).

The single known population is considered important to the survival of the species.

Habitat

The frigatebird nests in tall forest trees, particularly *Terminalia catappa* and *Celtis timorensis*, which are sheltered from prevailing trade winds (Stokes 1988). The birds forage over relatively warm, low salinity waters (Marchant & Higgins 1990).

Given the limited data on habitat requirements, nesting habitat critical to the survival of the Christmas Island frigatebird is defined as the area occupied by all current and former nesting colonies.

Threats

Supercolonies of crazy ants potentially threaten individual breeding birds and their nestlings, through predation or disturbance at nest sites and habitat changes.

Three invasive weed species may threaten the species. The disturbed fringes of the Cemetery breeding colony may be at risk of being invaded by the coastal vine *Antigonon leptopus*, which may smother nest trees and restrict access. *Leucaena leucocephala* has formed monocultural stands around some edges, completely excluding recruitment of preferred native nest-tree species. The spread of *Clausena excavata* throughout the Cemetery breeding colony has the potential to form monocultures, out-competing preferred nest-tree species and preventing recruitment.

The introduction of new invasive species is a threat across the island.

There is risk of catastrophic destruction of breeding colonies by climatic events like cyclones.

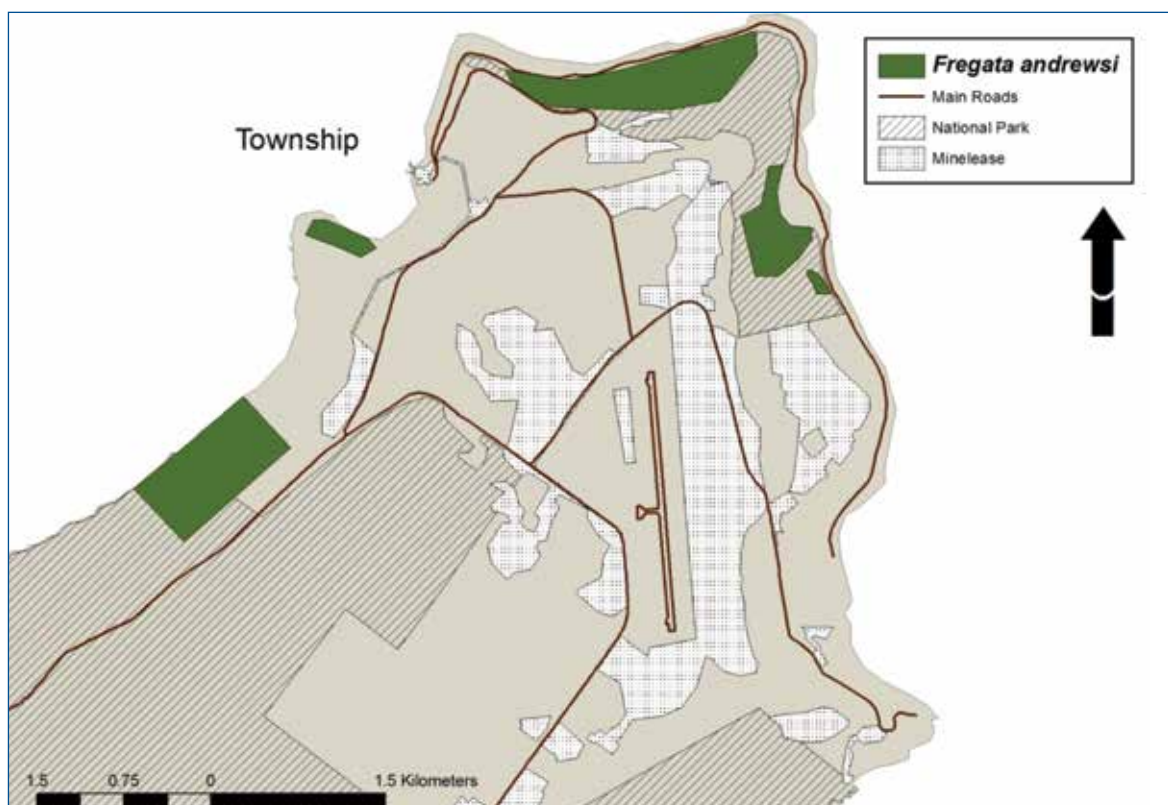
Much of the breeding area lies outside the national park and has no formal protection (Hill & Dunn 2004). Clearing of nesting sites could therefore pose a future threat.

Heavy metal poisoning (including from drinking at contaminated sites) is an unknown but potential threat.

Threats and potential threats in areas beyond the Christmas Island Territory include overfishing, marine pollution, changes to sea surface temperature affecting feeding or food availability, and off-island hunting, for example on non-breeding roost islands. Hunting is not a threat on Christmas Island.

Management Actions

- Control and reduce the impacts of crazy ants (Action 1.1).
- Control high risk weeds, especially those that impact on nesting sites (Action 3.1).
- Monitor population trends and site occupation (Action 5.2).
- Improve biosecurity to maintain effective quarantine against the introduction of invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Investigate the potential threat and risks of chemicals and toxins (Action 6.1).
- Protect nesting habitat from clearing or other disturbances. Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).
- Investigate at-sea distribution and habitat utilisation, using data loggers and satellite telemetry (Action 6.2) to determine:
 - foraging range, habitat and behaviour, both spatially and temporally, and accounting for sex, age class, season and breeding status
 - potential overlap of foraging behaviour and habitat with threatening processes, such as long-line fishing, marine pollution and hunting.



Map 4: Locations of Christmas Island frigatebird nesting colonies in 2004 (Parks Australia)

Map caveats: The data on this map represents areas where nesting colonies have been detected but does not represent all areas where the species or nesting colonies may exist and the map cannot be used for population estimate purposes.

Since 2011 the colony at Flying Fish Cove is not known to remain.

Papasula abbotti**Abbott's booby**

Family SULIDAE

Conservation Significance

Breeds only on Christmas Island

EPBC Act Listing: Endangered (also marine and migratory)

IUCN Listing: Endangered

Existing Conservation Measures

Monitoring through IWS

Surveys of chick survival rates and breeding activity undertaken

Restoration of nesting sites through rainforest rehabilitation program

Previous Recovery Plan

Department of the Environment and Heritage 2004

Distribution

Abbott's booby formerly bred on many islands in the Indian and Pacific oceans but since the early 1900s only known to breed on Christmas Island. Most nests are situated on the central and western areas (tall plateau forest) but are also found along the north coast (upper terrace forest). Most nests are now between cleared land and coastal terraces (Garnett et al. 2011). Map 5 shows detection sites for the species across the island.

Although the at-sea distribution of Abbott's booby is poorly known (DEH 2004) it is thought foraging occurs over a wide area. However, chick-rearing individuals in tracking studies utilised only a small area of the eastern Indian Ocean close to the island (Hennicke 2007).

An adult female recorded in the Mariana Islands indicates extensive foraging range, another possible breeding colony, or vagrancy (see Pratt et al. 2009).

Populations

Accurate estimates of population size are not available due to the rugged terrain of preferred breeding sites, and the inherent difficulty in locating breeding sites high in the canopy.

Total breeding population size was estimated at around 2500 pairs in a 1991 ground-based survey (Yorkston & Green 1997). A 2002 helicopter survey recorded 1500 nests (Commonwealth of Australia 2004) which compared favourably with the 1991 estimate (noting the species breeds biennially) although the validity of that comparison is open to question due to the different techniques involved (DNP 2008b). Garnett et al. (2011) estimated the population at 7000 mature individuals, citing earlier population estimates.

Recent surveys of chick survival rates and nesting occupancy suggest the population is stable (DNP unpub. data 2012) which is supported by anecdotal evidence of long-term island residents.

Populations important for survival of the species include all breeding populations (currently the only known extant breeding population is on Christmas Island).

Habitat

Abbott's booby nests in tall rainforest trees, mostly in uneven canopy containing emergent trees (Stokes 1988). Nest sites are largely restricted to areas above 150 m, mostly on the sides of northwest facing slopes (Nelson 1978, Stokes 1988) that are not impacted by windshear (DEH 2004).

The sole breeding habitat, tall rainforest mostly above 150 m elevation in the western, central and northern portions of the island, is critical to the survival of Abbott's booby. Most suitable nesting habitat lies within the national park.

Abbott's booby forages at sea but is a poor diver (DEH 2004). The at-sea distribution of the species is poorly known but contains specific areas of foraging habitat that are critical to survival of the species.

Threats

Degradation and loss of critical breeding habitat from previous land clearing for mining and other settlement activities (e.g. road construction) have had an impact on the population. Although clearing of breeding habitat does not currently occur, it is a potential threat outside the national park.

The impact of crazy ants on the island's ecosystem poses a threat to the species, along with predation or disturbance at nest sites.

Three invasive weed species are a potential threat. The invasive vine *Mucuna albertisii* can form enormous vine towers in canopy gaps and forest edges; it occurs directly adjacent to existing nest sites and could exclude birds from any trees that it smothers. The woody weeds *Clausena excavata* and *Aleurites moluccana* have the ability to germinate in full shade under intact rainforest and are a potential threat to the survival of the bird's preferred nest-tree species (e.g. *Planchonella nitida*, *Syzygium nervosum*, *Celtis timorensis*).

The introduction of new invasive species is also a threat.

Unsustainable exploitation of sub-surface predatory fish (e.g. tuna, billfish) in marine habitat may impact negatively. Marine pollution is a potential threat, along with entanglement or persecution in fisheries beyond Christmas Island.

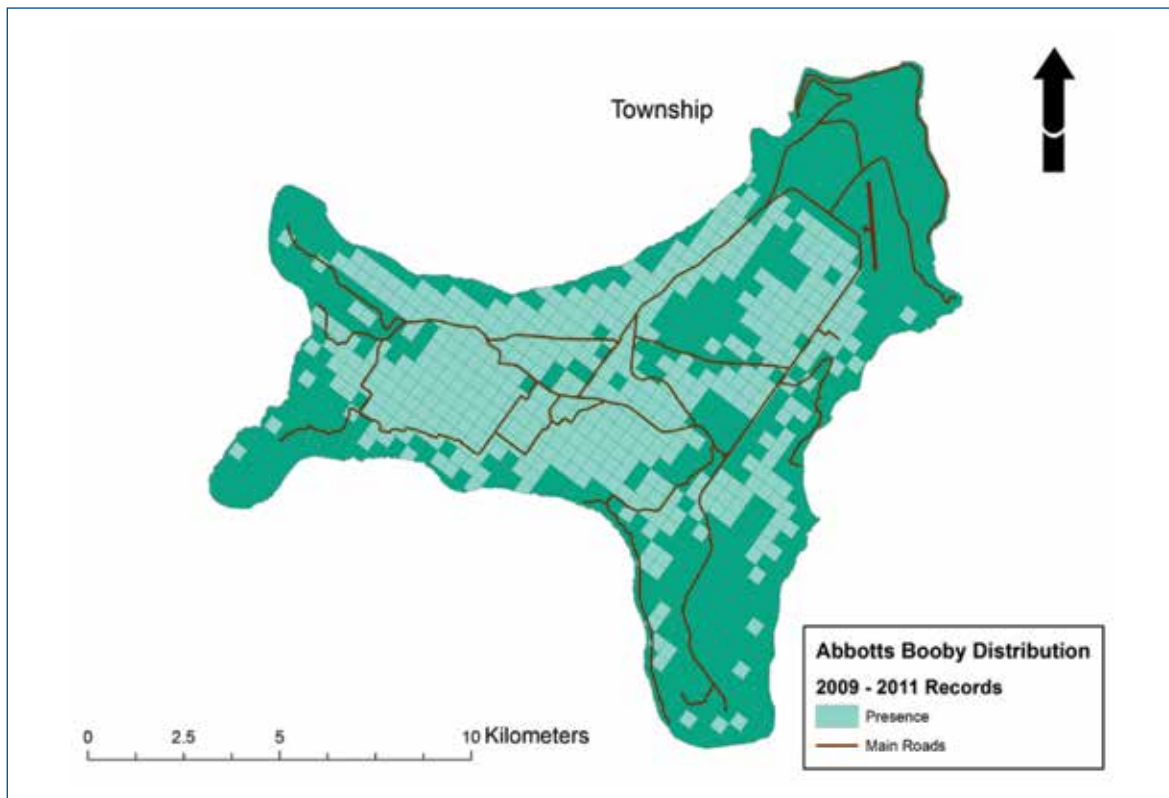
Climate change may result in changes to sea surface temperature, affecting feeding behaviour/food availability.

Potentially, harvest of the birds in other areas, such as Indonesia, might pose a threat (Hennicke 2012). Hunting on Christmas Island is not considered a threat.

Management Actions

- Monitor nest occupancy (Action 5.1), population demographics, breeding success and population trends (Action 5.2).
- Continue to implement the rainforest rehabilitation program (Action 3.3) and, in the long-term, monitor the use of these habitats to determine if and when they are used for nesting (not within the timeframe of this plan).

- Control high risk weeds (Action 3.1).
- Control and reduce the impacts of crazy ants (Action 1.1).
- Improve biosecurity to maintain effective quarantine against the introduction of native species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).
- Investigate potential threats (Action 6.1) and at-sea distribution and habitat utilisation, using data loggers and satellite telemetry (Action 6.2) to determine:
 - foraging range, habitat and behaviour, both spatially and temporally, and accounting for sex, age class, season and breeding status
 - potential overlap of foraging behaviour and habitat with threatening processes, such as long-line fishing and marine pollution.



Map 5: Sites at which Abbott's booby was detected from 2009 and 2011 Island Wide Surveys and 2009 Aerial Survey (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Breeds only on Christmas Island

EPBC Act Listing: Listed as migratory and marine (nomination for listing as threatened in 2006 was unsuccessful)

Existing Conservation Measures

Feral cat and rat control

Distribution

This endemic subspecies is widespread across Christmas Island.

The species as a whole is widespread in tropical and sub-tropical seas throughout the world.

Populations

Population estimates on Christmas Island over the last 25 years vary from 6000 to 12 000 pairs but there have been no definitive estimates. Unpublished data suggest that numbers have declined substantially since 2000 (Garnett et al. 2011).

Habitat

The golden bosun breeds in tree hollows in rainforest, and in rock crevices on terraces (Stokes 1988). It forages in warm waters for fish and squid (Marchant & Higgins 1990). Individuals range very widely when foraging, up to 1660 km from Christmas Island (Dunlop et al. 2001).

(Note: No map or additional spatial information of distribution or habitat is available)

Threats

Chicks may be taken by feral cats and eggs and nestlings could be taken by rats.

The introduction of new invasive species and diseases to the island also poses a threat. Existing invasive species are a potential threat, such as honey bees usurping nesting hollows.

Supercolonies of crazy ants potentially threaten individual nesting adults and chicks through predation and/or disturbance, and changes to habitat.

These threats are widespread, occurring across the range of this subspecies on Christmas Island.

Unsustainable exploitation of sub-surface predatory fish (e.g. tuna, billfish) may impact negatively. Marine pollution is a potential threat, along with entanglement or persecution in fisheries beyond Christmas Island.

Potentially, harvest of the birds in other areas, such as Indonesia, might pose a threat (Hennicke 2012). Hunting on Christmas Island is not considered a threat.

Climate change may result in changes to sea surface temperature, affecting feeding behaviour/food availability.

Management Actions

- Monitor population demographics, breeding success, population trends and, if possible, assess total population size (Action 5.2).
- Control cats and rats (Action 1.2) particularly near nesting habitats, and control crazy ants (Action 1.1).
- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Investigate potential threats, including rats and honey bees (Action 6.1) and identify critical nesting habitat (Action 6.2).

Conservation Significance

Endemic to Christmas Island

EPBC Act Listing: Endangered

Existing Conservation Measures

Monitoring through IWS

Restoration of habitat through rainforest rehabilitation program

Previous Recovery Plan

Hill 2004a

Distribution

Considered to be the rarest endemic bird on Christmas Island but it can occur across the entire island (Map 6).

Populations

There is a single population, restricted to Christmas Island. The population has probably declined in proportion to the areas of forest cleared since settlement.

Although there are no published data on adult or juvenile movements or population size estimates for the subspecies, the total population is thought to be very small (Hill 2004a). Ongoing banding studies initiated in 2004 suggest a total population size of fewer than 250 individuals but this estimate is very approximate (Hurley 2005). The population is possibly stable (Garnett et al. 2011).

The single population is considered necessary to the long-term survival of the subspecies.

The taxonomic affinities of the Christmas Island goshawk require clarification (Christidis & Boles 2008). It is currently variously treated as a subspecies of Variable goshawk *Accipiter hiogaster* or brown goshawk *A. fasciatus*. However, owing to on-going review of the *Accipiter* genus, further study including genetic analysis, may indicate the Christmas Island goshawk is more closely related to the grey goshawk (*A. novaehollandiae*), or a distinct species.

Habitat

Ranges from tall evergreen and semi-deciduous closed forests to suitable areas of secondary regrowth vegetation. Foraging can occur in any habitat type, including urban areas. Insects, centipedes and rats have been recorded in its diet (Hill 2004a). Goshawks are opportunistic hunters and are regularly observed taking Christmas Island white-eyes, thrush, emerald dove, feral chickens, booby nestlings and adult bosun birds (Holdsworth pers. comm. 2012).

Habitat critical to survival of the goshawk is not well known, however, all known nests are found within primary forest types (Garnett et al. 2011).

Applying a precautionary approach, habitat critical to the survival of the goshawk is defined as all evergreen tall closed forest and semi-deciduous closed forest (see Figure 3).

Threats

The decline of this subspecies has probably been the result of a combination of clearing of habitat since settlement, weeds, and crazy ants, either directly or through reduced prey availability or habitat changes. The small population size also increases vulnerability to a range of potential threats.

Protection of forest has reduced the risk of destruction of nest sites, however clearing of suitable nesting habitat would represent a threat.

Goshawks can nest close to road verges within forested areas. Clearing and other sustained road works close to nests at critical times may result in abandonment. The significant increased traffic associated with the operation of the Immigration Detention Centre has reduced the frequency of occurrence of goshawks along the road through the national park. It is not clear if this is due to increased disturbance, thus abandonment, or population reduction through road kill. Regardless, a significant area of foraging habitat is now not used to the same extent (Holdsworth pers. comm.).

The introduction of new invasive species and avian diseases to the island poses a threat. Previously introduced feral bird populations could form a reservoir for introduced avian disease.

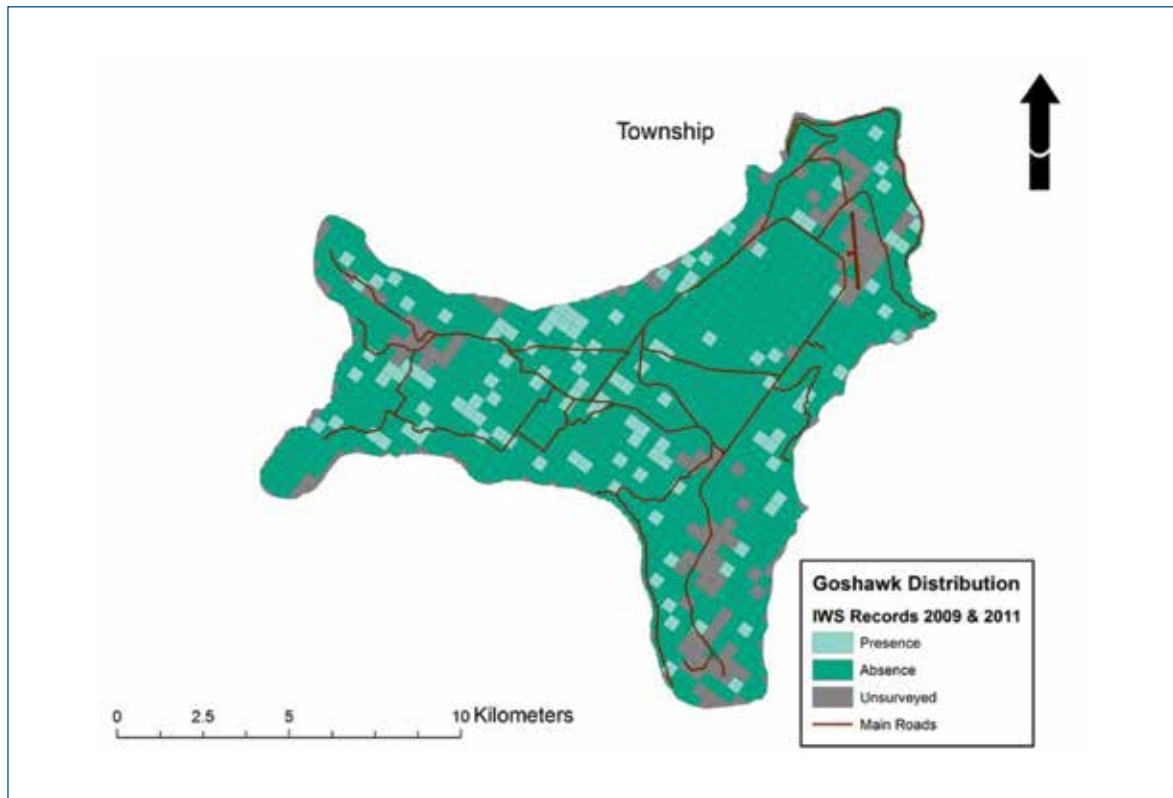
The indiscriminate use of second-generation rodent poisons poses a threat to the species through secondary poisoning. Changes to prey relationships across the island, as a result of cat and/or rat control, could also potentially affect goshawks.

Weeds may pose a potential threat by forming vine towers over nesting trees (Hill 2004a).

Management Actions

- Undertake research to determine foraging, nesting and breeding behaviour and habitat preferences. Conduct a taxonomic review to determine if a distinct species (Action 6.2).
- Undertake surveys to locate nest sites and gather data on breeding success (Action 5.2).
- Monitor presence, distribution and population trends and recruitment (Actions 5.1 and 5.2).
- Control and reduce the impacts of crazy ants including reducing off target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Minimise impacts on the goshawk (e.g. prey relationships, toxin impacts) in any cat and rat management program. (Action 1.2).
- Control high risk weeds as part of broader weed control programs (Action 3.1).
- Continue to implement the rainforest rehabilitation program (Action 3.3) and, in the long-term, monitor the use of these habitats to determine if and when they are used for nesting (not within the timeframe of this plan).

- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests, such as pigeons, that may enter and assessing the risk of threat (Action 2).
- Monitor deaths from vehicles and implement mitigation measures if vehicle deaths are identified as a threat (Action 1.3).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).



Map 6: Sites at which the Christmas Island goshawk was detected during 2009 and 2011 Island Wide Surveys (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island
Important role in island's ecology as seed disperser
EPBC Act Listing: Endangered

Existing Conservation Measures

Monitoring through IWS

Recovery Plan

This is the first recovery plan for this subspecies

Distribution

Endemic to Christmas Island where it is widespread and common (Garnett et al. 2011) (Map 7).

Area of occupancy may have been reduced by due to human settlement, mining, introduced predators and possibly hunting, but the species remains frequently seen in most habitats (Stokes 1988) and over recent years there appears to be some recovery (DNP unpub. data 2011).

Populations

There is a single population, restricted to Christmas Island. The most recent population estimates are 900–3500 individuals and 1000 pairs in 2002 (Corbett et al. 2003) although these are considered to be unreliable (DNP 2008b). Doves were detected at 21 per cent of the 932 waypoints visited during the 2011 IWS, excluding repeat visits (DNP unpub. data 2011).

The single population is considered necessary to the long-term survival of the subspecies.

Habitat

The Christmas Island emerald dove occurs in most forested habitats. It is most common in tall closed evergreen rainforest and open semi-deciduous rainforest, especially on the terraces that surround the central plateau of the island, but is also regularly observed in deciduous scrub, disturbed vegetation such as thickets of weeds and secondary regrowth (including areas dominated by *Muntingia calabura*), settled areas (lawns, gardens and around houses) and on forest tracks.

The subspecies appears to be a habitat generalist so it is not possible to determine or locate specific habitat critical for its survival.

Threats

Habitat loss through previous clearing may have reduced the area of occupancy.

Predation by cats, and possibly rats, poses an ongoing threat although the dove has successfully withstood such predation since settlement due to its adaptability (Stokes 1988).

Supercolonies of crazy ants are known to prey directly on nestlings and are responsible for widespread ecological changes across the island which may threaten the dove's survival (Garnett et al. 2011). It is less numerous in areas with ants than those without (Davis et al. 2008). However, little evidence was found of a negative impact of high density crazy ant colonies on the dove's distribution in the 2011 IWS (Smith et al. 2011).

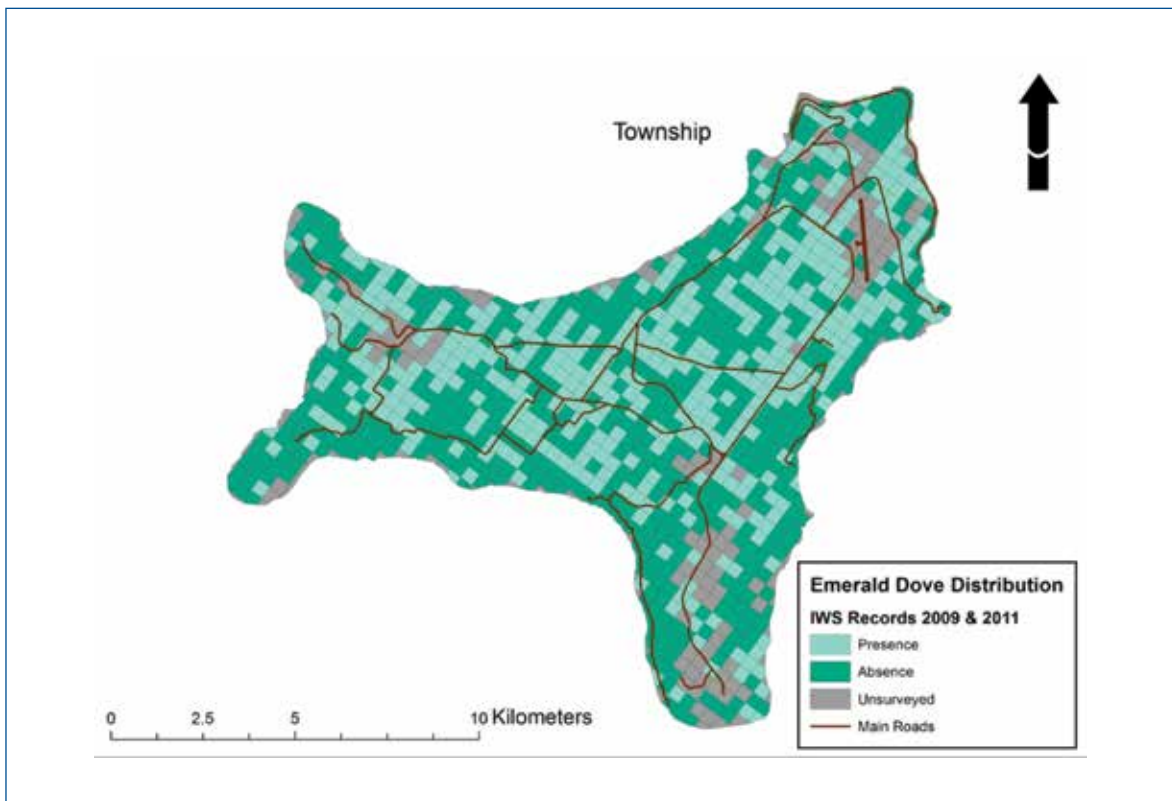
The introduction of new species and avian diseases to the island also poses a threat.

These threats can be considered to be widespread across the island.

Vehicle strike may be a threat in high-use road areas away from settlement.

Management Actions

- Continue to monitor population (Action 5.1).
- Control cats, rats and crazy ants (Actions 1.1 and 1.2).
- Conduct research on threats, including cats, rats and introduced ants (Action 6.1).
- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).
- Implement road management measures to reduce mortality (e.g. driver education, appropriate speed limits) (Action 1.3).



Map 7: Sites at which the Christmas Island emerald dove was detected during 2009 and 2011 Island Wide Surveys (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

EPBC Listing: found not eligible for listing as threatened in 2006

Existing Conservation Measures

No specific measures

Distribution

Endemic to Christmas Island where it is widespread and abundant. Present numbers are probably little changed since settlement (Stokes 1988; DNP unpub. data 2011).

Populations

Swiftlets can occur across the entire island and are considered to be widespread. While reliable population estimates are not available, an early estimate put the population at 100 000 to 1 000 000 individuals (van Tets 1975).

The single population is necessary to the long-term survival of the subspecies.

Habitat

The Christmas Island swiftlet roosts and nests in caves and feeds over most habitats including settlements, forests and terraces, taking aerial prey (Stokes 1988).

Habitat critical to the survival of the species includes all cave systems on the island.

(Note: No map or additional spatial information of distribution or habitat is available)

Threats

There are no demonstrated threats although it is possible that changes in invertebrate composition and abundance due to the impact of crazy ants could affect the species (EWG 2010). Vehicle strike has also been detected as a potential threat in high use road areas away from settlement.

As the population appears stable, addressing island-wide threats, particularly cats, rats, crazy ants and new invasive species, is considered the most effective means of maintaining the subspecies.

Management Actions

- Monitor the population (Action 5.2).
- Control cats, rats and crazy ants (Actions 1.1 and 1.2).
- Implement road management measures to reduce mortality (e.g. driver education, appropriate speed limits) (Action 1.3).
- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).

Ducula whartoni**Christmas Island imperial pigeon***Family* COLUMBIDAE**Conservation Significance**

Endemic to Christmas Island

Important role in island's ecology as seed disperser

EPBC Listing: found not eligible for listing as threatened in 2006

Existing Conservation Measures

Monitoring through IWS

Distribution

Endemic to Christmas Island where it is widespread. The imperial pigeon can occur across the entire island. Pigeons were detected at 92 per cent of the 932 waypoints visited during the 2011 IWS, excluding repeat visits (DNP unpub. data 2011) (Map 8).

Populations

Present numbers have probably been reduced due to human settlement, mining and, in the past, hunting but the species remains abundant (Stokes 1988; DNP unpub. data 2011). There is no current estimate of population size.

The single population is necessary to the long-term survival of the species.

Habitat

The Christmas Island imperial pigeon occupies mainly primary forest and some secondary regrowth dominated by the introduced Japanese cherry on which it extensively feeds, along with a range of rainforest fruits, leaves and buds (Crome 1987, Stokes 1988). As such, it is considered to play a major role in seed dispersal of rainforest plants. It nests in the tops of rainforest trees and other dense vegetation (Hicks & Yorkston 1982).

Threats

The imperial pigeon may be potentially threatened by supercolonies of invasive ants which could prey directly on nestlings as well as being responsible for widespread ecological changes across the island. However, little evidence was found of a negative impact of high density crazy ant colonies on the pigeon's distribution in the 2011 IWS (Smith et al. 2011).

Feral cats may take some individuals. The introduction of new diseases to the island may also pose a threat to the species.

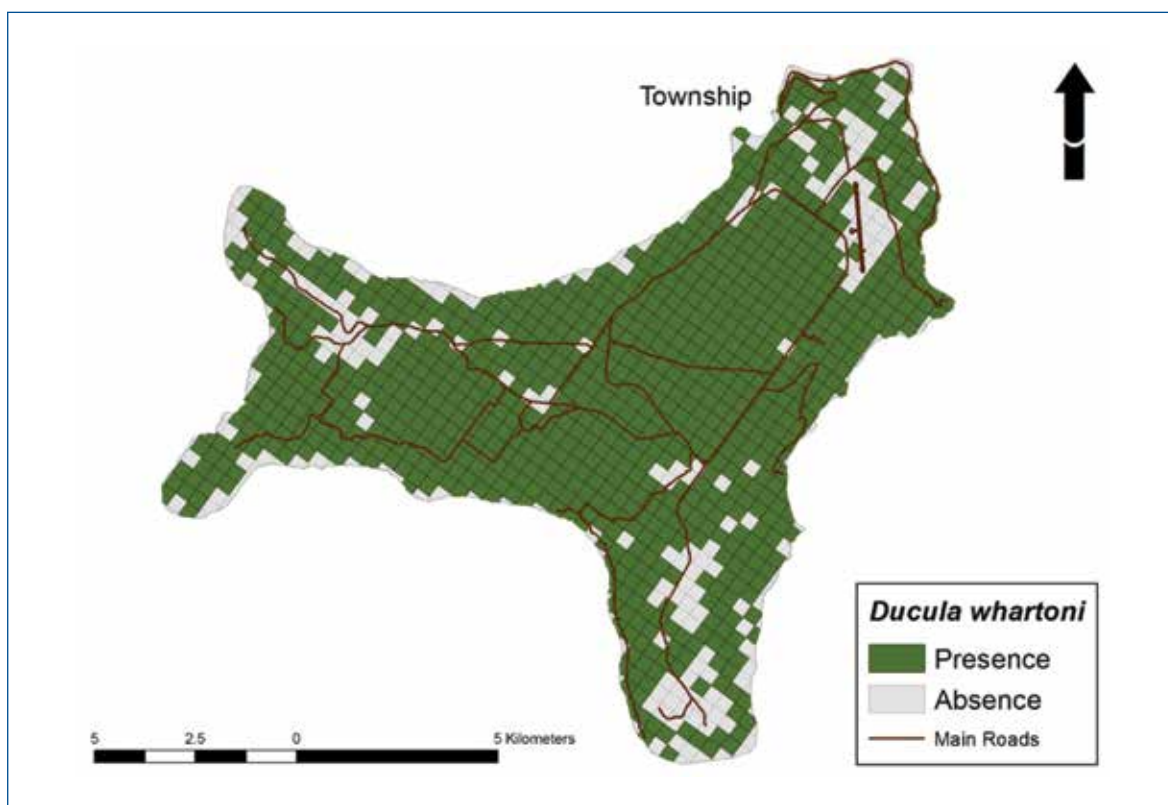
These threats can be considered to be widespread across the island.

Hunting occurred in the past but is no longer considered a threat.

As the population appears stable, addressing island-wide threats, particularly cats, rats, crazy ants and new invasive species, is considered the most effective means of maintaining the species.

Management Actions

- Continue to monitor the population (Action 5.1).
- Control cats, rats and crazy ants (Actions 1.1 and 1.2).
- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).



Map 8: Observation records of Christmas Island imperial pigeon in 2011 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

EPBC Act Listing: Vulnerable

IUCN Listing: Vulnerable

Existing Conservation Measures

Population monitoring (call surveys)

Survey of fixed sites on roads

Restoration of habitat through rainforest rehabilitation program

Previous Recovery Plan

Hill 2004b

Distribution

This species occurs across the entire island, primarily in primary rainforest (Map 9). It is absent from un-regenerated mine sites (Hill & Lill 1998a).

Populations

There is a single population, restricted to Christmas Island. The total population size was estimated at 820–1200 individuals in the mid 1990s (Hill & Lill 1998a). EWG (2010) reported anecdotal evidence suggesting the species may have declined abruptly over the last few years. However, surveys by the DNP in 2012 and 2013 (unpublished) indicate that the population appears to have been stable from 2006 to 2013.

Hill & Lill (1998a) estimated that prior to settlement the island had a carrying capacity in the order of 740 ± 135 owl territories. Between 1994 and 1996 the population was estimated to be 556 ± 101 occupied owl territories in evergreen tall closed forest, 6 ± 4 occupied owl territories in regrowth vegetation (a total population size of 562 ± 105 occupied territories). The total population has probably decreased by at least 25 per cent since settlement (Stokes 1988, Hill & Lill 1998a).

The single population is necessary to the long-term survival of the species.

Habitat

Occupy permanent territories in all forest types, with the highest densities in evergreen tall closed forest and lowest in regrowth (Hill & Lill 1998a). Prey is mainly insects but also small vertebrates including introduced rodents (Hill & Lill 1998b).

Based on the available information, habitat critical to the survival of the species cannot be precisely defined. However, as breeding is dependent on all evergreen tall closed forest and semi-deciduous closed forest, these areas should be considered habitat critical to survival. Figure 3 illustrates the location of this habitat across Christmas Island.

Threats

Threats are not fully understood. The main threats are believed to be the loss of vegetation since settlement from clearing and previous mining, degradation of habitat caused by supercolonies of crazy ants, and weed infestations. Crazy ant impacts may include predation on nestlings and eggs, changes to habitat and reduction in the prey base. However, there is no evidence of decline in the owl population where ants are present (Garnett et al. 2011). Usurpation of hollows by honey bees may also pose a threat.

Black rats and cats are also likely to kill birds and reduce nesting success (Garnett et al. 2011).

Second-generation rodent poison is a potential threat to the hawk-owl and other predatory species.

The introduction of new species and avian diseases to the island poses a threat.

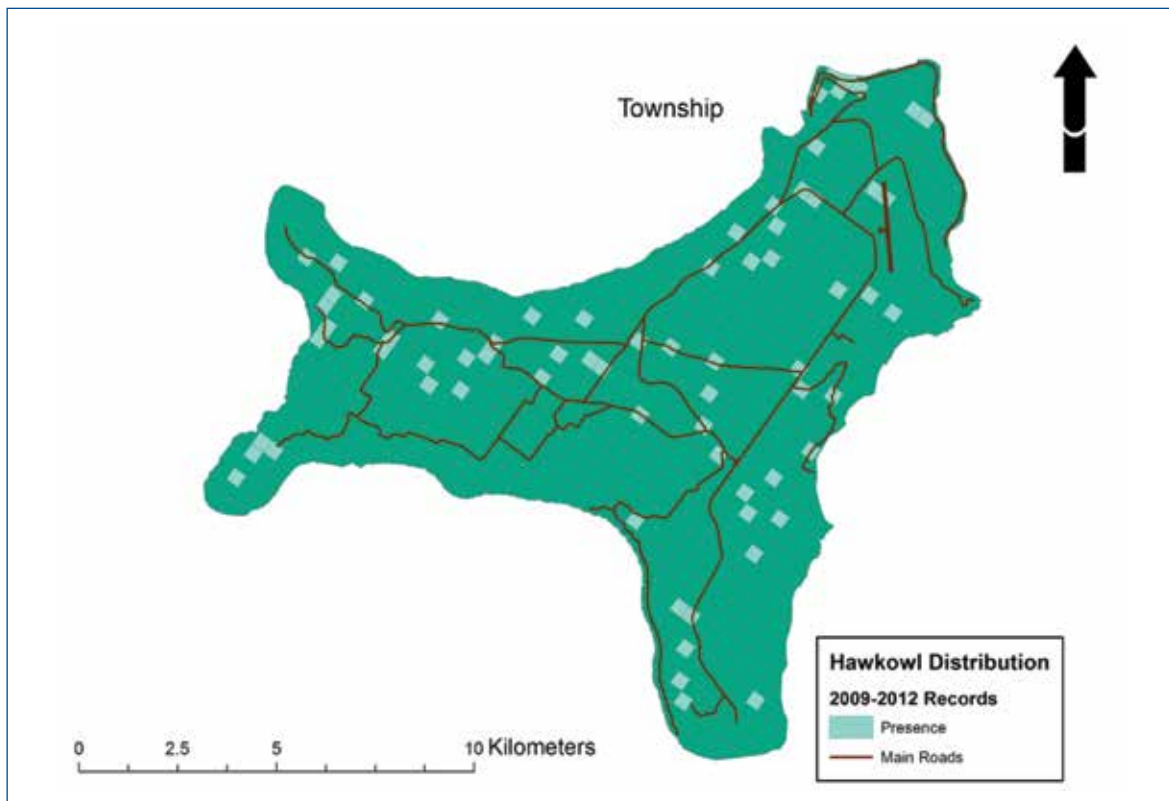
Inbreeding depression is also a risk, while natural catastrophes would also diminish an already small population.

These threats can be considered to be widespread across the island.

There have been previous reports of road mortalities (Hill 2004b); while the level of mortality is unknown it is not considered to be a significant threat.

Management Actions

- Monitor distribution and population trends (Action 5.2).
- Control cats and rats (Action 1.2).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Control high risk weeds as part of broader weed control programs (Action 3.1).
- Continue to implement the rainforest rehabilitation program (Action 3.3) and, in the long-term, monitor the use of these habitats to determine if and when they are used for nesting (not within the timeframe of this plan).
- Research threats, including rats and introduced ants, bees and chemical use (Action 6.1).
- Undertake research to determine foraging, nesting and breeding behaviour and habitat preferences (Action 6.2).
- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).



Map 9: Sites where the Christmas Island hawk-owl was detected 2009 to 2012 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island
EPBC Act Listing: Endangered

Existing Conservation Measures

Monitoring through IWS

Recovery Plan

This is the first recovery plan for this subspecies

Distribution

The species is widespread throughout south-east Asia and the south-west Pacific with many subspecies. The two other Australian subspecies (*T. p. poliocephalus* from Norfolk Island and *T. p. vinitinctus* from Lord Howe Island) are now extinct (Garnett et al. 2011).

This subspecies is endemic to Christmas Island where it is widespread (Map 10). It was introduced to the Cocos (Keeling) Islands between 1885 and 1900 but this population has since become extinct (Stokes 1988).

Populations

There is a single population, restricted to Christmas Island. The most recent estimate is 20 000–50 000 individuals (Corbett et al. 2003) although this is considered to be unreliable (DNP 2008b). Thrushes were detected at 83 per cent of the 932 waypoints visited during the 2011 IWS, excluding repeat visits (DNP unpub. data 2011).

The thrush is claimed to have undergone a moderate decline in numbers on Christmas Island in response to habitat alteration, predation by introduced animals and hunting by humans (Stokes 1988). However, it remains common.

The single population is considered necessary to the long-term survival of the subspecies.

Habitat

The thrush is found in most habitats, including tall closed evergreen rainforest, open semi-deciduous rainforest, secondary regrowth, thickets of weeds and semi-deciduous vines, settled areas (where it forages on lawns and nests on buildings) and on the Christmas Island golf course. It is most common in tall closed evergreen rainforest and open semi-deciduous rainforest on the coastal and higher terraces and plateau of Christmas Island. It is least common in disturbed habitats, such as regrowth and post-mining wasteland, and in suboptimal endemic vegetation such as *Pandanus* thickets and patches of low vegetation in coastal areas (Stokes 1988, DNP 2008b).

The subspecies appears to be a habitat generalist so it is not possible to determine or locate specific habitat critical for its survival.

Threats

The thrush is threatened by black rats, and potentially by supercolonies of crazy ants, which probably prey directly on nestlings. Nest success and the number of juveniles encountered are lower in areas with ants than without (Davis et al. 2008). However, little evidence was found of a negative impact of high density crazy ant colonies on the thrush's distribution in the 2011 IWS (Smith et al. 2011).

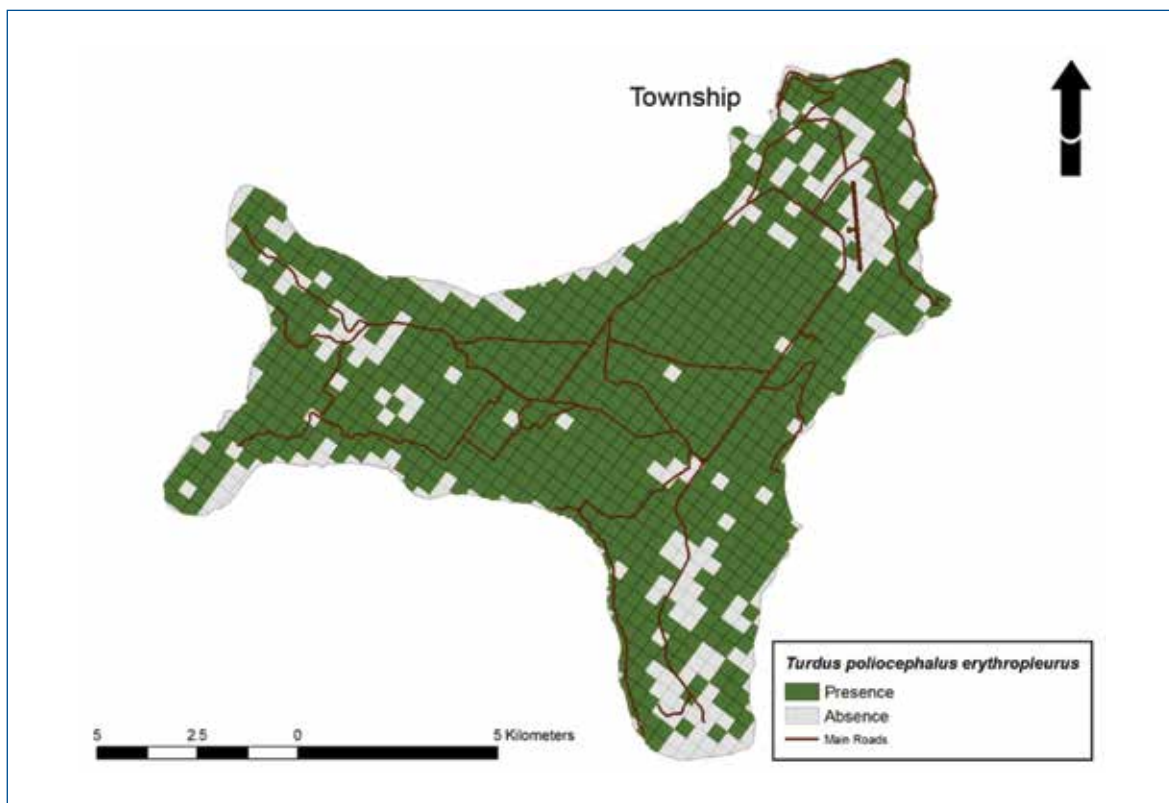
Ecological changes arising from the impact of crazy ants could favour the spread of black rats, which have been responsible for extinctions of island thrushes on other islands (Garnett et al. 2011).

Other threats include predation by feral cats, introduced bird diseases (Garnett et al. 2011) and, potentially, the introduction of new species and diseases.

These threats can be considered to be widespread across the island.

Management Actions

- Monitor population trends (Actions 5.1 and 5.2).
- Control cats and rats (Action 1.2).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Conduct research on threats, including rats and crazy ants (Action 6.1).
- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).



Map 10: Observation records of Christmas Island thrush in 2011 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

Important role in the island's ecology as seed disperser

EPBC Listing: found not eligible for listing as threatened in 2006

Existing Conservation Measures

Monitoring through IWS

Distribution

Endemic to Christmas Island, widely distributed and can occur across the entire island (Map 11). Introduced to the Cocos (Keeling) Islands (Horsburgh Island).

Populations

Present numbers have probably been reduced due to human settlement and mining but the species remains abundant (Stokes 1988; DNP unpub. data 2011).

The population has been estimated at 100 000 to 1 000 000 (van Tets 1975) but current population estimates are not available. White-eyes were detected at 83 per cent of the 932 waypoints visited during the 2011 IWS, excluding repeat visits (DNP unpub. data 2011).

The single population is considered necessary to the long-term survival of the species.

Habitat

The white-eye occupies all forested habitats and feeds on insects, nectar and fruit throughout the forest strata, with little sign of a preferred feeding zone. The species may play a major role in the ecological function of the island's forests through seed dispersal especially of smaller-fruited plants, pollination and insect predation. The white-eye has no known avian competitor on the island (Stokes 1988) but introduced Java sparrows may compete in settled areas.

Threats

The species is potentially threatened by supercolonies of invasive ants which could prey directly on nestlings. However, little evidence was found of a negative impact of high density crazy ant colonies on the white-eye's distribution in the 2011 IWS (Smith et al. 2011).

Predation by feral cats sometimes occurs and ecological changes arising from the impact of crazy ants could favour the spread of black rats which have been responsible for extinctions of white-eye species on other islands, although there is no evidence that numbers are currently being affected (Garnett et al. 2011).

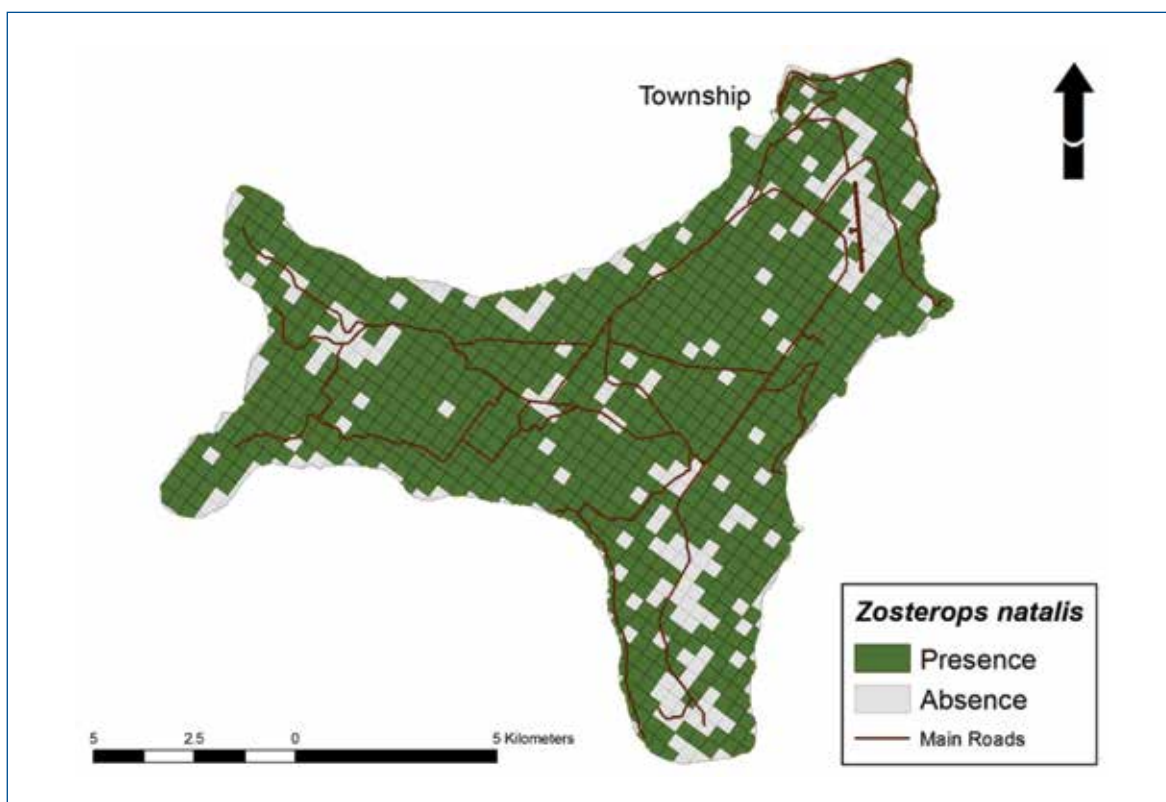
The introduction of new diseases to the island also poses a threat to the species.

The extent to which there is competition from introduced species is unknown, but may be a potential threat.

These threats can be considered to be widespread across the island.

Management Actions

- Continue to monitor population (Action 5.1).
- Control cats and rats (Action 1.2).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Improve biosecurity to maintain effective quarantine against the introduction of avian diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).



Map 11: Observation records of Christmas Island white-eye in 2011 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

Only shrew species recorded in Australia

EPBC Act listing: Endangered (but likely to be extinct)

IUCN Listing: Critically Endangered

Existing Conservation Measures

Opportunistic monitoring through IWS and other fauna surveys

Targeted surveys previously undertaken

Previous Recovery Plan

Schulz 2004

Distribution

The Christmas Island shrew is endemic to Christmas Island. Previously considered to be a subspecies of the more widely spread grey shrew (*Crocidura attenuata*) recent molecular studies established it as a separate species (Eldridge et al. 2009). Current distribution is unknown and it is considered extremely rare and possibly extinct (Schulz 2004).

The shrew was widespread and abundant at the time of settlement, occurring in rainforest on the plateau and adjacent to the shoreline (Schulz 2004). It has not been recorded since 1985, when two separate individuals were accidentally found at the western edge of the island over a period of less than a month (Tranter pers. comm. cited in Schulz 2004) (Map 12).

Populations

If still extant, there is a single population, restricted to Christmas Island. There have been no confirmed records since 1985 despite subsequent targeted surveys (Tidemann 1989; Meek 2000) and ongoing biodiversity monitoring. Any individuals located would be regarded as part of an important population.

The shrew was once extremely common across the island, but declined rapidly following settlement. By 1908 it was thought to be extinct, until the 1985 records. Subsequently it was discovered that two specimens had been encountered in 1958 during rainforest clearing operations for phosphate mining near South Point (Powell pers. comm. cited in Meek 2000).

Habitat

The shrew was widespread in rainforest extending from shoreline to plateau. The 1985 records were from tall plateau forest in deep soils and terrace rainforest with shallow soils (Schulz 2004).

Until further information is obtained, by applying a precautionary approach, habitat critical to the survival of the shrew is defined as all evergreen tall closed forest and semi-deciduous closed forest (see Figure 3).

Threats

As knowledge of the shrew's ecology and conservation requirements is limited, no known threats have been documented. However, the dramatic decline which occurred within 20 years of human settlement suggests direct or indirect human threat (Schulz 2004) for example, through invasive species associated with settlement.

Potential threats include:

- disease, probably caused by the parasite *Trypanosoma* carried by black rats, is implicated in the dramatic decline recorded following human settlement (Meek 2000)
- predation and/or competition by invasive species such as cats and rats (no instances of predation have been recorded however)
- direct and indirect effects of crazy ants (shrew declines occurred well before crazy ants were introduced however)
- habitat alteration and loss through past clearing
- introduction of new diseases and invasive species.

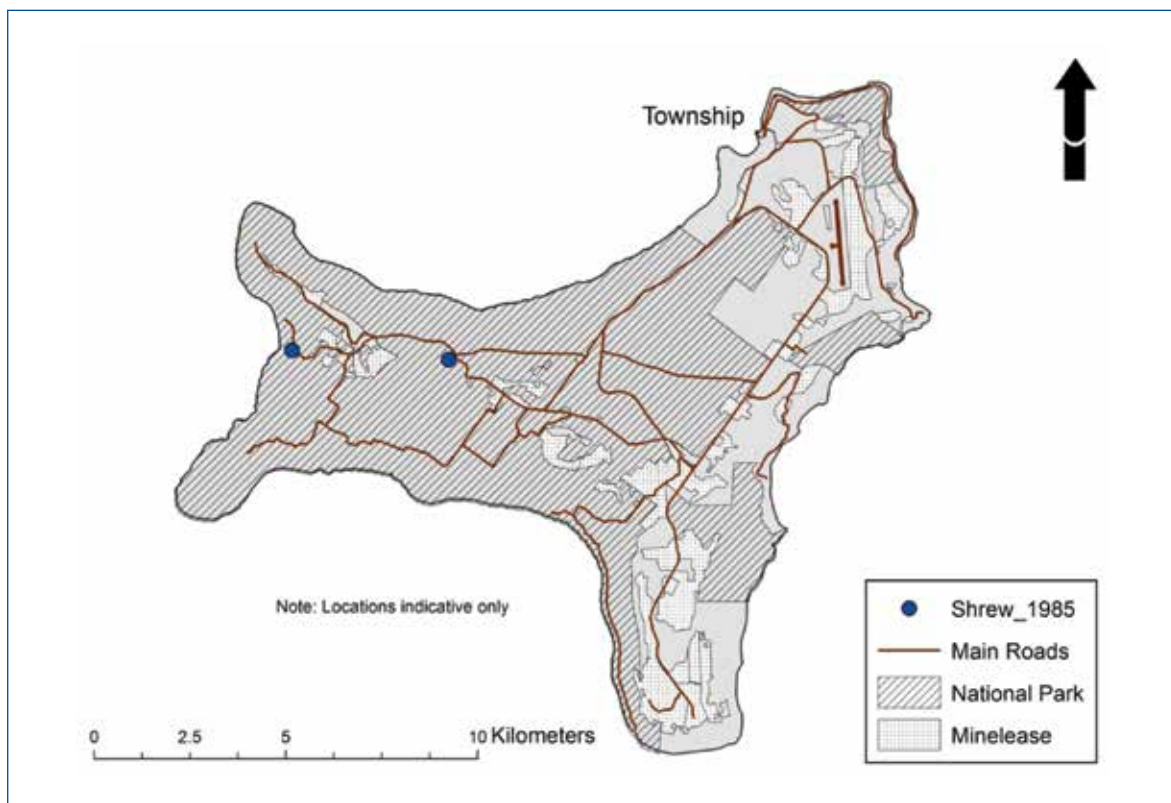
Apart from clearing, these potential threats can be considered to be widespread across the island.

Management Actions

- Collect data on opportunistic sightings through monitoring (Action 5).
- Control cats, rats and crazy ants (Actions 1.1 and 1.2).
- Conduct research on potential threats, including rats, crazy ants and *Trypanosoma* parasites (Action 6.1).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).

If individuals or populations are found the following actions should apply:

- Seek immediate scientific advice on the feasibility of a captive breeding program and implement if feasible (Action 4.3).
- Conduct surveys to determine population extent and habitats (Action 5.2).
- Seek scientific advice on the need for specific additional *in situ* threat management options, and, if required, develop and implement (Action 4.5).



Map 12: Location of two 1985 sightings of the Christmas Island shrew (Parks Australia)

Map caveats:

The data on this map represents areas where the species was last detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

EPBC Act listing: Critically Endangered (but likely to be extinct)

IUCN listing: Critically Endangered

Existing Conservation Measures

Intensive visual and acoustic monitoring of roosting and foraging habitat commenced in 1998 (since 2009 restricted to intermittent acoustic monitoring).

Artificial roosts erected in 2006 in response to shrinking population size and roost protection measures also installed; strict conditions in place since 2008 on clearing of vegetation for mining at the last known site.

Expert Working Group appointed in 2009 to advise on emergency conservation measures (EWG 2010); led to an unsuccessful attempt to establish a captive breeding population in 2009 by the Australasian Bat Society and supported by the DNP (no bats could be captured due to lack of detection).

Previous Recovery Plan

Schulz & Lumsden 2004

Distribution

Endemic to Christmas Island. This species was formerly widespread and common in primary and secondary rainforest (Tidemann 1985). In the 1990s targeted surveys indicated a marked reduction in abundance and a westward range contraction had occurred. The last individuals were detected in the far western section of the Island in Sydney's Dale (Lumsden & Schulz 2009) (Map 13).

Populations

Analysis established the pipistrelle was taxonomically distinct although closely related to other Indo-Australian *Pipistrellus* species (Helgen et al. 2009).

No individuals have been recorded since August 2009 (Lumsden et al. 2010). The species is likely to be extinct but if any individuals are located they would be regarded as part of an important population.

Habitat

An edge specialist which favoured vegetation ecotones, tracks and other small gaps within evergreen tall closed forest where its insectivorous prey was taken in flight. Foraging or commuting individuals also ranged into adjacent habitats including regrowth forest, minefield rehabilitation sites and formerly the Settlement area (Lumsden & Schulz 2004).

The pipistrelle roosted under exfoliating bark on dead trees, under loose dead fronds of palm and pandanus trees, in hollows in large live trees and under strangler figs (Lumsden et al. 1999).

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 is defined as: areas of evergreen tall closed forest and areas of regenerating rainforest regrowth (of all ages) especially in the western part of the island.

Threats

The factors responsible for the likely extinction of the pipistrelle are not clearly known. The EWG (2010) presented a plausible but speculative 'ecological cascade' scenario involving a complex interaction of multiple factors including predation and habitat change arising from the impact of crazy ant supercolonies.

Introduced species (e.g. black rats, honey bees, giant centipedes and supercolonies of crazy ants) have been implicated in their decline (Lumsden et al. 2007). Those potential threats can be considered to be widespread across the island.

There were previous reports of road mortalities (Tidemann 1985) however the level was unknown and is not considered to have been a significant threat.

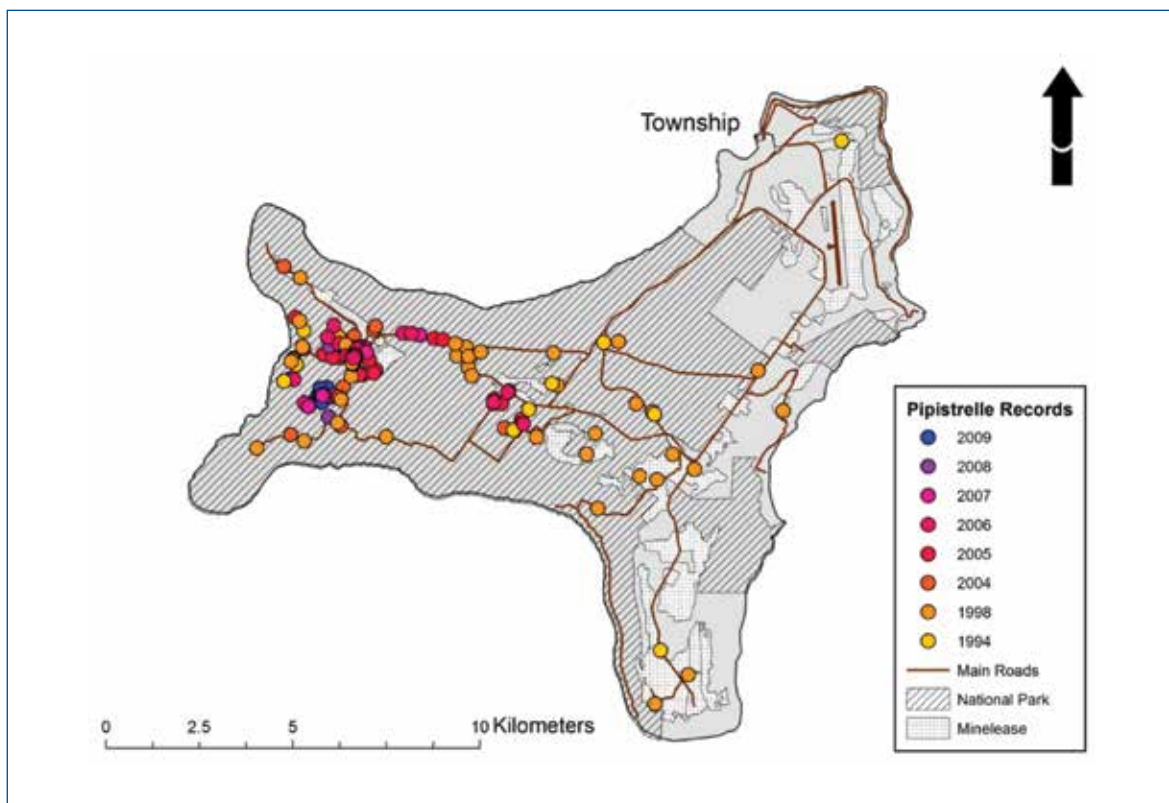
Neither habitat loss nor reduction in prey items appear to have been a threat (Lumsden et al. 2007) although the EWG (2010) did not accept the argument that the persistence of insectivorous diurnal birds was convincing argument against shortage of prey. No evidence that disease posed a threat was found but it cannot be ruled out (Lumsden et al. 2007, EWG 2010).

Management Actions

- Collect data on opportunistic sightings through monitoring (Action 5).
- Control cats, rats (Action 1.2) and crazy ants (Action 1.1).
- Conduct research on potential threats that also impact on other species, including wolf snake, black rat, honey bee, giant centipede and crazy ants (Action 6.1).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).

If individuals or populations are found the following actions should apply:

- Seek immediate scientific advice on the feasibility of a captive breeding program and implement if feasible (Action 4.3).
- Conduct surveys to determine population extent and habitats (Action 5.2).
- Seek scientific advice on the need for specific additional *in situ* threat management options, and, if required, develop and implement (Action 4.5).



Map 13: Compilation dataset of pipistrelle records from surveys occurring between 1994 and 2009—presence data only (Parks Australia and external researchers)

Map caveats:

The data on this map represents areas where the species was last detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Pteropus melanotus natalis**Christmas Island flying-fox****Family PTEROPODIDAE****Conservation Significance**

Endemic to Christmas Island

Important role in the island's ecology as pollinator and seed disperser

EPBC Act Listing: Critically Endangered

IUCN listing: species *Pteropus melanotus* listed as Vulnerable

Existing Conservation Measures

Monitoring through biennial IWS and targeted surveys in 2012 and 2013

Expert-based conservation workshop in 2012

Genetic and disease studies

Distribution

Endemic to Christmas Island, where it forages across the entire island. Congregates in distinct roost sites ('camps') of varying size and location, similar to other flying-foxes. Three of six historically known major roost sites are no longer occupied (DNP 2008b).

The three remaining major roost sites are at Hosnies Spring, McMicken Point (Dolly Beach) and Greta Beach totalling ca. 10 ha; a small roost site is also currently known from the golf course. However, there may be additional roost sites.

Map 14 shows 2013 survey results.

Populations

There is one population, restricted to Christmas Island. The total population was estimated in 2006 at about 1500 individuals, a dramatic decline since 1984 (DNP 2008b). A targeted survey in 2012 recorded a 35–39 per cent decline in detection at fixed survey points, which indicates a population decline since 2006. A similar incidence of detection was recorded in the 2013 survey, implying a similar population level. The population is estimated to be at least 1000.

The single population is considered necessary to the long-term survival of the subspecies. There are only a few breeding colonies which should constitute the pivotal conservation focus.

While currently considered a subspecies of a more widely distributed species, the taxonomic status of the flying-fox is poorly resolved. Genetic studies to date have not been sufficient to determine genetic distinctiveness, though a relatively high level of genetic diversity is indicated (Phalen et al. 2012).

Habitat

The flying-fox feeds on fruits found in most of the vegetation types present on the island and especially fond of introduced fruits, contributing to their wide dispersal (Gray 1995). It is a primary seed disperser and pollinator for many rainforest trees and other plants and is considered to be an important component of the island's rainforest ecosystem (Tidemann 1985).

All recorded campsites have been located on the coastal terrace or around the first land cliff and semi-deciduous forest, although the actual structure of sites varies. Four of the six historical sites are on the east coast of the island and one each on the north and south of the island. The seasonal variation of campsite usage is poorly understood (DNP 2008b).

Due to its declining population and because the species uses a range of rainforest vegetation types for feeding and roosting, all previously uncleared native vegetation is considered critical habitat. The flying-fox will also use urban and some mined areas for feeding but these are not critical habitats.

Threats

Threats to the species are not precisely known and it is possible that a combination of factors and threats is responsible for declining numbers.

Most likely threats include:

- supercolonies of crazy ants which cause widespread ecological changes across the island and possible disturbance at roost/maternity sites
- predation by cats which has been recorded through cat stomach content analysis (Tidemann 1985).

Potential threats include:

- habitat decline and loss through past clearing
- climatic events, such as severe storms and cyclones
- introduction of other or new invasive species, diseases, parasites and pathogens
- chemicals and toxins.

Apart from clearing, each of these threats is widespread and can be considered to be a threat across the entire island. Potential threats require investigation.

The diet of the flying-fox now includes a considerable proportion of fruits and nectar from introduced species. It is possible these provide less nutrition than native species (as reported for Pacific Island flying-foxes by Nelson et al. 2000) but there is no primary evidence for this for the Christmas Island flying-fox.

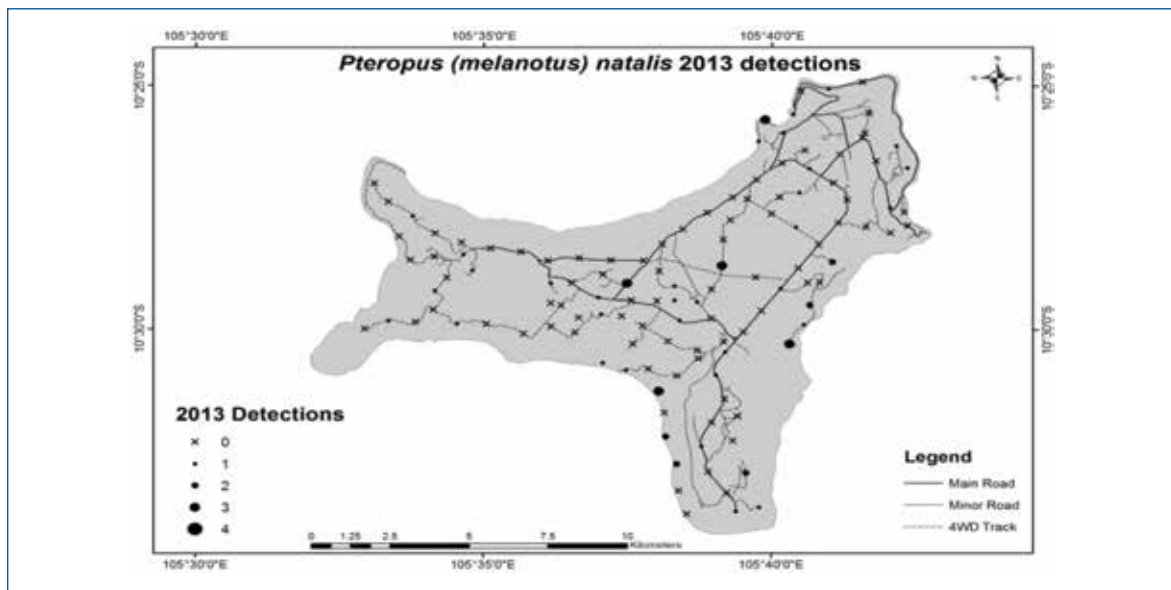
Heavy metal poisoning (including from drinking at contaminated sites) is an unknown but potential threat.

Hunting occurred in the past but is no longer a threat.

Management Actions

- Monitor population including searches for any additional camps (Actions 5.1 and 5.2).
- Conduct ecological and biological studies to inform recovery actions (Action 6.2).
- Investigate threatening processes including; crazy ants causing habitat decline and disturbance at roost/maternity sites, cats, diseases, pathogens and parasites (Action 6.1).

- Control cats (Action 1.2) and crazy ants (Action 1.1).
- Determine targets and thresholds for criteria and for management intervention (Action 9.2). If a decision is made that intervention is required, assess the need for, and feasibility of, establishing a captive breeding program, and implement if feasible (Action 4.3).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases, parasites, pathogens and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Investigate the potential threat and risks of chemicals and toxins (Action 6.1).
- Rehabilitate mine sites (Action 3.3).
- Continue to assess the environmental impacts of proposals in accordance with relevant legislation (Action 1.4).



Map 14: Sites where flying-foxes were detected during a 2013 survey (Parks Australia)

Map caveats:

The data on this map represents areas where the species was last detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes..

Conservation Significance

Endemic to Christmas Island

EPBC Act Listing: Critically Endangered

Existing Conservation Measures

Monitoring through IWS (but insufficiently powerful design) and dedicated native reptile survey (2012 and 2013).

Captive breeding population established on and off island.

Crazy ant control measures and disease studies

Distribution

Endemic to Christmas Island. Formerly common and widespread across the island (Map 15), the blue-tailed skink is now possibly extinct in the wild.

A 1979 reptile survey found it abundant with a sparse and widely-scattered distribution. A decline in numbers first recorded by Rumpff (1992) coincided with spread of the introduced wolf snake. A second survey in 1998 revealed a considerable contraction in non-coastal areas while island-wide biodiversity monitoring from 2004–06 found further decline (Cogger & Sadlier 2000, DNP 2008b).

Extensive surveying in 2008 (Schulz & Barker 2008) recorded this species from only two areas (Egeria Point and North West Point). Subsequent surveys by Parks Australia (Smith et al. 2012) have confirmed its disappearance from North West Point (mid–2008) and suggest disappearance from Egeria Point (mid–2010).

Extensive surveys undertaken in 2012 to locate native reptiles (including sites where the species had been previously recorded as well as previously unsurveyed areas) did not detect this species (DNP unpub. data 2012).

Populations

Since 2009, a captive breeding population has been established in holding cages at Christmas Island and at Taronga Zoo. The captive population is important for survival of the species.

If any individual or population is found in the wild, this would be considered a population necessary for the long-term survival of the species.

Habitat

The blue-tailed skink formerly occurred across all habitats; tall primary rainforest, deciduous thickets, coastal thickets, and settlement areas, including areas scarred and left unrehabilitated by previous mining. In 1979, it was abundant in household gardens, brick walls and roadside vegetation (Cogger et al. 1983). It was less common in tall primary rainforest, being recorded more frequently at their edges and in canopy gaps (Cogger & Sadlier 2000). It was also found commonly foraging on the bare faces of coastal cliffs, often within the splash zone, retreating to fringing ground cover when disturbed (DNP 2012b).

Given the broad habitats used, lack of records and the profound habitat changes that have occurred over the past 20 years, it is not possible to define or map habitat critical to the survival of this species.

Threats

Threats to the species are not precisely known, however the most likely factor of decline is predation by one or more exotic species. The most likely predators include the wolf snake, giant centipede and crazy ants. The first two of these have been confirmed to prey on this species and their distribution and abundance have increased in correlation with the species' decline (DNP 2012b). Feral cats have also been implicated in their decline.

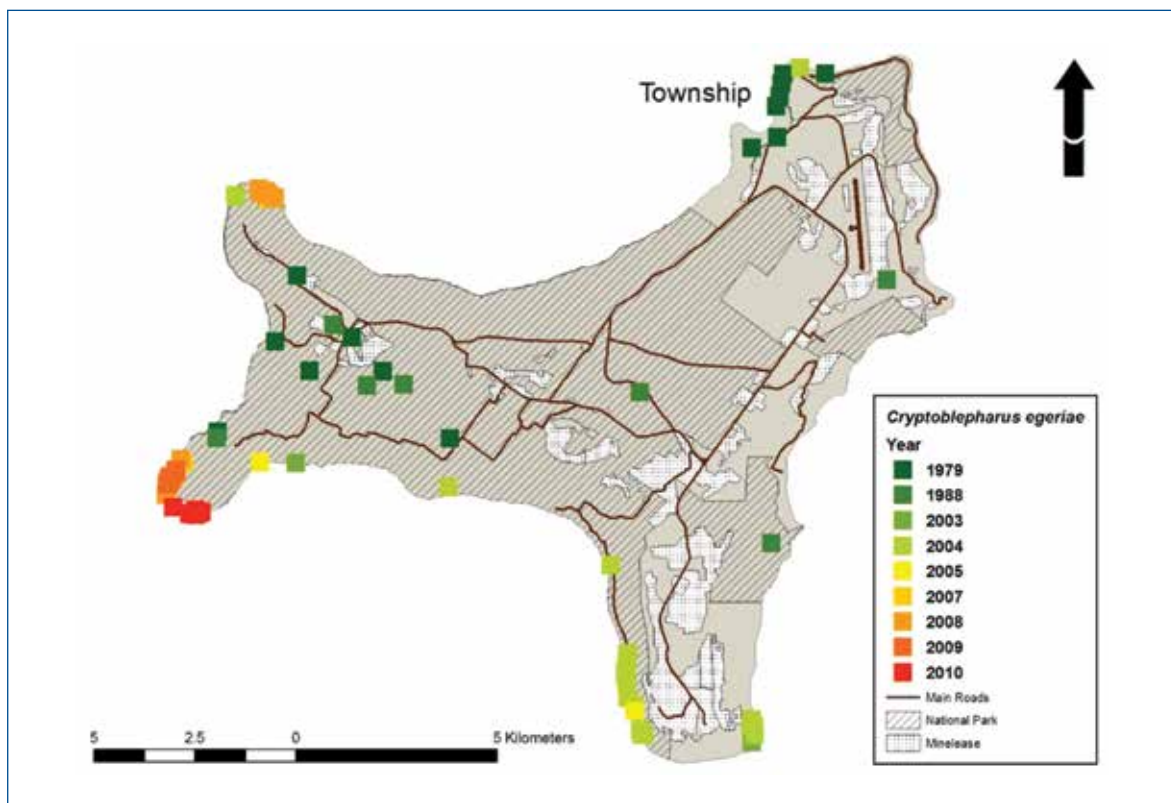
Potential threats include:

- other potential predators such as the black rat and (self-introduced) nankeen kestrel
- exotic reptiles, through predation, competition and/or spreading introduced disease (unlikely to have been the primary cause of decline however)
- supercolonies of crazy ants, through reduction in habitat suitability and/or food availability
- introduction of new diseases or invasive species.

These threats can be considered to be widespread across the island.

Management Actions

- Continue captive breeding programs, including adaptive release trials (Action 4.1).
- Monitor the extent and habitats of wild and/or reintroduced captive populations (Action 5.2).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Control cats and rats (Action 1.2).
- Investigate the feasibility of reducing the impacts of wolf snakes and centipedes and trial management (Action 3.4).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Investigate threatening processes including invasive species, pathogens, diseases and parasites (Action 6.1).



Map 15: Last recorded detections of the blue-tailed skink (Parks Australia)

Map caveats:

The data on this map represents areas where the species was last detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

EPBC Act Listing: Endangered

Existing Conservation Measures

Monitoring through IWS (but insufficiently powerful design to record declines)

Opportunistic monitoring as part of other monitoring programs and targeted monitoring (with other reptiles) in 2012 and 2013

Crazy ant control measures

Distribution

The current area of occupancy is uncertain, but the giant gecko probably persists across most of Christmas Island other than disturbed areas lacking woody regrowth (DNP 2012c) (Map 16).

Recorded as extremely abundant and widespread in a 1979 reptile survey (Cogger et al. 1983) and confirmed as common in subsequent surveys (Cogger & Sadlier 2000, DNP 2008b).

Following an extensive survey of Christmas Island reptiles in 2008, Schulz and Barker (2008) considered that it had “declined markedly, particularly in terrace rainforests and primary plateau rainforests in the western half of the island”. In this sampling, they also reported no giant geckoes from several sites where it was formerly abundant (DNP 2012c).

Populations

There are no data on the number of populations and no estimates of total population size. Future reduction in population size may be inferred given the recent catastrophic decline of the four other native lizards on Christmas Island (DNP 2012c).

Populations necessary to the long-term recovery and/or survival of the species are those located in primary forest on the central plateau, and any captive population established.

Habitat

The giant gecko is found in all island habitats except for areas lacking trees and shrubs, including formerly mined areas with dense regrowth. The species is most commonly encountered in primary forest on the central plateau (Cogger et al. 1983).

Habitat critical to survival of this species comprises evergreen-tall closed forest (Figure 3).

Threats

Threats to the species are not precisely known, however the most likely cause of population decline is predation by one or more exotic species. The most likely predators include the wolf snake, giant centipede and crazy ants. The first two of these have been confirmed to prey on the gecko and their distribution and abundance has increased in correlation with the decline of the gecko (DNP 2012c). The gecko is regularly found in areas with high densities of crazy ants and may be able to tolerate ant outbreaks (Cogger & Sadlier 2000). Feral cats are also implicated in their decline.

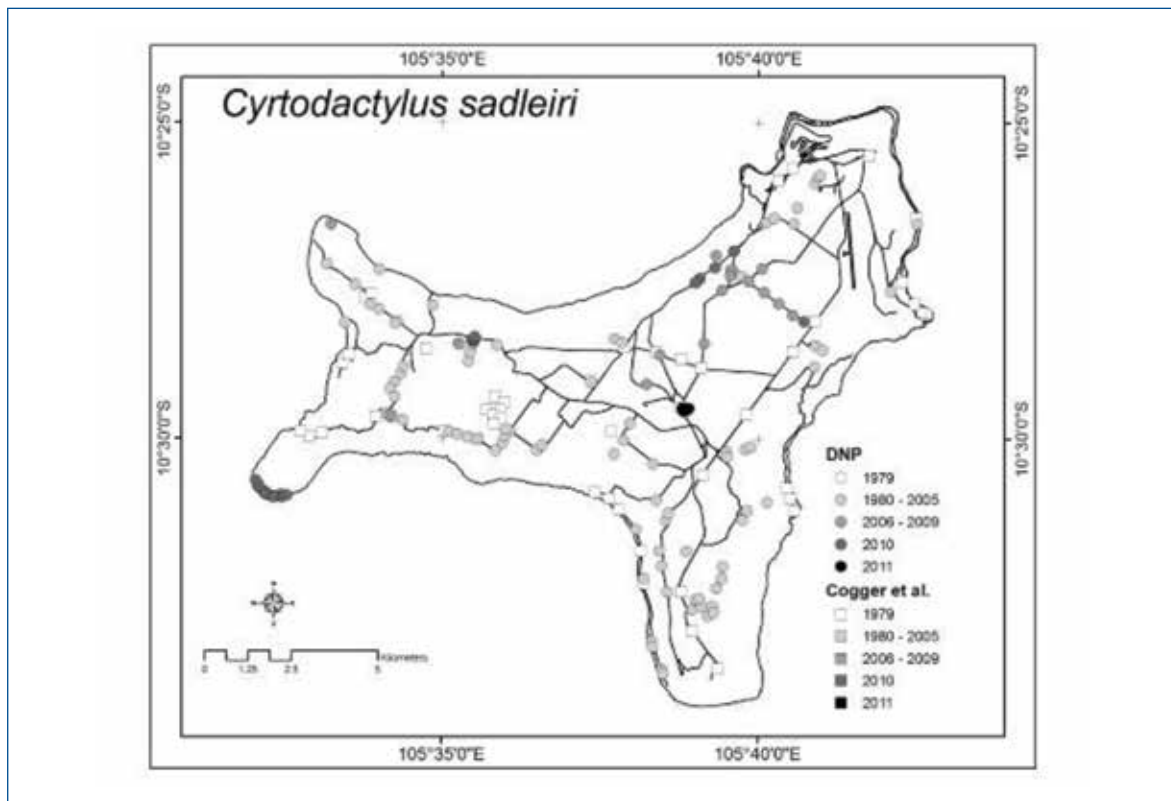
Potential threats include:

- other potential predators such as the black rat and (self-introduced) nankeen kestrel
- exotic reptiles, through disease, predation and competition, though this is unlikely to be the primary cause of decline
- supercolonies of crazy ants, through reduction in habitat suitability and/or food availability
- introduction of new diseases or invasive species.

These threats can be considered to be widespread across the island.

Management Actions

- Conduct surveys to determine the presence, and the extent, trends and habitats of populations (Action 5.2).
- Based on population monitoring, identify thresholds (Action 9.2) and methods for initiating captive breeding, including husbandry trials (Action 4.1).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Control cats and rats (Action 1.2).
- Investigate the feasibility of reducing the impacts of wolf snakes and centipedes and trail management (Action 3.4).
- Investigate reasons for the gecko's persistence despite the more rapid decline of other native reptile species (Action 6.2).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Investigate threatening processes including invasive species, pathogens, diseases and parasites (Action 6.1).



Map 16: Giant gecko records (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

EPBC Act Listing: none

Existing Conservation Measures

Monitoring through IWS (but insufficiently powerful design to record declines)

Dedicated native reptile survey (2012 and 2013)

Crazy ant control measures

Distribution

The coastal skink is found throughout South-east Asia and islands of the Pacific and Indian Oceans in littoral habitats. In Australia, it occurs on Christmas Island, some Torres Strait islands and the northern tip of Cape York Peninsula.

On Christmas Island, it is restricted to rocky coastal terraces in the intertidal zone (Map 17). Surveys in 1979 and 1998 suggest the species was common and widely distributed around all the island's foreshores (Cogger et al. 1983, Cogger & Sadler 2000).

Very few sightings were made during island-wide biodiversity monitoring from 2004–06 and during targeted searches, including in all sites where it had been previously recorded (Schulz & Barker 2008).

The last sighting of the coastal skink was in 2010 (Smith et al. 2012). Extensive surveys undertaken in 2012 and 2013 to locate native reptiles (including sites where the species had been previously recorded as well as previously unsurveyed areas) did not detect this species (DNP unpub. data 2012 and 2013).

Populations

At best this species may now only occur in a few small populations scattered around the island's perimeter. It may not be extant (DNP 2012d).

Any populations or individuals in the wild or captive population established would be regarded as necessary for the long-term survival of this species.

While the species is relatively widespread, the Christmas Island population is isolated and studies have not been undertaken to determine its genetic distinctiveness compared with other populations.

Habitat

On Christmas Island, the coastal skink "is confined to the intertidal zone where it forages at low tide, and extends inland only a few metres beyond the bare rocky foreshore, where the limestone rock is lightly covered by vines. The heavily eroded limestone contains numerous crevices and holes, in which *E. atrocostata* shelter when not actively foraging" (Cogger et al. 1983).

Habitat critical to survival includes coastal terraces but is difficult to determine and locate.

Threats

Not precisely known, however the most likely factor of population decline is predation by one or more exotic species. If extant, the population is now extremely small making the species more vulnerable to threats.

The most likely predators include the wolf snake, giant centipede and crazy ants. The first two of these have been confirmed to prey on native lizards and their distribution and abundance has increased in correlation with the decline of the coastal skink (DNP 2012d). Feral cats may also be implicated in the decline of the skink, as there is evidence of predation on other native reptiles on Christmas Island.

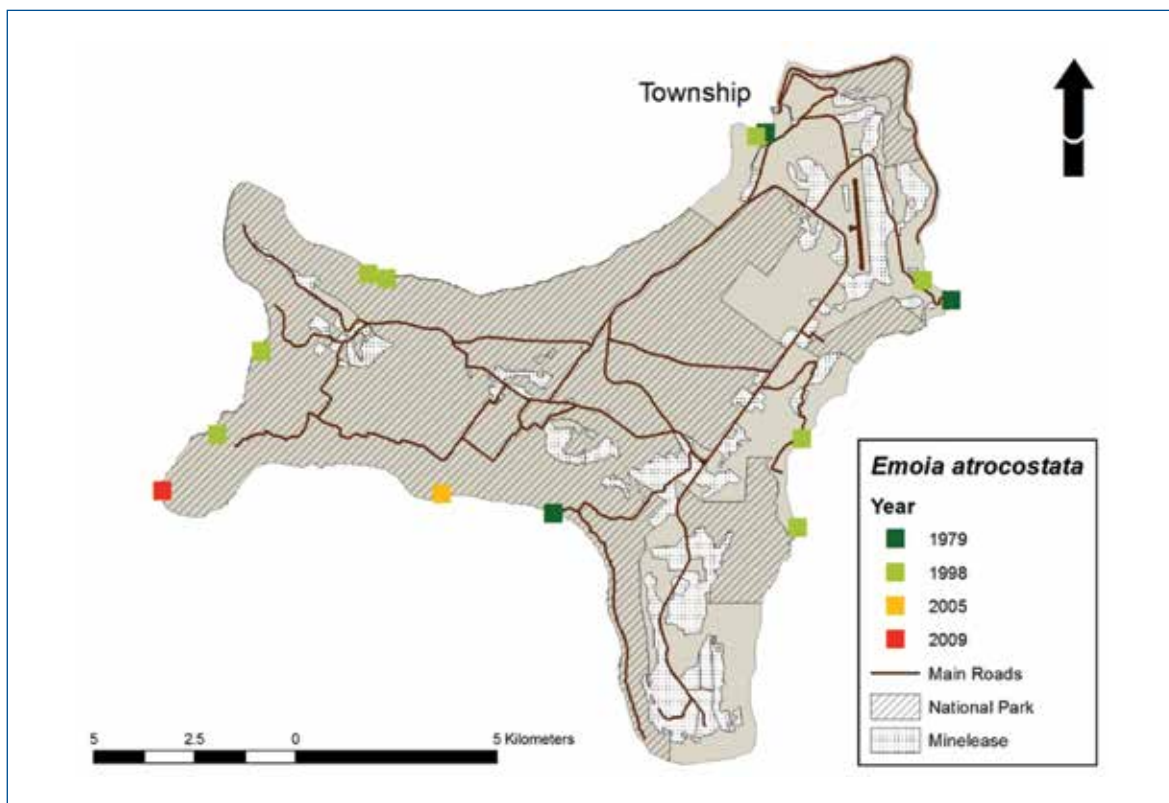
Potential threats include:

- other potential predators such as the black rat and (self-introduced) nankeen kestrel
- exotic reptiles, through competition, predation and/or introduced disease, (though this is unlikely to have been the primary cause of decline)
- supercolonies of crazy ants, through reduction in habitat suitability and/or food availability
- introduction of new diseases or invasive species.

These threats can be considered to be widespread across the island.

Management Actions

- Conduct surveys to determine presence, extent and habitats of any populations found (Action 5.2).
- If a sufficient number of individuals are found, add this species to the captive breeding program (Action 4.1).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Control cats and rats (Action 1.2).
- Investigate the feasibility of reducing the impacts of wolf snakes and centipedes and trial management (Action 3.4).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).



Map 17: Last recorded detections of the coastal skink (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

EPBC Act Listing: Critically Endangered

IUCN listing: Critically Endangered

Existing Conservation Measures

Monitoring through IWS (but insufficiently powerful design to record declines) and dedicated reptile survey (2012 & 2013)

Crazy ant control measures

Distribution

Endemic to Christmas Island. Cogger and Sadler (1981) reported it to be widespread in 1979 (“the most abundant and wide-ranging of the diurnal lizards”). They re-sampled the island in 1998 and “found no evidence that *Emoia nativitatis* had declined in either geographic range or numbers ... although our small sample sizes in 1998 made our estimates of relative abundance very unreliable.” (Cogger & Sadler 2000).

The species has subsequently become far less common and contracted severely in range. A biodiversity monitoring program from 2003 to 2005 sampled 320 sites across the Island for reptiles and reported that the forest skink “has declined severely..... now confined to scattered, localised pockets in remote areas of the coastal terraces and first inland cliff” (DNP 2008b).

Further decline was evident in subsequent targeted searches by Schulz & Barker (2008) who reported it from only one site. The current distribution is considered extremely restricted (DNP 2012e).

The last sighting of the forest skink was in 2010 (Smith et al. 2012). Extensive surveys undertaken in 2012 (including sites where the species had been previously recorded as well as previously unsurveyed areas) did not detect this species (DNP unpub. data 2012).

Map 18 shows forest skink record locations.

Populations

The current population size is uncertain. The species may no longer be extant, based on 2012 and 2013 surveys.

Between 2009 and 2011 three individuals were held in enclosures on Christmas Island but no breeding occurred as all three were female.

Any individual or population found to exist in the wild, and any captive breeding population established, would be considered necessary for the long-term survival of the species.

Habitat

The forest skink “is primarily a forest-clearing species largely restricted to the litter of the forest floor, but will climb about on low vegetation and among the buttress roots of rainforest trees when foraging... this species appears to be as abundant

on the plateau as it is on the terraces and in the low forest backing the rocky coastline” (Cogger & Sadler 1981).

Habitat critical to survival is difficult to determine as it has not been detected in the wild since 2010. If extant, it is likely to include coastal terraces including Egeria Point.

Threats

Threats are not precisely known, however the most likely cause of population decline is predation by one or more exotic species. The most likely predators include the wolf snake, giant centipede and crazy ants. The first two are confirmed as preying on native lizards and their distribution and abundance has increased in correlation with forest skink decline (DNP 2012e). Feral cats may also be implicated in declines, as there is evidence they prey on other native lizards on Christmas Island.

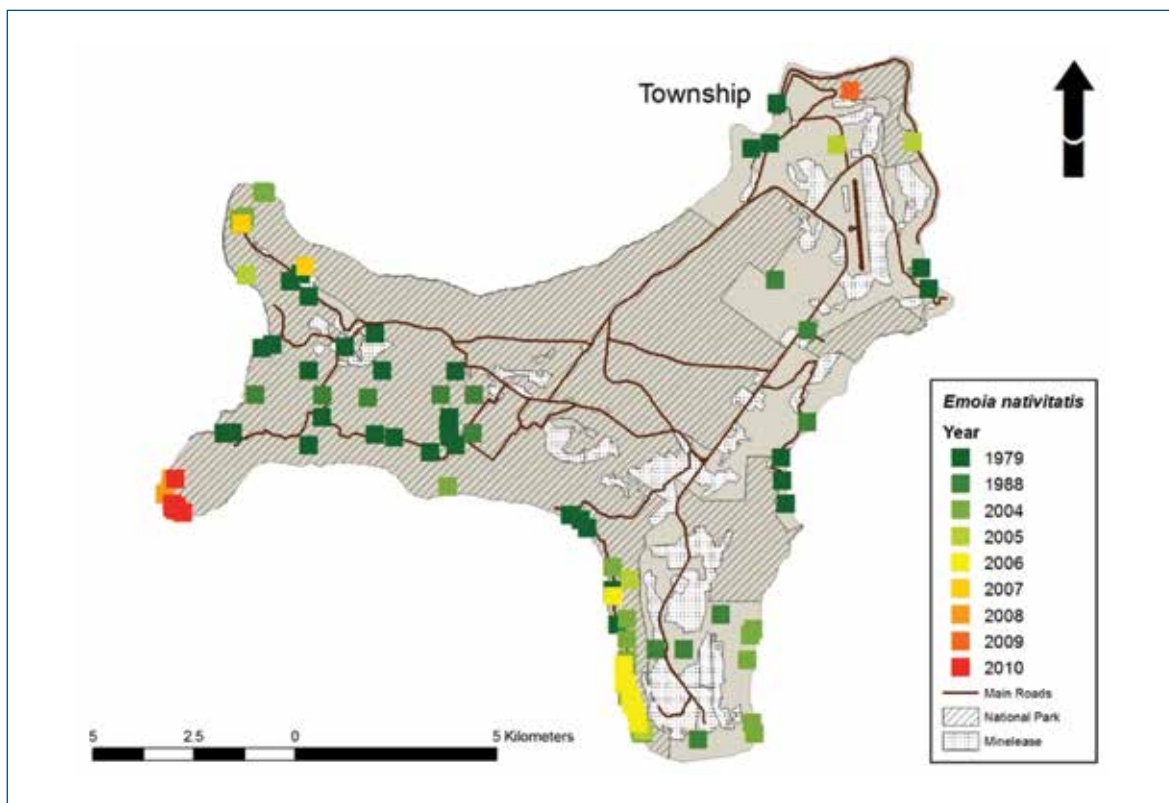
Potential threats include:

- other predators like the black rat and (self-introduced) nankeen kestrel
- exotic reptiles, through competition and/or introduced disease (though unlikely to have been the primary cause of decline)
- supercolonies of crazy ants, through reduction in habitat suitability and/or food availability
- introduction of new diseases or invasive species.

These threats can be considered to be widespread across the island.

Management Actions

- Conduct surveys to determine the presence, and the extent and habitats of any populations found (Action 5.2).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Control cats and rats (Action 1.2).
- Investigate feasibility of reducing the impacts of wolf snakes and centipedes and trial management (Action 3.4).
- Conduct ecological and biological studies to inform recovery (Action 6.2).
- Determine targets and thresholds for management intervention (Action 9.2). If intervention is decided, and a sufficient number of individuals are found, add this species to the captive reptile breeding program (Action 4.1).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Investigate threatening processes including invasive species, pathogens, diseases and parasites (Action 6.1).



Map 18: Last recorded detections of the forest skink (Parks Australia)

Map caveats:

The data on this map represents areas where the species was last detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

EPBC Act listing: Critically Endangered

IUCN listing: Vulnerable

Existing Conservation Measures

Monitoring through IWS (but insufficiently powerful design to record declines)

Specific monitoring program maintained at Egeria Point plus dedicated native reptile survey (2012 and 2013)

Captive breeding population established on and off island

Crazy ant control measures

Previous Recovery Plan

Cogger 2006

Distribution

Endemic to Christmas Island where it is now only known from two small sites. The population may be declining in a southerly direction (Smith et al. 2012). The species was originally widely distributed across the island (Cogger 2005) (Map 19).

Populations

The most recent records were in October 2012 (four individuals at Egeria Point and one individual at North West Point) during extensive surveys undertaken to locate native reptiles (DNP unpub. data 2012).

Since 2009 a captive breeding population has been established in holding cages at Christmas Island and at Taronga Zoo.

All wild and captive populations of this species are regarded as important for its survival.

Habitat

Historically the species was most abundant in evergreen tall closed forest, less abundant on lower terraces and absent from mined areas. It appears to be entirely arboreal, sheltering during the day under the bark of living or dead trees and active at night on tree trunks (Cogger 2006).

However, more recent studies at Egeria Point detected it most frequently within the foliage of *Pandanus* spp. and *Scaevola taccada* in the coastal spray zone and less frequently, on the trunks and branches of *Barringtonia racemosa* and *Terminalia catappa* in the shore terrace forest. Some individuals were captured on large pinnacles/boulders covered with salt damaged vines (few leaves) found on the coastal vegetation/rock margin (DNP 2012f).

Until more populations are detected, evergreen tall closed rainforest on the plateau (Figure 3) and the shore terraces of Egeria Point and North West Point should be regarded as habitat critical to the species' survival.

Threats

No specific threatening processes have yet been proven as the cause of decline. However, invasive species are the most significant threat. The key factors in the decline are the timing, pace and extent, suggesting a newly-arrived predator, disease, or island-wide rapid habitat change (Smith et al. 2012) which may also be exacerbating the impacts of other invasive species.

Likely threats include:

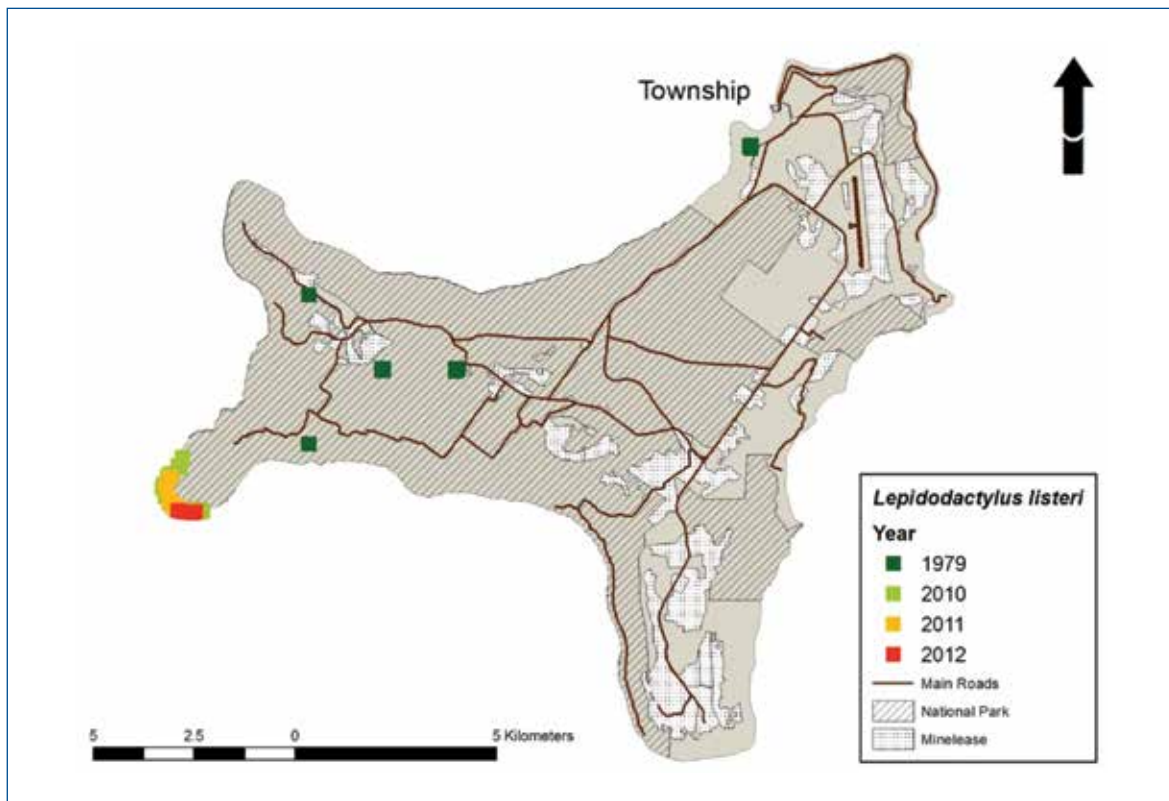
- introduced predators particularly the wolf snake and giant centipede (both confirmed predators of Lister's gecko) as well as crazy ants, black rats and cats
- competition from introduced geckoes
- habitat degradation, particularly from the impacts of crazy ants
- new introduced species and diseases (Hall et al. 2011 found no evidence of current disease threats).

The closely related *L. lugubris* occurs on the Cocos (Keeling) Islands (and many other islands in the region) and may represent a further threat through competition should it colonise the island.

All of these potential threats can be considered to be widespread across the island.

Management Actions

- Continue captive reptile breeding programs, including adaptive release trials such as through the use of enclosures (Action 4.1).
- Monitor the extent and habitats of wild and/or reintroduced captive populations (Action 5.2).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Control cats and rats (Action 1.2).
- Investigate the feasibility of reducing the impacts of wolf snakes and centipedes and trial management (Action 3.4).
- Conduct ecological and biological studies to inform recovery actions (Action 6.2).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Investigate threatening processes including invasive species, pathogens, diseases and parasites (Action 6.1).



Map 19: Last recorded detections of Lister's gecko (Parks Australia)

Map caveats:

The data on this map represents areas where the species was last detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

EPBC Act listing: Vulnerable

IUCN listing: Vulnerable

Existing Conservation Measures

Monitoring through IWS (but detection difficult and insufficiently powerful design to record declines)

Dedicated native reptile survey (2012 and 2013)

Crazy ant control measures

Previous Recovery Plan

Cogger 2006

Distribution

Endemic to Christmas Island. Despite targeted surveys the species was not recorded from 1986 until 2009, when an individual was recorded at the western end of the island at Powell's Hill (Maple et al. 2013). Map 20 shows records for the species which can be located accurately.

Cogger (2005) collated a total of 22 records since settlement, some of which may be misidentifications of the introduced flowerpot snake which is very similar. These records reveal no clear pattern of distribution although it was likely to have originally occurred across the entire island (Cogger 2005).

Populations

The number of populations and total number of remaining individuals are unknown.

The 2009 sighting remains the only recent record. Extensive surveys undertaken in 2012 and 2013 to locate native reptiles (including sites where the species had been previously recorded as well as previously unsurveyed areas) did not detect this species although prevailing dry conditions may have hindered detection in 2012 (DNP unpub. data 2012).

Should any individuals be located, they would be regarded as part of an important population.

Habitat

The few available records suggest the species occurs in evergreen tall closed forest on deeper soils in the island's central plateau where it occupies the sub-surface and litter layer of the forest floor (Cogger 2006).

The 2009 specimen was found in evergreen tall closed forest typical of the central plateau, under a small piece of rotting wood at the periphery of a yellow crazy ant colony and at 361 m altitude, the island's maximum elevation (Maple et al. 2013). The understorey vegetation was *Pandanus elatus* and the dominant canopy was *Inocarpus fagifer* and the emergent *Syzygium nervosum* was also present.

Until knowledge of the population size and ecological requirement of the Christmas Island blind snake is available and understood, all forested parts of the island should be regarded as potential critical habitat. These areas are included in Figure 3 as evergreen tall closed forest and semi-deciduous closed forest.

Threats

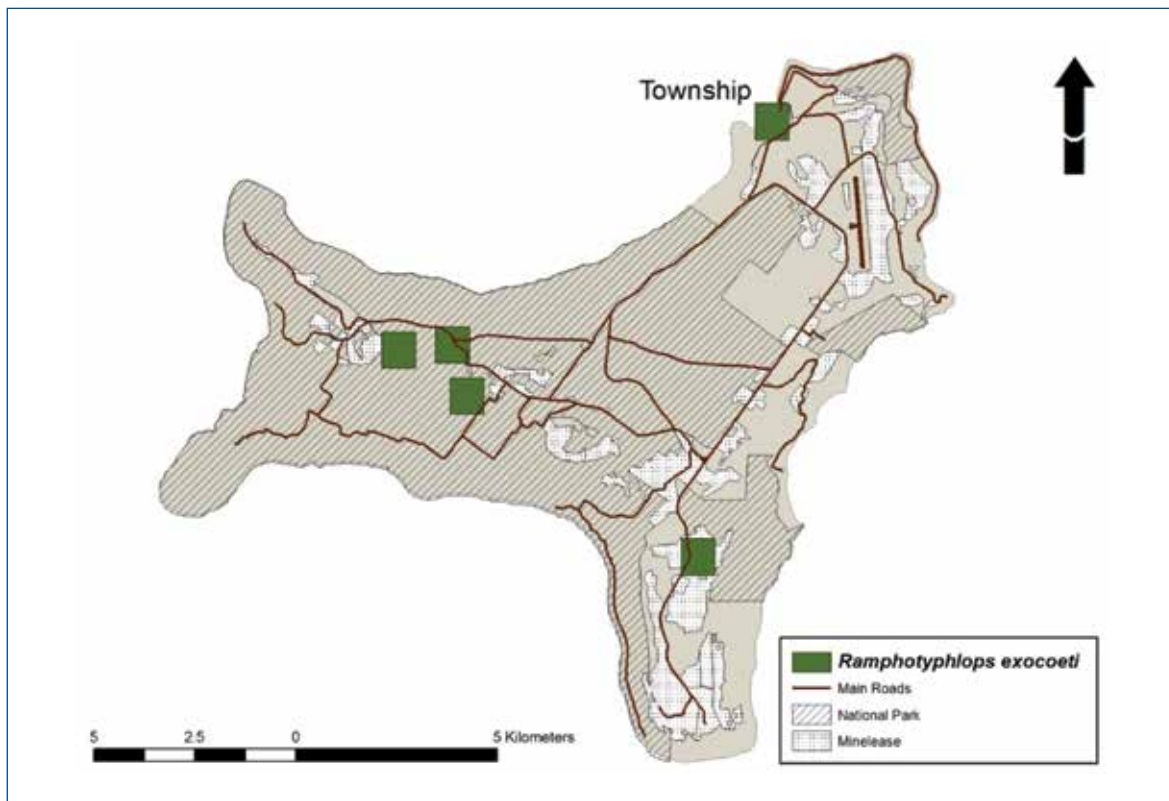
No specific threats have been demonstrated due to lack of ecological studies. Potential threats include:

- introduced predators including the black rat, giant centipede, wolf snake, cats and crazy ants
- impacts of crazy ant supercolonies, including through habitat degradation. This species is known to eat ant larvae but the interactions between the two species are unknown (Cogger 2006). However, the 2009 specimen was found in the presence of crazy ants (Maple et al. 2013). Crazy ants may also deplete prey
- introduction of new diseases or other species, which could further exacerbate existing threats
- competition from the introduced flowerpot snake.

These threats can be considered to be widespread across the island.

Management Actions

- Collect data on opportunistic sightings (Action 5). If individuals are detected, conduct surveys to determine the extent and habitats of populations (Action 5.2) and conduct relevant research (Action 6.2).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Control cats and rats (Action 1.2).
- Assess and manage the impacts of the wolf snake, giant centipede and flowerpot snake (Actions 3.4 and 6.1).
- Improve biosecurity to maintain effective quarantine against the introduction of diseases and invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).



Map 20: Last recorded detections of the Christmas Island blind snake (Parks Australia)

Map caveats:

The data on this map represents areas where the species was last detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Birgus latro**robber crab****Family COENOBITIDAE****Conservation Significance**

Largest terrestrial crustacean in the world

Largest known population in the world inhabits Christmas Island

EPBC Act Listing: none

IUCN listing: Data Deficient

Existing Conservation Measures

The EPBC Regulations apply similar protection measures to robber crabs outside the national park as apply within the national park (other than for limited harvesting for personal consumption in certain circumstances).

The crazy ant control program aids robber crabs as they are threatened by crazy ant supercolonies; strategies are adopted during baiting to reduce potential deaths of robber crabs (Boland et al. 2011).

Monitoring of monthly road mortality provides a basis for education and road management activities to reduce mortality from vehicle impacts.

Distribution

The robber crab is widespread on islands of the Pacific and Indian oceans, where it is also known as the coconut crab, but scarce and secretive on inhabited islands due to extensive hunting for food (Buden 2012).

Christmas Island now represents one of the species' major sanctuaries (Hicks et al. 1990). It remains common and widely distributed across the island. However, population sampling undertaken as part of island-wide monitoring in 2004–06 identified a skewed sex ratio in favour of males and found smaller crabs rare which may have conservation management implications for the species (DNP 2008b).

Populations

There is a single population on Christmas Island which is important for the survival of the species, both on Christmas Island and globally. The size of the Christmas Island population is unknown but may be over 500 000 (Drew pers. comm. 2012) and is one of the largest known worldwide.

Habitat

Christmas Island is an internationally significant habitat for this species where it inhabits a wide range of habitats, including forest areas and sometimes disturbed areas. Robber crabs are omnivorous, feeding on ripening and falling fruits, coconuts, carrion and other crabs; occasionally climbs trees in search of food (Hicks et al. 1990). They moult deep inside burrows (Drew et al. 2010).

As a habitat generalist, all areas of previously uncleared rainforest vegetation can be considered critical habitat.

(Note: No map or additional spatial information of distribution or habitat is available)

Threats

Threats include:

- supercolonies of crazy ants via predation and habitat changes
- Fipronil bait used to control crazy ants (toxic to robber crabs however food lures are used to entice robber crabs away from supercolonies before baiting occurs)
- road traffic mortality
- chemicals used to control rats and cats may also pose a threat
- the introduction of new invasive species which poses a high risk.

These threats are found, or impact, across the island.

Significant mortality due to traffic occurs when visibility is low, during times of rain/wet season, and in the evening and at night, when the crabs are feeding on land crabs killed on the road during the day (Ng & Orchard unpub. data). Surveys showed that at least 854 (in 2010), 667 (in 2011) and 677 (in 2012) robber crabs were killed by vehicles (DNP unpub. data).

Changes to marine habitat e.g. sea temperature, current, may result in sustained mortality of immature stages.

Limited harvesting for food which occurs in restricted areas outside the national park may have a minor impact on numbers (Ng & Orchard unpub. data) but is not currently considered a threat.

Critical knowledge of habitat, ecological role, population demographics and structure for this species is absent. This information is vital in determining the need for and timing of management actions.

Management Actions

- Monitor for presence at The Dales and Hosnies Spring and population trends (Action 5.4).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Reduce impacts on robber crabs from cat and rat baiting (e.g. by elevating baits and using robber crab proof bait stations) (Action 1.2).
- Reduce vehicle impacts on robber crabs including education and awareness raising programs (Action 1.3).
- Improve biosecurity to maintain effective quarantine against the introduction of invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).
- Complete a study of robber crab ecology and population dynamics (Action 6.2) with the aim of identifying:
 - habitat needs and their ecological role
 - population demographics and structures
 - population abundance or trends.

Conservation Significance

Endemic to Christmas Island

Characterises a significant ecosystem

EPBC Act Listing: none

Existing Conservation Measures

The EPBC Regulations apply similar protection measures to blue crabs outside the national park as apply within the national park.

The crazy ant control program aids blue crabs as they are threatened by crazy ant supercolonies.

Distribution

Endemic to Christmas Island. The species was previously confused with *D. hirtipes* which occurs from the northern Indian Ocean to the central Pacific Ocean but was described as distinct in 2012 (Ng & Davie 2012).

The blue crab has a restricted distribution in perennially wet/moist areas and seepages, including The Dales and Hosnies Spring where it is locally common (Hicks et al. 1990) (Map 21).

Populations

There are five known populations of which the largest is located at The Dales; populations at other springs areas of equal importance to the long term viability of the species (Hicks et al. 1990, Turner et al. 2011).

All occurrences of the species, including any future populations found, are important populations, based on its endemic status and its highly restricted occurrence.

Little is known about population dynamics (but see Turner et al. 2011).

Habitat

The blue crab prefers moist areas near freshwater seepages (Hicks et al. 1990) including swampy areas, streams and springs; it burrows in soft earth.

All springs and wetland areas on Christmas Island are considered habitat critical to the survival of the blue crab, in particular those located at The Dales, as well as other wetlands including Hosnies Spring (Figure 4). Blue crabs need freshwater to maintain respiratory function so are restricted to the springs and wetland areas in the drier months. In the wet season there is sufficient moisture in the forests to enable them to range over large areas (Hicks et al. 1990).

Threats

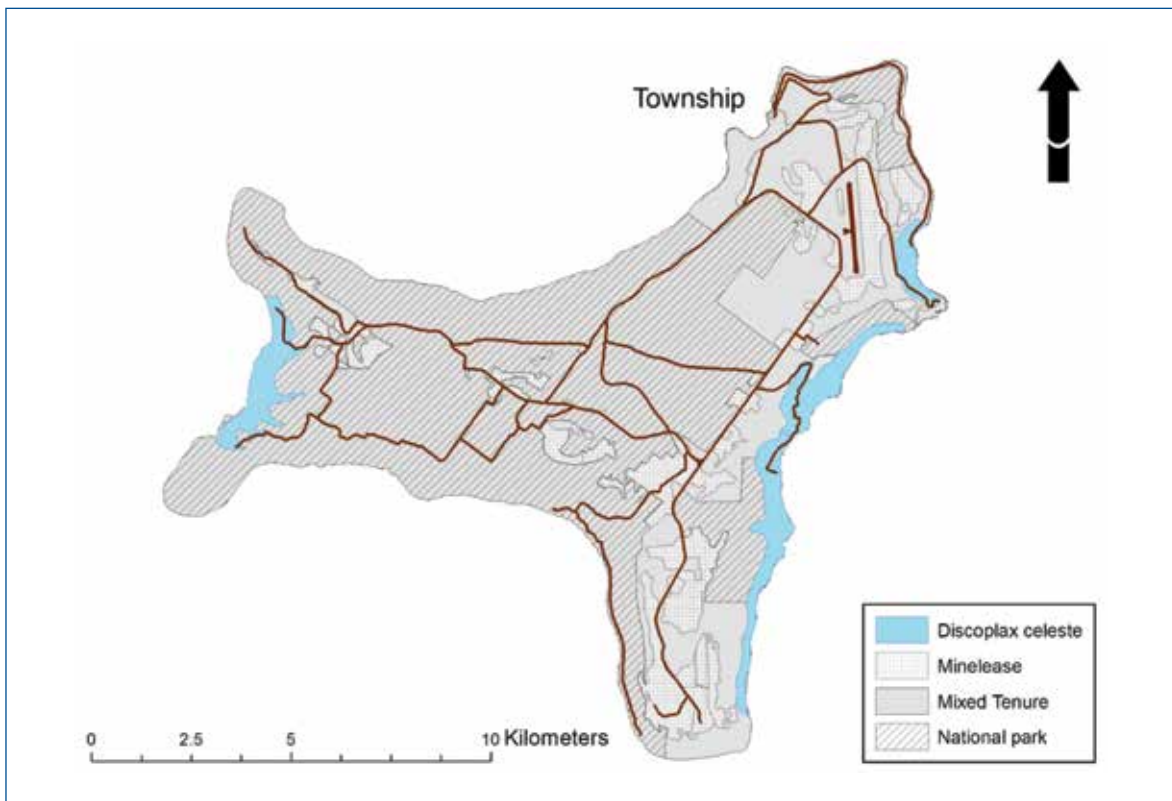
Supercolonies of crazy ants are a threat via predation and habitat changes. The introduction of new invasive species poses a high risk. These threats are found, or impact, across the island.

Loss, diversion and/or decreased water flows at spring sites, for instance due to anthropogenic influences like island water supply, natural variations and/or climate changes is currently a major risk (Ng unpub. data).

Changes to marine habitat e.g. sea temperature, current, may result in sustained mortality of immature stages.

Management Actions

- Monitor for presence at The Dales and Hosnies Spring and population trends (Action 5.4).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Monitor and manage use of subterranean groundwater (Action 3.5).
- Conduct studies of population dynamics and juvenile dispersal (Action 6.2).
- Improve biosecurity to maintain effective quarantine against the introduction of invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).



Map 21: Estimated peak blue crab distribution (wet season) (Parks Australia)

Map caveats:

The data on this map represents areas where the species may or is likely to be detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Conservation Significance

Endemic to Christmas Island

Keystone species for the island's forests

Internationally iconic species with a unique lifecycle/ breeding migration, which characterises the island's natural environment

EPBC Act Listing: none

Existing Conservation Measures

Monitoring through biennial Island Wide Survey (IWS) (burrow counts).

Crazy ant control program largely focused on conservation of red crabs

Roads are managed to protect red crabs from traffic impacts (via installation of crab crossings and use of road closures, as well as through public education activities, including promotion of slower driving speeds).

The EPBC Regulations apply similar protection measures to red crabs outside the national park as apply within the national park.

Distribution

Endemic to Christmas Island, apart from a small population on North Keeling Island where it is very rare and may have been accidentally introduced in the early 1900s (Tweedie 1950).

Widespread across the island (Map 22) and abundant.

Populations

There is a single population on Christmas Island. The original population size is not known but was previously estimated at 120 million (Hicks et al. 1990). A major population reduction occurred following the establishment of crazy ant supercolonies. The 2011 IWS results suggest a population (based on burrow counts) of about 45 million. However, small crabs (e.g. 3–4 years of age) will not have burrowed so this may underestimate actual population size.

Population sampling undertaken as part of island-wide monitoring in 2004–06 identified a skewed sex ratio in favour of males which may have conservation management implications for the species (DNP 2008b). Returns from the sea, and the implications on the age-structure and recruitment, have not been investigated in detail.

The single genetic population on Christmas Island has no apparent spatial genetic structure or restricted gene flow between sampled locations. Further, red crabs from North Keeling Island are not genetically distinct and are likely to be recent immigrants from Christmas Island.

The effective population size has likely remained large and stable on Christmas Island throughout its evolutionary history with relatively moderate to high levels of genetic diversity.

The single population is important for the survival of the species.

Habitat

Adult red crabs are fully terrestrial but depend on the sea for breeding. Red crabs live in burrows and karst areas in forest and shaded areas, with highest densities in evergreen tall closed forest (Hicks et al. 1990).

Habitat critical to survival occurs across the whole island (except for areas of land devoid of vegetation and/or soil such as bare mine fields and houses/buildings) and particularly includes previously uncleared rainforest vegetation. However, crabs may migrate through areas such as roads (but not generally open areas like cleared mine fields) during their annual breeding migration.

Red crabs are considered to have a major role in the ecological functioning of the island's forests. Red crabs are omnivorous, and a main portion of their diet is fruits, seeds, and seedlings as well as leaf litter. Crabs also prey on the invasive giant African land snail. Where red crabs have been removed by crazy ants there has been a significant impact on the forest ecology.

Threats

Supercolonies of crazy ants across the island pose the primary and most significant threat, as red crabs do not survive near supercolonies (O'Dowd et al. 1999, 2003). Although baiting crazy ants with Fipronil may affect red crabs, only the supercolonies are baited so this threat is minimal.

During the breeding migration, significant mortality due to traffic may occur on roads which are open and have no crab barriers.

Climate change may impact on the species through favouring conditions for crazy ants.

The introduction of new invasive species poses a high risk.

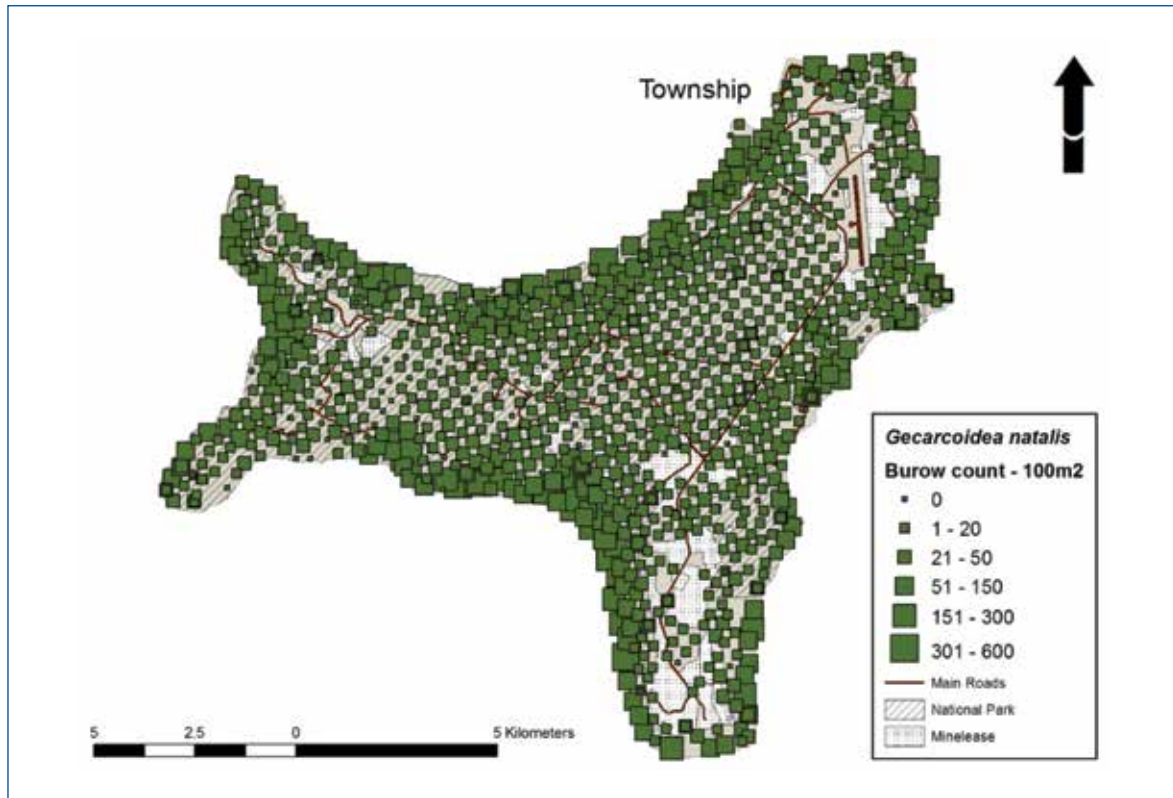
Habitat loss and clearing, especially previously uncleared rainforest vegetation, could also impact on population size.

Crabs may also be vulnerable during their at-sea life cycle (e.g. due to changing sea swell conditions, currents, temperature) which may affect the return of crabs.

Management Actions

- Reduce vehicle impacts on red crabs, for example through education and awareness raising programs (Action 1.3).
- Control and reduce the impacts of crazy ants including reducing off-target baiting impacts and by investigating alternative control methods, particularly biological control and lower off-target baits and baiting methods (Action 1.1).
- Monitor burrow abundance and distribution trends, and presence at wetlands (Actions 5.1 and 5.2).
- Reduce impacts from cat and rat baiting, such as by elevating baits and using red crab proof bait stations (Action 1.2).

- Investigate migration patterns including at sea life cycles and returns (Action 6.2).
- Monitor the annual red crab migration (Action 5.3).
- Trial the re-establishment of red crabs (Action 4.4).
- Rehabilitate previously mined areas (Action 3.3).
- Improve biosecurity to maintain effective quarantine against the introduction of invasive species. This includes rapidly controlling pests that may enter and assessing the risk of threat (Action 2).



Map 22: Red crab burrow density 2011 (Parks Australia)

Map caveats:

The data on this map represents areas where the species has been detected but does not represent all areas where the species may exist and the map cannot be used for population estimate purposes.

Page no.	Image credits
Front cover	Red crab eating. Photo credit: Parks Australia
xiv	Rainforest is the dominant vegetation type on Christmas Island. Photo credit: Parks Australia
12	Each year, most of Christmas Island's adult red crabs spawn (lay their eggs) in the sea. On the years when ocean conditions are favourable, there is a spectacular return migration as the young crabs make their way from the ocean to the forests. Photo credit: Parks Australia, Caitlyn Pink
16	Hugh's Dale waterfall is spring fed and flows all year round. The Dales—a series of seven picturesque watercourses on the western coastline—is listed as a Wetland of International Importance under the Ramsar Convention. Photo credit: Christmas Island Tourism Association
21	The tall evergreen rainforest on Christmas Island provides habitat for species such as the Abbott's booby and the flying fox which are both found nowhere else in the world. Photo credit: Parks Australia
29	The tall evergreen rainforest on Christmas Island is the last remaining nesting habitat for the Abbott's booby. Photo credit: Parks Australia
33	Christmas Island is home to tens of millions of red crabs. Their annual migration to the sea—usually between November and January—coincides with the beginning of the monsoon rains and the correct phase of the moon. Photo credit: Parks Australia, Samantha Flakus
36	Yellow crazy ants are a major threat to Christmas Island's biodiversity, and are a particular problem for red crabs. The national park has used recurring aerial baiting to keep ant super colonies at bay. As a long term solution, the park is working with LaTrobe University to explore the potential to control the ants via indirect biological control of scale insects (a major food source for the ants). Photo credit: Parks Australia
49	The whole Christmas Island community works together to protect migrating red crabs from vehicle traffic. Crossings like this crab bridge help keep crabs safe as they march across the island, including over roads. Other protection measures include road underpasses and temporary road closures. Photo credit: Parks Australia
51	When the red crabs begin their annual migration, nothing stops them—least of all roads! Specially designed underpasses channel the marching crabs away from the wheels of passing traffic. Photo credit: Parks Australia
56	Every two years, staff from Christmas Island National Park conduct an island-wide biodiversity survey. The aim is to gauge the health of the island's ecosystems, by estimating red crab populations and the area of crazy ant super-colonies. The survey also collects data on the status of other native and invasive species. Photo credit: Parks Australia
58	Robber crabs are the largest living land crab in the world. They are extremely slow-growing and research suggests that they can live to more than 70 years old. Christmas Island provides habitat for one the largest remaining populations of robber crabs in the world. Photo credit: Parks Australia
Back cover	Red crab. Photo credit: Parks Australia

