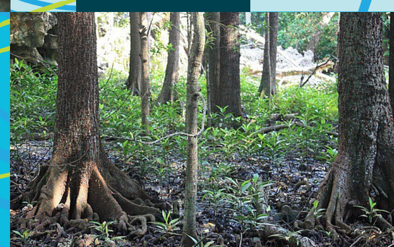
Australian Government

Department of Sustainability, Environment, Water, Population and Communities



# Hosnies Spring
## Ramsar Site

## Ecological Character Description

Image credits: D. Simon, C. Totterdell & Parks Australia, M. Orchard & DSEWPaC, D.Simon

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- Parks Australia, Planning, Tourism and National Landscapes Section
- Parks Australia, Christmas Island National Park
- Water Reform Division, Wetlands Section



This document was prepared in accordance with the DSEWPaC style guideline.

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# Glossary

Definitions of words associated with ecological character descriptions (DEWHA 2008 and references cited within).

| | |
|---|---|
| **Benefits** | benefits/services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems (Ramsar Convention 2005, Resolution IX.1 Annex A).<br>See also “Ecosystem Services”. |
| **Biogeographic region** | a scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc (Ramsar Convention 2005). |
| **Biological diversity** | the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes. This definition is largely based on the one contained in Article 2 of the Convention on Biological Diversity (Ramsar Convention 2005). |
| **Change in ecological character** | is defined as the human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention 2005, Resolution IX.1 Annex A). |
| **Community** | an assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (ANZECC and ARMCANZ 2000). |
| **Community Composition** | all the types of taxa present in a community (ANZECC and ARMCANZ 2000). |
| **Conceptual model** | wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (Gross 2003) |
| **Contracting Parties** | are countries that are Member States to the Ramsar Convention on Wetlands; 159 as at March 2010. Membership in the Convention is open to all states that are members of the United Nations, one of the UN specialized agencies, or the International Atomic Energy Agency, or is a Party to the Statute of the International Court of Justice |
| **Critical stage** | stage of the life cycle of wetland-dependent species. Critical stages being those activities (breeding, migration stopovers, moulting etc.) which if interrupted or prevented from occurring may threaten long-term conservation of the species. (Ramsar Convention 2005). |
| **Ecological character** | is the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time. |
| **Ecosystems** | the complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services). (Millennium Ecosystem Assessment 2005). |
| **Ecosystem components** | include the physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes) (Millennium Ecosystem Assessment 2005). |

| | |
|---|---|
| **Ecosystem processes** | are the changes or reactions which occur naturally within wetland systems. They may be physical, chemical or biological. (Ramsar Convention 1996, Resolution VI.1 Annex A). They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment, that result in existing ecosystems and bring about changes in ecosystems over time (Australian Heritage Commission 2002) |
| **Ecosystem services** | are the benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (e.g. food & water), regulating (e.g. flood control), cultural (e.g. spiritual, recreational), and supporting (e.g. nutrient cycling, ecological value). (Millennium Ecosystem Assessment 2005).<br>See also “Benefits”. |
| **Essential elements** | a component or process that has an essential influence on the critical components, processes or services (CPS) of the wetland. Should the essential element cease, reduce, or is lost, it would result in a detrimental impact on one or more critical CPS. Critical CPS may depend in part or fully on essential elements, but an essential element is not in itself critical for defining the ecological character of the site. |
| **Fluvial geomorphology** | the study of water-shaped landforms (DEWHA 2008). |
| **Indigenous species** | a species that originates and occurs naturally in a particular country (Ramsar Convention 2005). |
| **Limits of Acceptable Change** | the variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the criteria for which the site was Ramsar listed’ (modified from definition adopted by Phillips 2006). |
| **List of Wetlands of International Importance ("the Ramsar List")** | the list of wetlands which have been designated by the Ramsar Contracting Party in which they reside as internationally important, according to one or more of the criteria that have been adopted by the Conference of the Parties. |
| **Ramsar** | city in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Convention's short title, "Ramsar Convention on Wetlands". |
| **Ramsar Criteria** | Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values. |
| **Ramsar Convention** | Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names "Convention on Wetlands (Ramsar, Iran, 1971)" or "Ramsar Convention" are more commonly used. |
| **Ramsar Information Sheet (RIS)** | the form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed. |
| **Ramsar List** | the List of Wetlands of International Importance. |
| **Ramsar Sites** | wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria. |

| | |
|---|---|
| **Waterbirds** | "birds ecologically dependent on wetlands" (Article 1.2). This definition thus includes any wetland bird species. However, at the broad level of taxonomic order, it includes especially:<br>• penguins: *Sphenisciformes*.<br>• divers: *Gaviiformes*;<br>• grebes: *Podicipediformes*;<br>• wetland related pelicans, cormorants, darters and allies: *Pelecaniformes*;<br>• herons, bitterns, storks, ibises and spoonbills: *Ciconiiformes*;<br>• flamingos: *Phoenicopteriformes*:<br>• screamers, swans, geese and ducks (wildfowl): *Anseriforme*s;<br>• wetland related raptors: *Accipitriformes* and *Falconiformes*;<br>• wetland related cranes, rails and allies: *Gruiformes*;<br>• Hoatzin: *Opisthocomiformes*;<br>• wetland related jacanas, waders (or shorebirds), gulls, skimmers and terns: *Charadriiformes;*<br>• coucals*: Cuculiformes;* and<br>• wetland related owls: *Strigiformes*. |
| **Wetlands** | are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention 1987). |
| **Wetland types** | as defined by the Ramsar Convention's wetland classification system [http://www.ramsar.org/ris/key_ris.htm#type]. |

# List of Abbreviations

| | |
|---|---|
| **CAMBA** | China Australia Migratory Bird Agreement |
| **CEPA** | Communication, Education, Participation and Awareness |
| **CMS** | Bonn Convention on Migratory Species |
| **CPS** | Components, Processes and Services |
| **DEWHA** | Department of the Environment, Water, Heritage and the Arts (Commonwealth) |
| **DSEWPaC** | Department of Sustainability, Environment, Water, Population and Communities (formerly DEWHA) |
| **ECD** | Ecological Character Description |
| **EPBC Act** | Environment Protection and Biodiversity Conservation Act, 1999 (Commonwealth) |
| **IUCN** | International Union for Conservation of Nature |
| **JAMBA** | Japan Australia Migratory Bird Agreement |
| **LAC** | Limits of Acceptable Change |
| **ROKAMBA** | Republic of Korea Australia Migratory Bird Agreement |

# Executive Summary

Hosnies Spring Ramsar site is located on the eastern side of Christmas Island in the Indian Ocean approximately 2800 kilometres west of Darwin, Australia and 900 kilometres northeast of the Cocos Islands. The site is located within the Christmas Island National Park in the east of Christmas Island (Figure E1). At the time of listing (1990) Hosnies Spring comprised less than one hectare of freshwater spring. In 2010 the boundary of Hosnies Spring was expanded from 0.33 hectares to 202 hectares. This extension increased the boundary of the Ramsar site to match that of the national park boundary on the eastern side of Christmas Island.

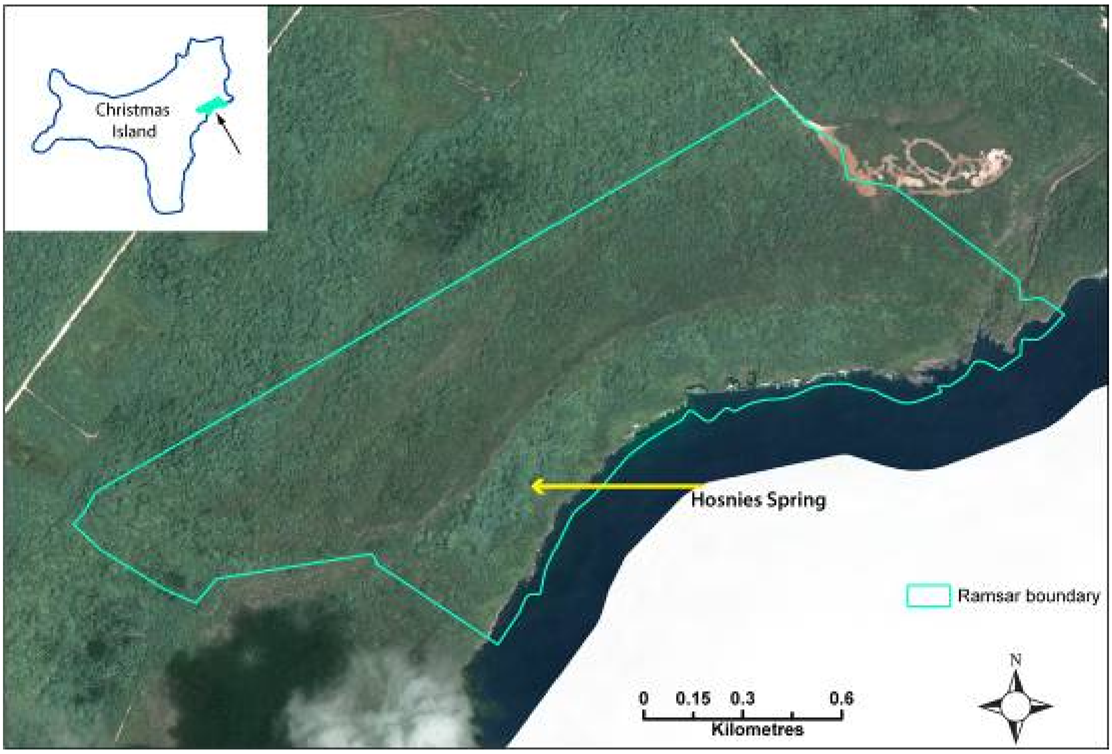



**Figure E1: Location of Hosnies Spring Ramsar Site. Green polygon shows the 2010 boundary; arrow indicates the approximate location of the spring (data supplied by DSEWPaC).**

Hosnies Spring Ramsar site meets the following three Ramsar listing criteria:

**Criterion 1:** Christmas Island represents the only land mass within the bioregion and the wetlands associated with Hosnies Spring, particularly the spring system and mangrove stand are unique in a bioregional (and in fact broader) context.

**Criterion 3:** The mangrove forest present at the site is unique within the bioregion and possibly worldwide. The stand comprises of two species; *Bruguiera gymnorhiza* and *B. sexangula*, both of which usually occur in intertidal zones. However, at Hosnies Spring the trees are located at the spring some 120 metres inland and 37 metres above sea level. It is thought that the stand is a relict of times when the site was inundated by the sea more than 120 000 years ago (Woodroffe 1988).

**Criterion 4:** The site is important for the blue crab (*Discoplax (Cardisoma) hirtipes*), which is reliant on the freshwater provided by the spring to maintain respiratory function (Hicks et al. 1984). The spring is one of the few permanent sources of freshwater on Christmas Island and acts as a dry season refuge for a number of terrestrial species. In addition, the site provides a connection from the plateau to the ocean and as such is a likely migratory route for endemic red crab (*Gecarcoidea natalis*) during breeding migrations.

A summary of the components and processes of the Hosnies Spring Ramsar site is provided in Table E1. This includes those that are considered critical to the ecological character of the site, as well as a number of components and processes that were considered essential elements of the sites character, but not necessarily critical. Critical components and processes and essential elements were selected on the basis of their role in maintaining the ecological character of the site, the ecosystem services they support (Table E2) and the Ramsar criteria for which the site is listed.

**Table E1: Summary of components and processes important for maintaining the ecological character of the Hosnies Spring Ramsar site.**

| Component / process | Description |
|---|---|
| **Essential elements** | |
| Climate | • Warm tropical climatic zone.<br>• High rainfall (2000 millimetres per year); warm to hot year round. |
| Geomorphic setting | • Site is located within the shore terrace on an area of gravel overlying phosphoric soils.<br>• Spring is situated at the base of the inland cliffs where spring water flows over a limestone flowstone. |
| Water quality | • Limited information (two snap shot surveys only).<br>• Typical of limestone karst systems with alkaline conditions and relatively high concentrations of calcium.<br>• Trace elements and metals are all low.<br>• Nitrogen is predominantly in the form of nitrate.<br>• High concentrations of sulphate result in a sulphurous odour. |
| **Critical components and processes** | |
| Hydrological regime | • Groundwater dominant.<br>• Source for Hosnies Spring in a perched, unconfined aquifer that discharges where impermeable volcanic rocks are close to the surface.<br>• Flow rate is not known, but expected to be low.<br>• Spring is perennial. |
| Mangroves | • Stand of mangroves from the genus *Bruguiera* covers the majority of the wetland.<br>• Comprises a range of age classes with evidence of active regeneration.<br>• A number of very large trees (large than typical for the species), with the largest tree measuring 82 centimetres diameter at breast height and exceeding 40 metres.<br>• Between 300 and 600 trees in total (more than 2.5 centimetres diameter at breast height) and a density of between 10 and 20 trees per 100 metres square. |
| Land Crabs | • Supports large populations of at least three species:<br>  • Red crabs (*Gecarcoidea natalis*);<br>  • Robber crabs (*Birgus latro*); and<br>  • Blue crabs (*Discoplax hirtipes*) |

**Table E2: Summary of the benefits and services of the Hosnies Spring Ramsar site (critical services have been shaded).**

| Category | Description |
|---|---|
| **Cultural services** | |
| Recreation and tourism | While the site is open to the public, tourism is not promoted at the site. Rather, the site is managed to provide a limited number of visitors an opportunity to visit a unique wetland that is largely undisturbed by humans. |
| Scientific and educational | The unique nature of the site and the pristine condition, provide excellent opportunities for research. |
| **Supporting services** | |
| Supports near-natural wetland types | The spring at the Ramsar site is in near-natural condition and significant within the bioregion. It is the only area on Christmas Island that supports freshwater mangroves. |
| Biodiversity | Supports a variety of wetland species, communities and habitats including marine, terrestrial and freshwater dependent species. |
| Food webs | Interactions between land crabs and mangroves form an important food web at the site. |
| Distinct wetland species | Blue crabs are reliant on the few permanent freshwater sites on Christmas Island (including Hosnies Spring) for reproduction, and for survival in the dry season. |
| Ecological connectivity | Red crabs migrate from the plateau to the ocean to breed each year. |

"Limits of acceptable change" (LAC) is the terminology used to describe complex judgements as to the extent key aspects of the ecology of the site can vary without representing a change in the ecological character. LAC for the Hosnies Spring Ramsar site have been proposed for critical components, processes and benefits and services and are summarised in Table E3.

**Table E3: Proposed Limits of Acceptable Change for the Hosnies Spring Ramsar site.**

| Component/Process Benefit / Service | Limit of Acceptable Change |
|---|---|
| **Component:** Hydrology<br>**Service**: Near natural wetland types | *No loss of permanence of the spring and extent of surface water to remain greater than 0.3 hectares.* |
| **Component:** Mangroves<br>**Services:** Near natural wetland types; Biodiversity | • *Tree density (trees greater than 2.5 centimetres diameter at breast height) to be at least 10 trees per 100 metres square.*<br>• *Seedlings and saplings present as indicators of active regeneration.* |
| **Component:** Land crabs<br>**Service:** Food webs; Distinct wetland species; Biodiversity | • *Blue crabs present at the site during the dry season.*<br>• *Red crabs and robber crabs present at the site for at least part of their lifecycle.* |

There are a number of potential and actual threats that may impact on the ecological character of Hosnies Spring Ramsar site. A stressor model shows the interactions between threats and critical components, processes and service (Figure E2) and a description of each threat is provided in Table E4.

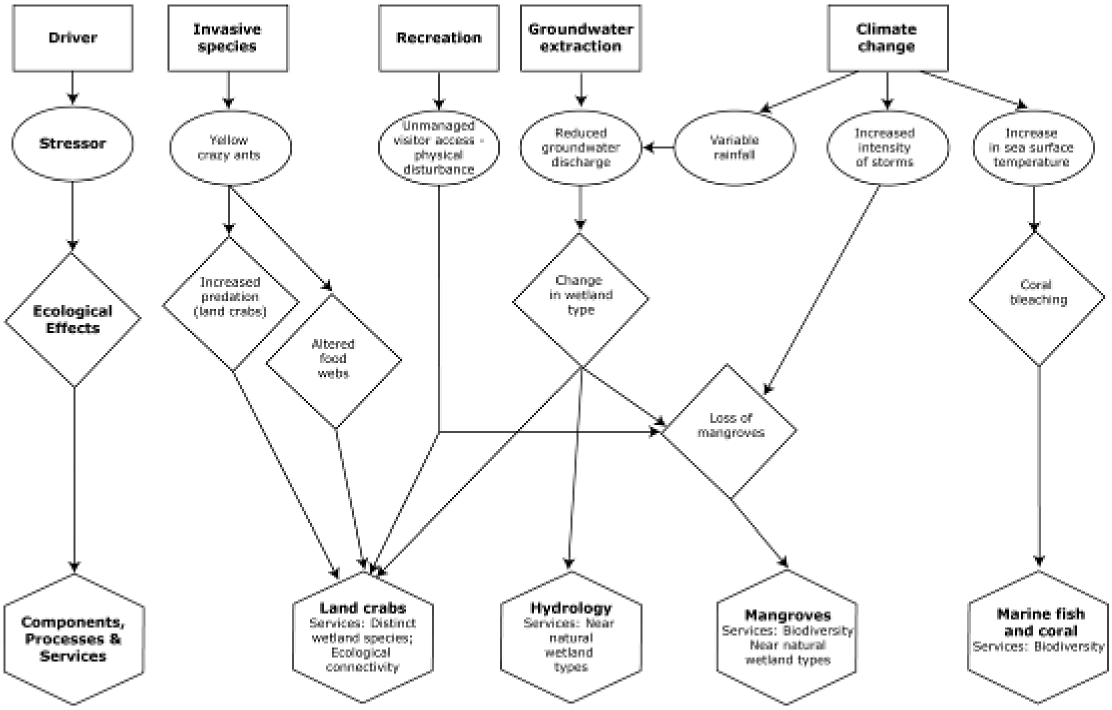



**Figure E2: Stressor conceptual model of the threats to Hosnies Spring Ramsar site.**

**Table E4: Summary of threats to the ecological character of the Ramsar site.**

| Actual or likely threat | Potential impact(s) to wetland components, processes and/or service | Likelihood | Timing |
|---|---|---|---|
| Groundwater extraction | Decrease in flow and loss of permanent surface water. This would result in a loss of mangroves and blue crabs. | Medium | Current |
| Invasive species: yellow crazy ants | Predation on crabs, resulting in alteration to the forest ecosystems and consequent increase in other invasive species. | Certain | Current |
| Climate change – reduced rainfall | Reduced recharge of aquifer and loss of freshwater. Corresponding loss of habitat for mangroves and blue crabs. | Medium | Medium to long term |
| Climate change – increased storms | Direct physical damage to mangroves, potential loss of entire stand. | Medium | Medium to long term |

There is no evidence that there has been any change to the hydrology, geomorphology or biota at Hosnies Spring since listing. The threats of groundwater extraction and yellow crazy ants were present at the time of listing and there is no evidence that there have been significant changes since. The expansion of the site represents a positive change in the ecological character of the site. However, the ecological character of the expanded site boundary, particularly marine area remains a significant knowledge gap.

Knowledge gaps have been identified (Table E5) and monitoring to address knowledge gaps and assess against LAC are recommended (Table E6).

**Table E5: Knowledge gaps relevant to the ecological character of the Ramsar site.**

| Component / process | Knowledge Gap | Recommended Action |
|---|---|---|
| Hydrology | Flow rates at the spring including seasonal variability.<br>Extent and duration of inundation at the site. | • Monitor flow rates at the spring on a monthly basis.<br>• Measure the extent and depth of inundation in wet and dry season. |
| | Connectivity between groundwater source for Hosnies Spring and the groundwater resources used for human consumption. | • Ongoing groundwater monitoring and investigations. An assessment of the sustainable extraction volumes from groundwater. |
| Mangroves | Changes in community composition, size classes and regeneration since the initial survey of Woodroffe in 1988. | • Repeat survey of mangrove extent, size classes and regeneration every 5 to 10 years. |
| Land crabs | Quantitative information on crab densities and the importance of the site for different crab species (including breeding migrations). | Survey of crab burrow density within the Ramsar site. |
| Waterbirds | The importance of the expanded site for waterbird species – breeding in terrestrial forest, or on sea cliffs; feeding in the marine areas. | Surveys of waterbirds within the Ramsar site, including the sea cliffs. |
| Marine environment | Complete knowledge gap, there is no site specific information on any marine features in the site, including the number of species, types of habitat and any special ecological features. | Surveys of marine habitat and fauna, within the Ramsar site boundary. |
| Site use | Quantitative information on visitors to the site and the impact they may be having to the Spring portion of the Ramsar site. | Assessment of visitor numbers. |

**Table E6: Recommended monitoring for the Hosnies Spring Ramsar site.**

| Component/ Process | Purpose | Indicator | Locations | Frequency | Priority |
|---|---|---|---|---|---|
| Hydrology | Set baseline | Flow | Hosnies Spring | Monthly | High |
| | Set baseline | Extent and duration of inundation | Hosnies Spring | Seasonally | High |
| Vegetation - mangroves | Establishment of variability detection of change, refinement of LAC | Species composition, size classes, tree density (as per methods of Woodroffe 1988) | Hosnies Spring | Every five to ten years | High |
| Land crabs | Establishment of variability detection of change, refinement of LAC | Crab burrow density – blue crab | Hosnies Spring | Every two years | Medium |
| | Establishment of variability detection of change, assessment of threats (yellow crazy ants) refinement of LAC | Crab burrow density – red crabs | Entire (expanded) Ramsar site | Every two years | Medium |
| Yellow crazy ants | Assessment of threat | Super colony presence and location | Entire (expanded) Ramsar site | Every two years | High |
| Marine environment | Establishment of baseline, informing the development of LAC, detection of change | Benthic habitat, fish and invertebrate diversity and abundance | Marine portion of the site | Every two to five years | Medium |
| Waterbirds (including sea birds) | Establishment of baseline | Survey of habitats: spring, terrestrial forest, sea cliffs | Entire (expanded) Ramsar site | Every two to five years | Low |

# 1. Introduction

## 1.1 Site details

Hosnies Spring Ramsar site comprises a freshwater spring surrounding terrestrial vegetation and a small portion of coast including coral reef in the Christmas Island National Park in the Australian territory of Christmas Island. The site is located approximately 2600 kilometres northwest of Perth in the Indian Ocean. It was nominated and designated as a "Wetland of International Importance" under the Ramsar Convention in 1990. At that time, the site encompassed just the area of spring itself and comprised less than one hectare. In 2010 the boundary of Hosnies Spring was expanded from 0.33 hectares to 202 hectares. This extension increased the boundary of the Ramsar site to match that of the national park boundary on the eastern side of Christmas Island. This additional area around the original 0.33 hectares gives greater protection to the unique and ancient freshwater mangrove stand This ECD describes the core site, as listed at 1990, and the expanded site as of 2010. For clarity, this document uses the term "Hosnies Spring" to indicate the 0.33 hectare spring, and "Hosnies Spring Ramsar site" to indicate the entire 202 hectare Ramsar boundary. Site details for this Ramsar wetland are provided in Table 1.

**Table 1: Site details for the Hosnies Spring Ramsar site taken from the Ramsar Information Sheet (1999).**

| | |
|---|---|
| Site name | Hosnies Spring |
| Location in coordinates | Latitude: 10° 28' S<br>Longitude: 105° 41' E |
| General location of the site | Hosnies Spring Ramsar site is located in the Australian Territory of Christmas Island in the Indian Ocean. The site is 2800 kilometres west of Darwin (Northern Territory) and 2600 kilometres northwest of Perth (Western Australia); within the Christmas Island National Park. Christmas Island Province (IMCRA v4 Commonwealth of Australia 2006). |
| Area | Less than one hectare at time of listing; expanded to 202 hectares in 2010. |
| Date of Ramsar site designation | Designated on 11 December 1990 |
| Ramsar criteria met by wetland | Ramsar criteria 1, 3, 4 |
| Management authority for the site | Hosnies Spring is situated in the Australian External Territory of Christmas Island, which is under the jurisdiction of the Commonwealth of Australia. The site is located wholly within the Christmas Island National Park, which is managed by Parks Australia. |
| Date the ECD applies | 1990 for original area and 2010 for expanded site boundary. |
| Status of description | This represents the first ECD for the site. |
| Date of compilation | May 2010 |
| Name(s) of compiler(s) | Jennifer Hale and Rhonda Butcher on behalf of the Australian Government Department of Sustainability, Environment, Water, Population and Communities. |
| References to the Ramsar Information Sheet (RIS) | Hosnies Spring Ramsar Site RIS compiled by Parks Australia in 1998. Updated by Jennifer Hale on behalf of Australian Government Department of Sustainability, Environment, Water, Population and Communities in 2010. |
| References to management plan(s) | Christmas Island National Park Management Plan, Director of National Parks, 2002. |

## 1.2 Statement of purpose

The act of designating a wetland as a Ramsar site carries with it certain obligations, including managing the site to retain its 'ecological character' and to have procedures in place to detect if any threatening processes are likely to, or have altered the 'ecological character'. Thus, understanding and describing the 'ecological character' of a Ramsar site is a fundamental management tool for signatories and local site managers which should form the baseline or benchmark for management planning and action, including site monitoring to detect negative impacts.

The Ramsar Convention has defined "ecological character" and "change in ecological character" as (Ramsar 2005):

"Ecological character is the combination of the ecosystem components, processes and benefits/services that characterise the wetlands at a given point in time"

And

"…change in ecological character is the human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/service."

In order to detect change it is necessary to establish a benchmark for management and planning purposes. Ecological character descriptions (ECD) form the foundation on which a site management plan and associated monitoring and evaluation activities are based. The legal framework for ensuring the ecological character of all Australian Ramsar sites is maintained is the *Environment Protection and Biodiversity Conservation Act, 1999* (the EPBC Act) (Figure 1). A Ramsar Information Sheet is prepared at the time of designation. However whilst there is some link between the data used for listing a site (based on the various criteria) the information in an RIS does not provide sufficient detail on the interactions between ecological components, processes and functions to constitute a comprehensive description of ecological character. To assist in the management of Ramsar sites in the face of insufficient detail, the Australian and state/territory governments have developed a *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands. Module 2 of Australian National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia* (DEWHA 2008).

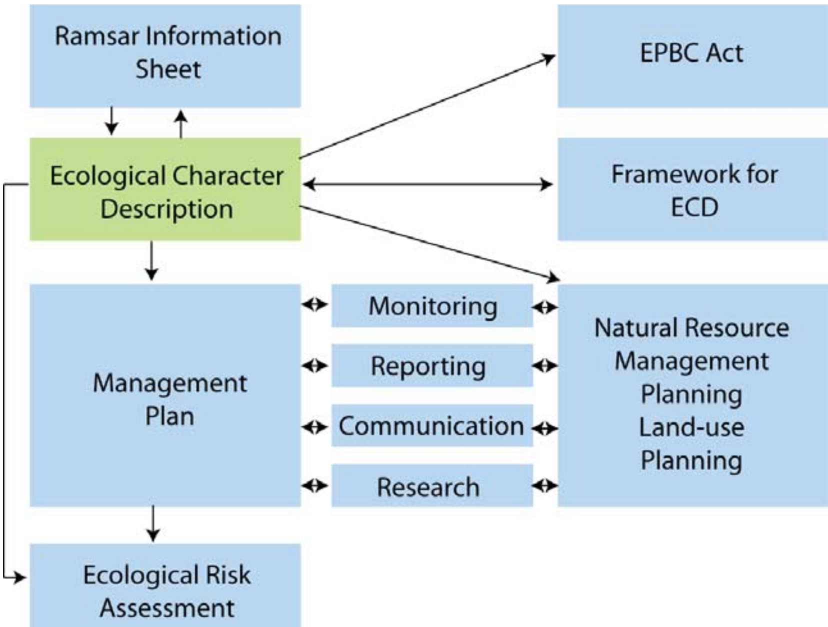



**Figure 1: The ecological character description in the context of other requirements for the management of Ramsar sites (adapted from DEWHA 2008).**

The framework emphasises the importance of describing and quantifying the ecosystem components, processes and benefits/services of the wetland and the relationship between them. It is also important that information is provided on the benchmarks or ecologically significant limits of acceptable change that would indicate when the ecological character has or is likely to change.

McGrath (2006) detailed the general aims of an ECD as follows:

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing Wetlands of International Importance) of the *Environment Protection and Biodiversity Conservation Regulations* 2000 (Commonwealth):
    a) To describe and maintain the ecological character of declared Ramsar wetlands in Australia; and
    b) To formulate and implement planning that promotes:
        i) Conservation of the wetland; and
        ii) Wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.
2. To assist in fulfilling Australia's obligation under the Ramsar Convention to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.
3. To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, form an official record of the ecological character of the site.
4. To assist the administration of the EPBC Act, particularly:
    a) To determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act; or
    b) To assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland.
5. To assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.
6. To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

## 1.3 Relevant treaties, legislation and regulations

This section provides a brief listing of the legislation and policy that is relevant to the description of the ecological character of the Ramsar site.

**International**

*Ramsar Convention*

The Convention on Wetlands of International Importance, otherwise known as the Ramsar Convention, was signed in Ramsar Iran in 1971 and came into force in 1975. It provides the framework for local, regional and national actions, and international cooperation, for the conservation and wise use of wetlands. Wetlands of international importance are selected on the basis of their international significance in terms of ecology, botany, zoology, limnology and or hydrology.

*Migratory bird bilateral agreements and conventions*

Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds, which are relevant to the Hosnies Spring Ramsar site. The bilateral agreements are:

- *JAMBA (Japan Australia Migratory Bird Agreement)* – The agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment, 1974;
- *CAMBA (China Australia Migratory Bird Agreement)*- 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 1986;
- *ROKAMBA (Republic of Korea Australia Migratory Bird Agreement)* - The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment, 2006; and
- *The Bonn Convention on Migratory Species (CMS)* - The Bonn Convention adopts a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

**National legislation**
*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
The EPBC Act regulates actions that will have or are likely to have a significant impact on any matter of national environmental significance, which includes the ecological character of a Ramsar wetland (EPBC Act 1999 s16(1)). An action that will have or is likely to have a significant impact on a Ramsar wetland will require an environmental assessment and approval under the EPBC Act. An 'action' includes a project, a development, an undertaking or an activity or series of activities (http://www.environment.gov.au/epbc/index.html).

The EPBC Act establishes a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles (EPBC Act 1999 s335), which are set out in Schedule 6 of the *Environment Protection and Biodiversity Conservation Regulations 2000*. These principles are intended to promote national standards of management, planning, environmental impact assessment, community involvement, and monitoring, for all of Australia's Ramsar wetlands in a way that is consistent with Australia's obligations under the Ramsar Convention. Some matters protected under the EPBC Act are not protected under local or state/territory legislation, and as such, many migratory birds are not specifically protected under State legislation (though they are in Western Australia). Species listed under international treaties (JAMBA, CAMBA and CMS) have been included in the List of Migratory species under the Act. Threatened species and communities listed under the EPBC Act may also occur, or have habitat in the Ramsar site; some species listed under State legislation as threatened are not listed under the EPBC Act as threatened, usually because they are not threatened at the national (often equivalent to whole-of-population) level. The Regulations also cover matters relevant to the preparation of management plans, environmental assessment of actions that may affect the site, and the community consultation process.

The Christmas Island National Park is managed under Part 15 of the EPBC Act and was declared for:

a. the preservation of the area in its natural condition; and
b. the encouragement and regulation of the appropriate use, appreciation and enjoyment of the area by the public.

Administration and management of Commonwealth reserves are a function of the Director of National Parks under the EPBC Act (s.514B).

## 1.4 Method

The method used to develop the ecological character description for the Hosnies Spring Ramsar site is based on the twelve-step approach provided in the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (DEWHA 2008a) illustrated in Figure 2. A more detailed description of each of the steps and outputs required is provided in the source document.

This ECD was developed primarily through a desktop assessment and is based on existing data and information. A stakeholder advisory group was formed to provide input and comment on the ECD (see Appendix A).

**1. Introduction to the description**
Site details, purpose of the description, relevant legislation

**2. Describe the site**
Site location, climate, maps and images, tenure, criteria and wetland types

**3. Identify and describe the critical components, processes, benefits and services**
3.1 Identify all possible components, processes, benefits and services
3.2 Identify the critical components, processes benefits and services responsible for determining the ecological character of the site
3.3 Describe each of the critical components, processes, benefits & services

**4. Develop a conceptual model of the wetland**
Depict the critical components & processes of the wetland and their interactions

**5. Set limits of acceptable change (LAC)**
Determine LAC for critical components, processes and services

**6. Identify threats to the ecological character of the site**
Identify the actual or likely threats to the site

**7. Describe changes to ecological character**
Describe changes to the ecological character since the time of listing
Include information on the current condition of the site

**8. Summarise knowledge gaps**
Use information from Steps 3 - 7 to identify knowledge gaps

**9. Identify site monitoring needs**
Use information from Steps 3 - 8 to identify monitoring needs

**10. Identify communication and education messages**
Identify any communication & education messages highlighted during the development process

**11. Compile the description of ecological character**

**12. Prepare or update the Ramsar Information Sheet**
Submit as a companion document to the ecological character description

**Figure 2: Twelve step process for developing an ECD (adapted from DEWHA 2008).**

# 2. General Description of Hosnies Spring Ramsar Site

## 2.1 Location

Hosnies Spring Ramsar site is located on the eastern side of Christmas Island in the Indian Ocean approximately 2800 kilometres west of Darwin, Australia and 900 kilometres northeast of the Cocos Islands. The site is located within the Christmas Island National Park in the east of Christmas Island (Figure 3). The population of the Christmas Island was 1351 in 2006 (Attorney General's Department 2009) and the Shire of Christmas Island is the local government authority. The site is located approximately five kilometres south of the main settlement at Flying Fish Cove and just 1.5 kilometres south of the airport runway (Figure 4).

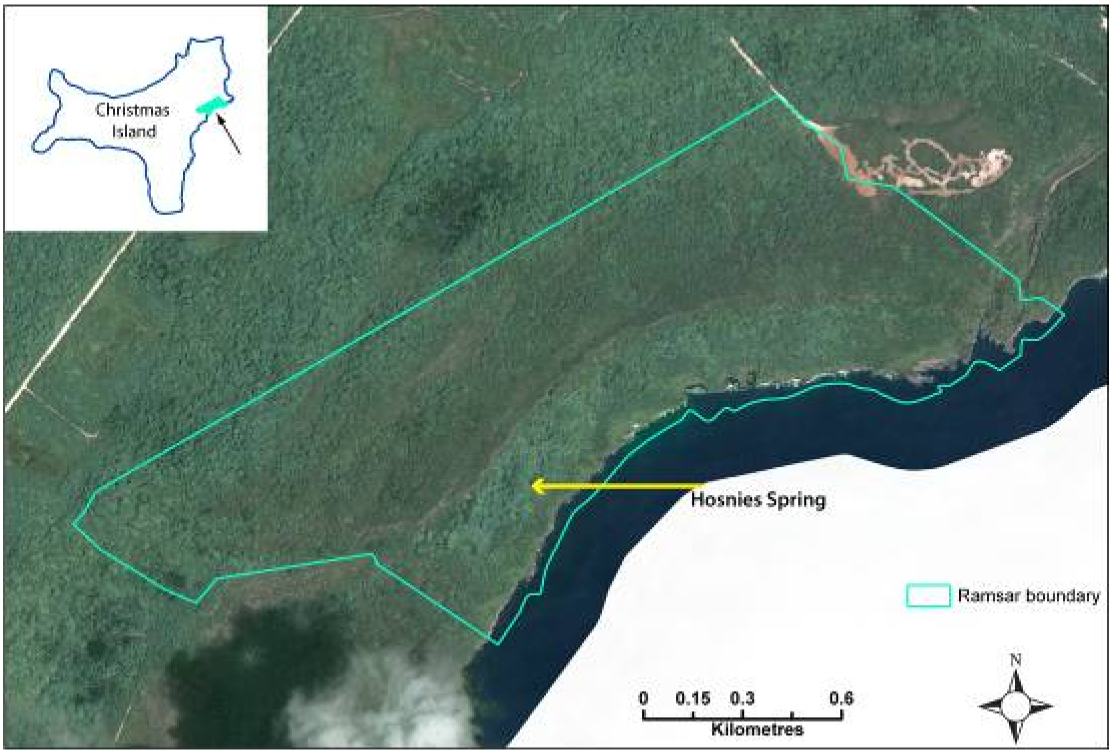



**Figure 3: Location of Hosnies Spring Ramsar Site. Green polygon shows the 2010 boundary and the arrow indicates the approximate location of the spring (data supplied by DSEWPaC).**

## 2.2 Overview of the site

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 of the seaward cliff. The wetland was covered by a stand of mangroves including *Bruguiera gymnorhiza* and *B. sexangula* estimated to be 120 000 years old (Woodroffe 1988). The margins of the wetland were well defined, with limestone cliffs to the north and west and a sharp transition to hibiscus and pandanus to the south (Parks Australia 1998).

The area within the Ramsar site that surrounds the spring, is predominantly rainforest characterised by a 20 to 30 metre tall canopy of evergreen and deciduous tree species such as *Pisonia grandis* and *Barringtonia racemosa* and a conspicuous lack of a herb and shrub layer. There is a narrow band of coastal scrub with hardy species such as *Scaevola taccada* at the seaward margin of the shore terrace, with an unvegetated area of limestone pinnacles at the top of the sea cliffs (Woodroffe 1988). 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.

The spring within the site is remarkable for a number of reasons. Firstly, it is one of very few permanent freshwater areas on Christmas Island. Secondly, the mangroves occur at an elevation not recorded elsewhere in the world. Thirdly, the age of the mangrove stand is extraordinary and finally, the size of the individual trees is very large (Parks Australia 1998).

The site also supports a large number of crabs, and in particular three species have been observed at high densities within the site: red crabs (*Gecarcoidea natalis*), robber crabs (*Birgus latro*) and blue crabs (*Discoplax hirtipes*[1]).

A total of eight species of wetland bird have been recorded within (or near) the site (Appendix B), as well as a number of terrestrial bird species. Of note is the presence of the following endemic bird species (Parks Australia 1998):

- Christmas Island imperial pigeon (*Ducula whartoni*) – vulnerable (EPBC Act)
- Christmas Island emerald dove (*Chalcophaps indica natalis*)
- Christmas Island goshawk (*Accipiter fasciatus natalis*) – vulnerable (EPBC Act)
- Christmas Island hawk-owl (*Ninox natalis*) – endangered (EPBC Act)
- Christmas Island thrush (*Turdus poliocephalus erythropleurus)*
- Christmas Island white-eye (*Zosterops natalis*).

In addition, two species of bat have been observed within or near to the Ramsar site: Christmas Island fruit bat (*Pteropus melanotus natalis*) and now believed extinct Christmas Island pipistrelle (*Pipistrellus murrayi*). However, the Ramsar site does not provide core habitat for either of these bat species.

## 2.3 Land tenure

Hosnies Spring Ramsar site is entirely within a declared Commonwealth Reserve under the control of the Director of National Parks. The site was included in the Park in 1996 and is separated from other parts of the National Park by freehold land (Figure 4).

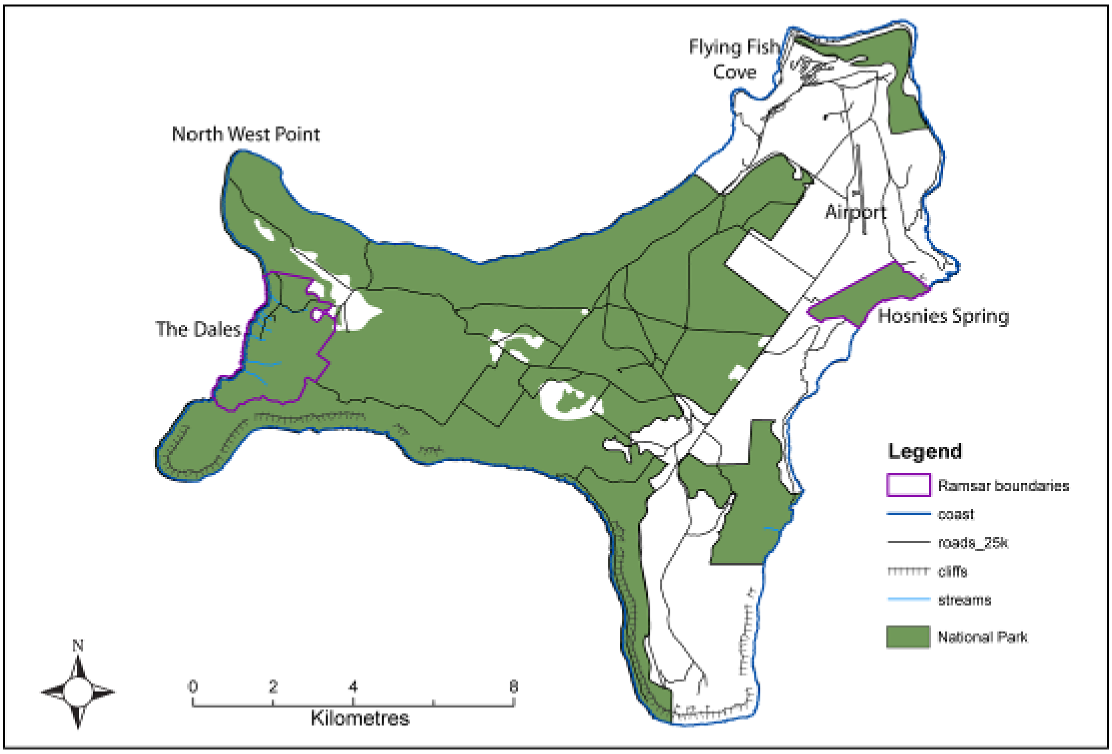



**Figure 4: Land tenure on Christmas Island.**

[1] Formerly *Cardisoma hirtipes*

## 2.4 Wetland types

The 1998 RIS for the site (Parks Australia 1998) identified the following three Ramsar wetland types within the Hosnies Spring Ramsar site:

- M – Permanent rivers/streams/creeks
- Xf – Freshwater, tree dominated wetlands
- Y - Freshwater springs; oases.

However, although water from the spring flows over short distances, it is not a channelised flow that is consistent with what would normally be considered a river or stream. As such, the spring itself can be considered to comprise two wetland types, “freshwater springs” (Type Y) and freshwater, tree dominated wetlands (Type Xf) (Figure 5).

The eastern boundary of the Ramsar site now extends 50 metres seaward from low water mark and so includes marine areas. As such additional wetland types within the Ramsar site include (Figure 6):

- C – Coral reefs; and
- D – Rocky shores.

Although comprehensive mapping of wetland types within the site is not available. The approximate locations of Ramsar wetland types are illustrated in Figure 7.

**Figure 5: Hosnies Spring, wetland types Y “freshwater springs” and Xf “freshwater tree dominated wetland” (photograph Daniel Simon).**

Figure 6: Indicative marine areas near the Ramsar site; rocky shore (type D) and coral reef (type C) wetland types (photography by Colin Totterdale, Parks Australia).

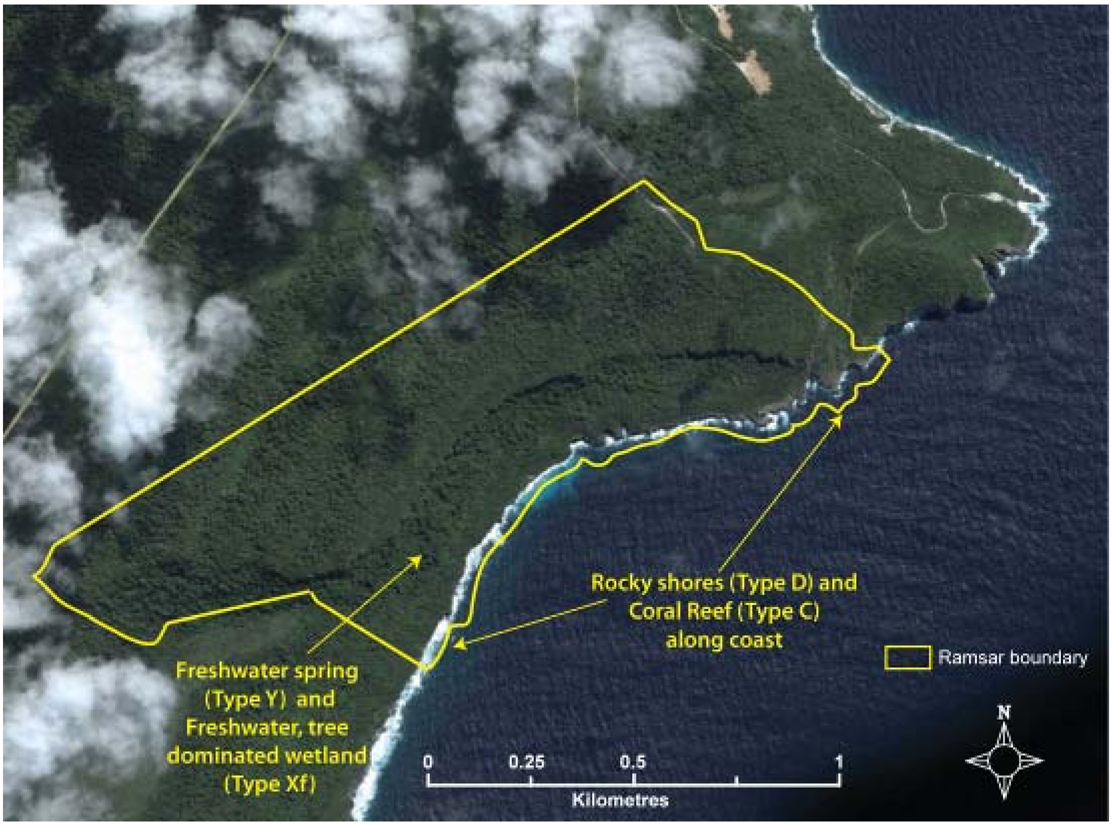



Figure 7: General location of examples of wetlands types within the Hosnies Spring Ramsar site.

## 2.5 Ramsar criteria

### *2.5.1 Criteria under which the site was designated*

At the time that the Hosnies Spring site was first nominated as a Wetland of International Importance (1990), the criteria for identifying Wetlands of International Importance were those, adopted at the fourth conference of contracting parties in Montreaux in 1990. The original nomination documentation for the Ramsar site considered that the site met three of these criteria as shown in (Table 2). However, no specific justification for these criteria was provided.

**Table 2: Criteria for Identifying Wetlands of International Importance as at listing date, 1990. Criteria for which Hosnies Spring Ramsar site has been listed are highlighted in green.**

| Basis | Number | Description |
|---|---|---|
| Criteria for representative or unique wetlands | 1a | it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region. |
| | 1b | it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region. |
| | 1c | it is a particularly good representative example of a wetland, which plays a substantial hydrological, biological or ecological role in the natural functioning of a major river basin or coastal system, especially where it is located in a trans-border position. |
| | 1d | it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region. |
| General Criteria based on plants and animals | 2a | it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species. |
| | 2b | it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna. |
| | 2c | it is of special value as the habitat of plants or animals at a critical stage of their biological cycle. |
| | 2d | it is of special value for one or more endemic plant or animal species or communities. |
| Specific criteria based on waterfowl[2] | 3a | it regularly supports 20 000 waterfowl. |
| | 3b | it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity. |
| | 3c | where data on populations are available, it regularly supports one percent of the individuals in a population of one species or subspecies of waterfowl. |

### *2.5.2 Assessment based on current information and Ramsar criteria*

There have been a few developments since the site was nominated in 1990 that influence the application of the Ramsar criteria to wetland sites. These includes:

- Refinements and revisions of the Ramsar criteria. They have been re-numbered and in 1996, an additional two criteria (criteria seven and eight) were adopted by the Ramsar Convention in Brisbane and a ninth criterion was added at the ninth Ramsar Conference in Uganda in 2005.

[2] Note in this equates to the term waterbird in the current context (see glossary for definition of waterbird).

- Revision of population estimates for waterbirds (Wetlands International 2006; Bamford et al. 2008), which influences the application of criterion six.

- A decision with respect to the appropriate bioregionalisation for aquatic systems in Australia, which for inland systems are now based on drainage divisions and for marine systems the interim marine classification and regionalisation for Australia (IMCRA). This affects the application of criteria one and three.

- Updating of threatened species listings, which affects criterion two.

Therefore an assessment of the Hosnies Ramsar site against the current nine Ramsar criteria has been undertaken and included in the updated RIS completed in conjunction with this ECD as detailed below and summarised in (Table 3).

**Table 3: Criteria for Identifying Wetlands of International Importance (adopted by the 7th (1999) and 9th (2005) Meetings of the Conference of the Contracting Parties). Criteria for which the Hosnies Spring Ramsar site qualifies are highlighted in green.**

| Number | Basis | Description |
|---|---|---|
| **Group A. Sites containing representative, rare or unique wetland types** | | |
| Criterion 1 | | A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region. |
| **Group B. Sites of international importance for conserving biological diversity** | | |
| Criterion 2 | Species and ecological communities | A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities. |
| Criterion 3 | Species and ecological communities | A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region. |
| Criterion 4 | Species and ecological communities | A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions. |
| Criterion 5 | Waterbirds | A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds. |
| Criterion 6 | Waterbirds | A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of waterbird. |
| Criterion 7 | Fish | A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity. |
| Criterion 8 | Fish | A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend. |
| Criterion 9 | Other taxa | A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species. |

**Criterion 1:** The application of this criterion must be considered in the context of the bioregion within which the site is located. As an offshore site, the appropriate bioregionalisation is the IMCRA v4.0 (Commonwealth of Australia 2006). The corresponding

bioregion is the Christmas Island Province, which encompasses 277 180 square kilometres of the Indian Ocean surrounding Christmas Island (Heap et al. 2005).

Christmas Island represents the only land mass within the bioregion and the wetlands associated with Hosnies Spring, particularly the spring system and mangrove stand are unique in a bioregional (and in fact broader) context. As such Hosnies Spring Ramsar site met this criterion at the time of listing and continues to do so.

**Criterion 2:** In the Australian context, it is recommended that this criterion should only be applied with respect to nationally threatened species/communities, listed under the EPBC Act or the International Union for Conservation of Nature (IUCN) Red List. A number of threatened species listed at the national and / or international level have been recorded within the boundary of the expanded Hosnies Spring Ramsar site. However, central to the application of this criterion are the words “a wetland” and “supports”. Guidance from Ramsar (Ramsar 2005) in applying the criteria indicates that the wetland must provide habitat for the species concerned. For this reason, vagrant species; such as the observations of passing whales have not been considered to contribute to the meeting of this criterion; nor have purely terrestrial species that are not reliant on aquatic habitats as a primary foraging ground, reproduction or other key part of their lifecycle.

There are two threatened wetland bird species that have been recorded within the Hosnies Spring Ramsar: Abbott’s booby (*Papasula abbotti*) and Christmas Island frigatebird (*Fregata andrewsi*). However, the Ramsar site is not considered to provide core habitat in terms of feeding, roosting or nesting for these species (Peter Green, pers. comm.). There are few records for these wetland birds from within the Ramsar site and they are numerous in other areas of Christmas Island (Hennicke 2007). Therefore, although threatened species have been recorded within the site, the wetlands within the site are not considered to play a significant role in supporting them.

**Criterion 3:** Like criterion one, application of this criterion must be taken in the context of the appropriate bioregion, in this instance the IMCRA (v4) Christmas Island Province. Guidance from the Convention indicates that this criteria should be applied to "hotspots" of biological diversity, centres of endemism, sites that contain the range of biological diversity (including habitat types) occurring in a region; and/or support particular elements of biological diversity that are rare or particularly characteristic of the biogeographic region.

In terms of Hosnies Spring, the mangrove forest present at the site is unique within the bioregion and possibly worldwide. The stand comprises of two species; *Bruguiera gymnorhiza* and *B. sexangula*, both of which usually occur in intertidal zones. However, at Hosnies Spring the trees are located at the spring some 120 metres inland and 37 metres above sea level. It is thought that the stand is a relict of times when the site was inundated by the sea more than 120 000 years ago (Woodroffe 1988).

This criterion was met at the time of listing and continues to be met.

**Criterion 4:** The basic description of this criterion implies a number of common functions/roles that wetlands provide including supporting fauna during migration and breeding as well as acting s a drought refuge. Hosnies Spring is one of a small number of permanent water sources on Christmas Island and one of even fewer water sources that have not been directly tapped for human consumption. The site is important for the blue crab (*Discoplax hirtipes*), which is reliant on the freshwater provided by the spring to maintain respiratory function (Hicks et al. 1984). There is also anecdotal evidence that the site provides important dry season refuge for terrestrial species of birds, mammals and reptiles (Mike Misso, Parks Australia, pers. comm.).

The expanded site provides a connection from the plateau to the ocean and as such is a migratory route for red crabs during breeding migrations.[3]

This criterion was met at the time of listing and continues to be met.

**Criteria 5 and 6:** These criteria were not included in the original nomination document, and there is no indication that Hosnies Spring Ramsar site supports significant numbers of waterbirds. These criteria are not considered to be met.

**Criteria 7 and 8:** The expansion of the site to include the adjacent shore and coral reef includes a small proportion of marine wetlands. The marine fish population of Christmas Island is unique and has a high degree of hybridisation (Hobbs et al. 2009). However, this is not unique to Hosnies Spring Ramsar site and there are no marine monitoring locations within the Ramsar site upon which an assessment of marine values and character can be made. Therefore, this criterion cannot be assessed on available information.

**Criteria 9:** The application of this criterion relies on estimates of the total population of non-bird species. In the case of Hosnies Spring Ramsar site this would require estimates of crab numbers. This criterion cannot be assessed based on current information.

**Christmas Island blue crab (photograph by Daniel Simon).**

[3] Note that blue crab migrations are not considered to be supported by this site as the blue crabs require freshwater streams to intersect with the ocean for successful breeding and return of baby crabs (Hicks et al. 1984).

# 3. Critical Components and Processes

## 3.1 Identifying critical components and processes

The basis of an ECD is the identification, description and where possible, quantification of the critical components and processes of the site. Wetlands are complex ecological systems and the complete list of physical, chemical and biological components and processes for even the simplest of wetlands would be extensive and difficult to conceptualise. It is not possible, or in fact desirable, to identify and characterise every organism and all the associated abiotic attributes that are affected by, or cause effect to, that organism to describe the ecological character of a system. This would result in volumes of data and theory but bring us no closer to understanding the system and how to best manage it. What is required is to identify the key components, the initial state of the systems, and the basic rules that link the key components and cause changes in state (Holland 1998). Thus, we need to identify and characterise the key or critical components, processes, benefits and services that determine the character of the site. These are the aspects of the ecology of the wetland, which, if they were to be significantly altered, would result in a significant change in the system.

DEWHA (2008) suggest the minimum components, processes, benefits and services, which should be included in an ECD are those:

1. that are important determinants of the sites unique character;
2. that are important for supporting the Ramsar criteria under which the site was listed;
3. for which change is reasonably likely to occur over short to medium time scales (less than 100 years); and / or
4. that will cause significant negative consequences if change occurs.

In addition, the role that components and processes play in the provision of critical ecosystem services should also be considered in the selection of critical components and processes. The linkages between components, processes, benefits and services and the criteria under which the site was listed are illustrated conceptually in Figure 8. This simple conceptual model for the Hosnies Spring Ramsar site shows not only the components and processes that are directly related to critical ecosystem services and benefits and are considered critical to the ecological character of the site, but also the components and processes that are important in supporting these (essential elements) and the critical services the site provides.

It is difficult to separate components (physical, chemical and biological parts) and processes (reactions and changes). For example, aspects of hydrology such as rainfall and water regime may be considered as components, while other aspects of hydrology such as groundwater flow and connectivity could be considered processes. Similarly the species composition of crabs at a site may be considered a component, but breeding and migration are processes. In the context of this ECD a separation of the ecology of wetlands into nouns (components) and verbs (processes) is an artificial boundary and does not add clarity to the description. As such components and processes are considered together. The interactions between components and processes, the functions that they perform and the benefits and services that result are considered in detail in section 4.

Each of the identified critical components and processes meet the four criteria provided by DEWHA (2008) in that they are central to the character of the site, are directly linked to the Ramsar criteria for which the site was listed, could potentially change in the next 100 years and for which change would result in negative consequences and a change in the ecological character of the site.

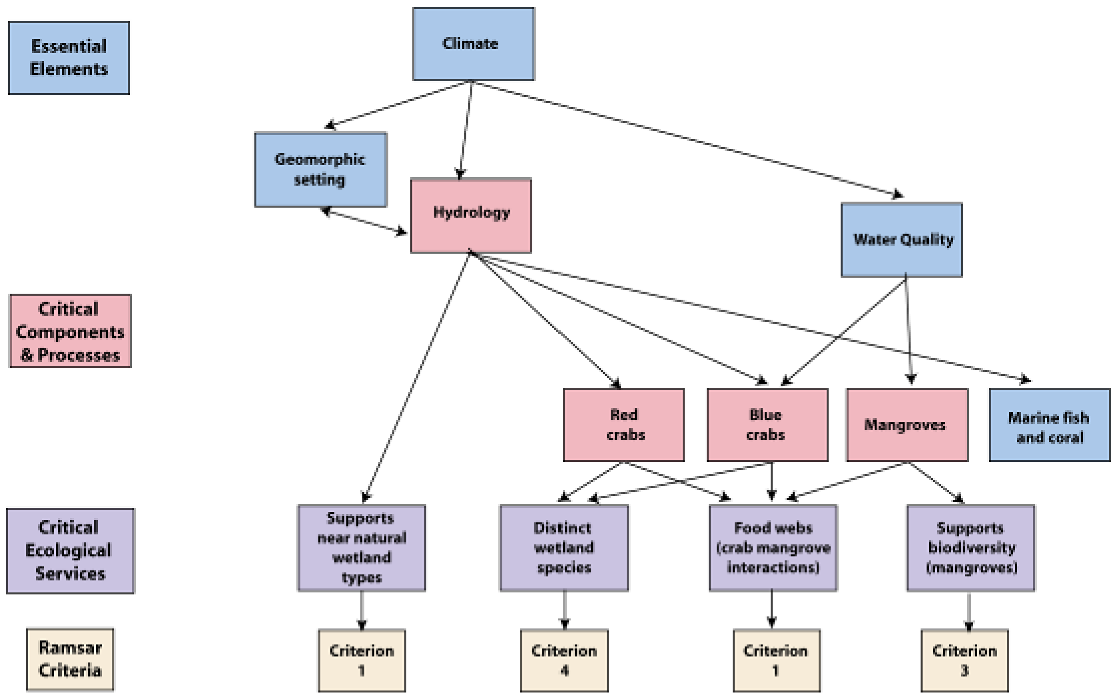



**Figure 8: Simple conceptual model showing the key relationships between components and processes; benefits and services and the reasons for the site being listed as a Wetland of International Importance.**

The remaining components and process identified in Figure 8, although important in supporting the critical components and processes, benefits and services are not considered critical as a change in these components and process, in isolation (i.e. without a corresponding biological response) would not result in a change in the ecological character of the site. Nevertheless, these supporting components and processes (termed essential elements) are important in managing the site to maintain ecological character and some may provide early warning indicators of change. As such, this ECD includes a description of the following essential elements that are important in supporting the ecological character of the site:

- Climate
- Geomorphic setting
- Water quality, and
- Marine fish and corals.

## 3.2 Essential elements

The components and processes of the Hosnies Spring Ramsar site that are considered important in supporting the critical components, processes, benefits and services of the site (and hence termed essential elements) are described briefly below and summarised in Table 4.

**Table 4: Summary of essential elements within Hosnies Spring Ramsar site.**

| Component / process | Description |
|---|---|
| Climate | • Warm tropical climatic zone.<br>• High rainfall (2000 millimetres per year); warm to hot year round. |
| Geomorphic setting | • Site is located within the shore terrace on an area of gravel overlying phosphoric soils.<br>• Spring is situated at the base of the inland cliffs where spring water flows over a limestone flowstone. |
| Water quality | • Limited information (two snap shot surveys only).<br>• Typical of limestone karst systems with alkaline conditions and relatively high concentrations of calcium.<br>• Trace elements and metals are all low.<br>• Nitrogen is predominantly in the form of nitrate.<br>• High concentrations of sulphate result in a sulphurous odour. |
| Marine fish and coral | • Data deficient.<br>• Christmas Island characterised by a narrow band of sub-tidal coral reef dominated by hard corals.<br>• Butterflyfish are the most dominant form of fish in terms of number of species and abundance. |

### *3.2.1 Climate*

Christmas Island lies within the moist tropical climatic zone of the Indian Ocean. The general climatic pattern is warm to hot temperatures and high rainfall occurring year round. The nearest weather station to Hosnies Ramsar site is located at the Christmas Island airport (two kilometres north).

Rainfall, on average, occurs year round with highest monthly average rainfall in February (345 millimetres) and lowest in August (44 millimetres). There is some degree of variability in rainfall as evidenced by the $10^{th}$ and $90^{th}$ percentiles, which range from less than one millimetre per month to greater than 550 millimetres per month (Figure 9). However, this is considerably more stable than rainfall in arid zones within Australia (Bureau of Meteorology 2009a).

Annual average rainfall at Christmas Island is in the order of 2000 millimetres per year. Once again, although there is some degree of variability in annual rainfall (ranging from less than 1250 millimetres to greater than 3700 millimetres in 30 years of records from this site) (Figure 10) this is relatively low compared to areas in mainland Australia.

Temperatures are warm to hot year round (Figure 11), with little seasonal variation. Maximum monthly temperatures are between 26 and 28 degrees Celsius and average minimum temperatures between 22 and 24 degrees Celsius.

Christmas Island is located in an area subject to tropical cyclones. Thirteen tropical cyclones were recorded in the vicinity of Christmas Island between 1972 and 2005. On average this equates to a tropical cyclone every five years. However, in the 20 years of wind records, there has only been one severe gust recorded of at least 90 kilometres per hour. That was 107 kilometres per hour in December 1980 during tropical cyclone Dan. (Bureau of Meteorology 2009b).

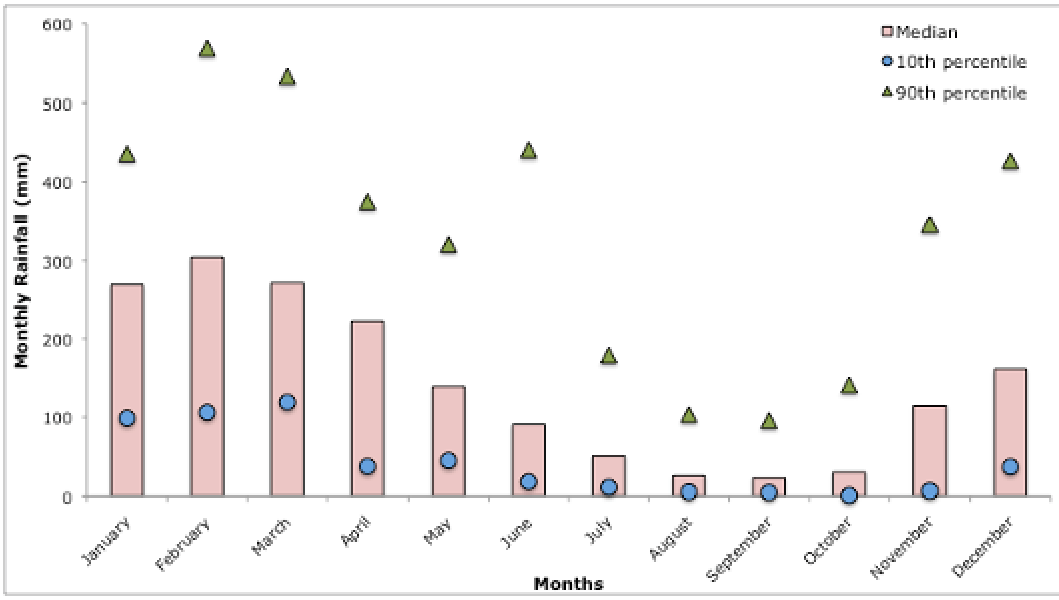



**Figure 9: Median (10th and 90th percentile) monthly rainfall at Christmas Island Airport (1973 – 2009; Bureau of Meteorology 2009a).**

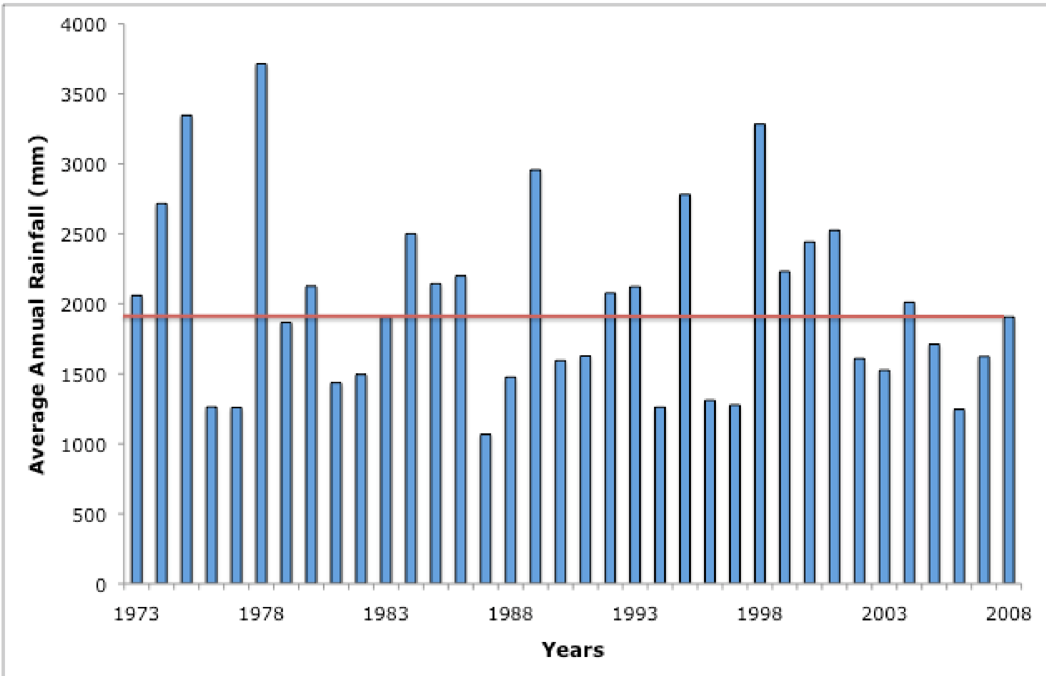



**Figure 10: Average annual rainfall at Christmas Island Airport (1973 – 2006; Bureau of Meteorology 2009a). Note horizontal line shows long term average.**

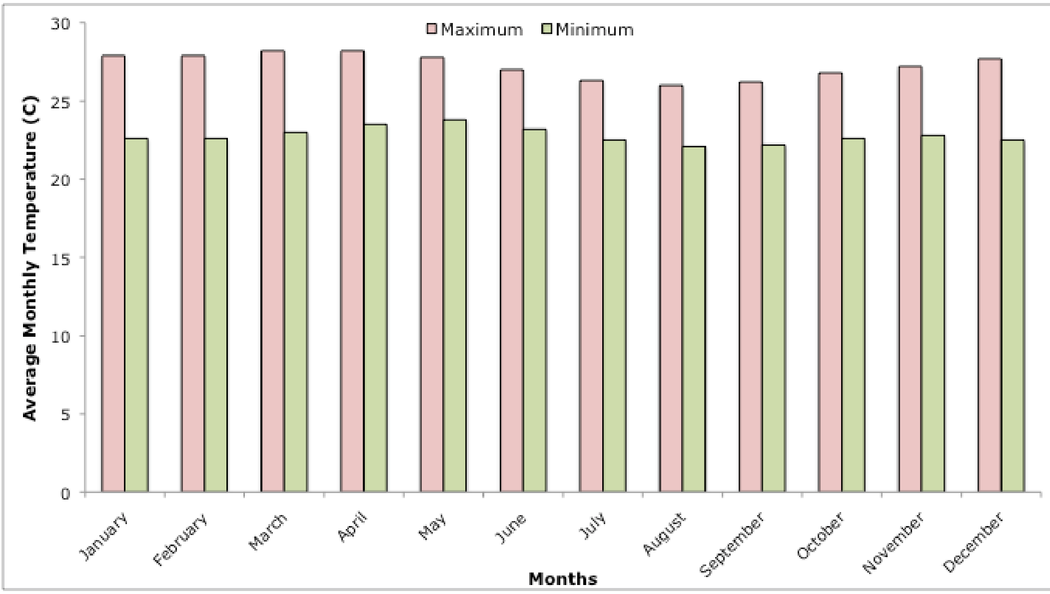



**Figure 11: Average monthly maximum and minimum temperatures at Christmas Island Airport (1973 – 2009; Bureau of Meteorology 2009a).**

**Spider crabs (photograph by Daniel Simon).**

### *3.2.2 Geomorphic setting*

Christmas Island is a seamount island, which rises above the 5500 metre deep abyssal area of the Western Australian Basin (SKM 2000). The island has a basaltic volcanic core overlain with limestone of predominantly Tertiary origins (Woodroffe 1988). The island is characterised by a series of stepped terraces, which developed during uplift events. The most prominent of the limestone terraces, is the lowest one, called the "shore terrace". This feature surrounds the entire island, with the exception of a short break in the northeast at Flying Fish Cove. The spring lies wholly within the shore terrace, however the Ramsar site spans the plateau, shore terrace and shores (Figure 12).

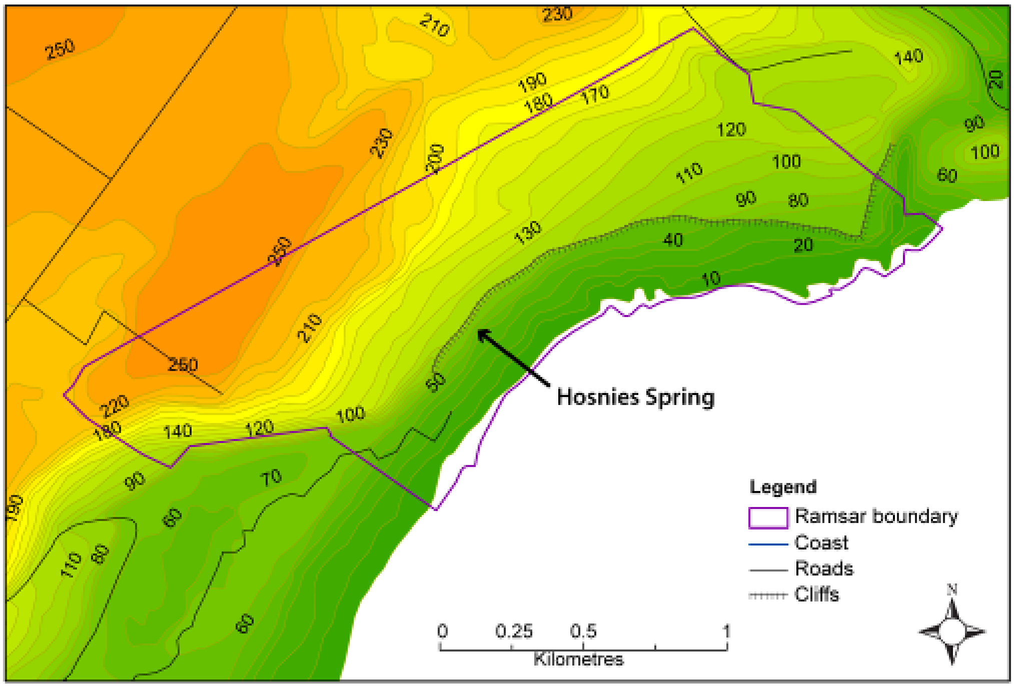



**Figure 12: Topography of Christmas Island showing the location of the shore terrace and Hosnies Spring (data supplied by Parks Australia). Shore terrace below a line of inland cliffs is shown in dark green. Note that boundary shown is the 2010 extended boundary.**

Thought to be an ancient fringing reef, corals within the shore terrace date back approximately 124 000 years Before Present (Veeh, 1985 in Woodroffe 1988). The shore terrace extends from 120 to 300 metres inland; and adjacent to the Ramsar site is approximately 200 metres wide (Woodroffe 1988). In general terms, the terrace rises at a sea cliff eight to 12 metres above sea level. The top of the sea cliff is dissected into pinnacles; a central sloping area covered by phosphoric soil then becomes steeper with limestone blocks towards the rear. Although the inland edge of the shore terrace is difficult to define, it has a broad elevation range of 22 to 30 metres (Woodroffe 1988).

Hosnies Spring is located at the inland extent of the shore terrace where freshwater trickles over a calcareous flowstone at the base of a limestone cliff. The wetland stretches from approximately 120 metres inland of the coast on gravel soils, which cover 0.33 of a hectare (Figure 13; Woodroffe 1988).

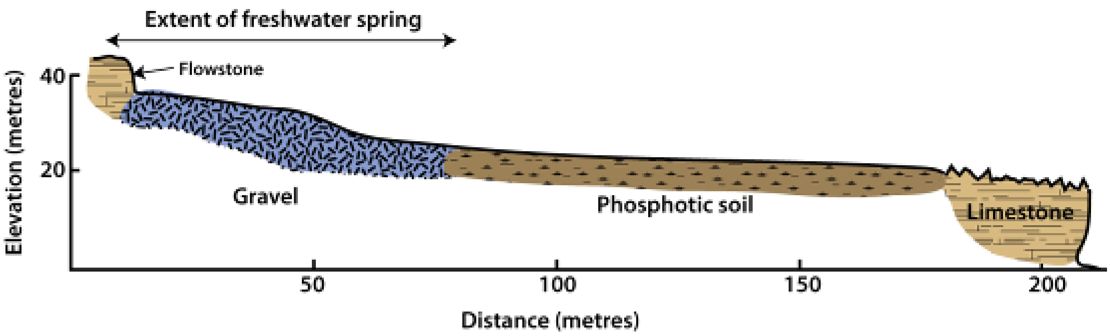



**Figure 13: Transect across the shore terrace at Hosnies Spring (adapted from Woodroffe 1988).**

### *3.2.3 Water quality*

There is very little information on the water quality within Hosnies Spring, with available data limited to a snapshot survey in 1988 (Woodroffe 1988) and another in 2003 (EWL Sciences and Tallegalla Consultants 2005). The water is slightly alkaline (pH 7.4 to 8) and relatively high in calcium (approximately 90 milligrams per litre), which is typical of limestone based karst systems (Ford and Williams 2007). Water is fresh with an electrical conductivity of 400 to 550 micro-siemens per centimetre. Water clarity is high, with turbidity ranging from one to 13 NTU and suspended solids of 16 milligrams per litre measured in May 2003 (EWL Sciences and Tallegalla Consultants 2005). Concentrations of trace elements and heavy metals were all low (mostly below laboratory detection limits) in samples collected in May 2003, although concentrations of sulphate ranged from five to eight milligrams per litre. This is consistent with the observations of Woodroffe in 1998, who noted a strong smell of sulphur at the site. Total nitrogen was recorded at 6.4 milligrams per litre in 2003, and over 96 percent of this was in dissolved form as nitrate (EWL Sciences and Tallegalla Consultants 2005).

### *3.2.4 Marine fish and corals*

There is no information on the marine areas specific to the Ramsar site and this remains a significant knowledge gap. What is presented here is a general description of the marine fish and corals compiled from information collected outside the site boundary. This provides an overview of the types of components, processes and services that may be important to the marine areas in the extended site boundary. Observations and anecdotal evidence suggests that the marine environment and biota of the east coast of Christmas Island is similar to other marine areas that have been surveyed (Jean-Paul Hobbs, pers. comm.). Therefore what is presented below can be considered indicative of the character of the Ramsar site.

Although Christmas Island is completely surrounded by coral reef, the extent of this habitat is limited (Gray and Clarke 1995). At the seaward edge, reef is limited by a steep drop off some 20 to 100 metres from shore, where the underwater terraces descend steeply. At the landward edge, reef is limited by the exposed coastline and high impact of waves and consequently only extends to the intertidal zone in sheltered locations (Gray and Clarke 1995). Gilligan et al. (2008) measured the extent of reef platform at several locations around the Island and determined an average extent of 79 metres (range = 20 to 150 metres).

The reef at Christmas Island is dominated by hard corals, with low cover of soft corals, encrusting algae and other biota (Figure 14). The abiotic benthos is comprised mostly of dead hard coral. The overall mean cover of live coral (51.5 percent) is considered “good” condition according to the reef health index of Gomez et al. (1991, in Gilligan et al. 2008); but is higher than most other comparable oceanic reef systems in the Indo-Pacific (Gilligan et al. 2008).

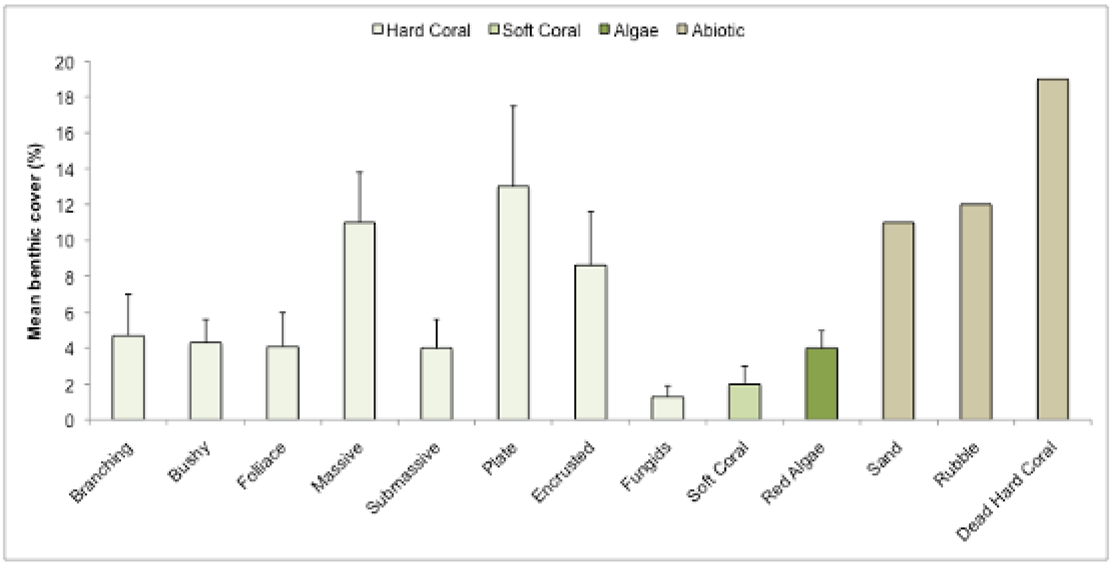



**Figure 14: Mean benthic cover (and standard error) across eleven sites at Christmas Island (data from Gilligan et al. 2008).**

Six hundred and twenty-two species of fish from 80 families have been recorded in the waters of Christmas Island (Hobbs et al, in press). The list includes species of Indo-Pacific, Pacific Ocean and Indian Ocean origins and Christmas Island is considered as an important "stepping-stone" in the dispersal of species between the Indian and Pacific Oceans (Hobbs et al, in press). The marine community at Christmas Island is globally unique because the island is located on a marine biogeogaphic border where Indian and Pacific Ocean fishes intermix (Hobbs and Salmond 2008). Consequently, there are more hybridising reef fishes recorded at Christmas Island than anywhere else in the world (Hobbs et al, 2009).

Christmas Island fish community also consists of seven endemic or near-endemic species or sub-species (*Eviota natalis, Pseudochromis viridis, Praealticus natalis, Aseraggodes crypticus, Centropyge joculator, Centropyge flavissima, Stegastes insularis*). The endemic damselfish (*Stegastes insularis*), is locally abundant in shallow waters (Gilligan et al. 2008) and two of the endemic angelfishes (*C. joculator and C. flavissima)* also have a high local abundance (Hobbs et al. 2010).

Christmas Island is also a globally significant area for whale sharks because juveniles aggregate at the Island in summer to feed on the larvae of red crabs (Hobbs et al, 2009b). They have been observed along the east coast of the island within 50 metres of the shoreline (Jean-Paul Hobbs, pers. comm.) and so potentially could occur at times within the Ramsar site. Whale sharks are the largest fish in the world and travel throughout the tropics. At certain times of the year, whale sharks migrate to specific locations to aggregate and feed on the mass spawning of other organisms. There are only a small number of these feeding locations and they represent important habitat for the long-term conservation of these "vulnerable" species.

## 3.3 Critical components and processes

The attributes and characteristics of each of the identified critical components and processes of the Hosnies Spring Ramsar site are described below (sections 3.3.1 to 3.3.3). Where possible, quantitative information is included. However, as with many ecological character descriptions, there are significant knowledge gaps (see section 8). A summary of the critical components and processes within the Hosnies Spring Ramsar site is provided in Table 5.

**Table 5: Summary of critical components and processes within the Hosnies Spring Ramsar site.**

| Component / process | Description |
|---|---|
| Hydrological regime | • Groundwater dominant.<br>• Source for Hosnies Spring in a perched, unconfined aquifer that discharges where impermeable volcanic rocks are close to the surface.<br>• Flow rate is not known, but expected to be low.<br>• Spring is perennial. |
| Mangroves | • Stand of mangroves from the genus Bruguiera covers the majority of the wetland.<br>• Comprises a range of size classes with evidence of active regeneration.<br>• A number of very large trees (large than typical for the species), with the largest tree measuring 82 centimetres diameter at breast height and exceeding 40 metres.<br>• Between 300 and 600 trees in total (more than 2.5 centimetres diameter at breast height) and a density of between 10 and 20 trees per 100 metres square. |
| Land Crabs | • Supports large populations of at least three species:<br>  • red crabs (*Gecarcoidea natalis*);<br>  • robber crabs (*Birgus latro*); and<br>  • blue crabs (*Discoplax hirtipes*) |

### *3.3.1 Hydrological regime*

The hydrology of Christmas Island is driven strongly by the underlying geology. The high porosity of the surface soils and underlying limestone limits the formation of permanent surface water. Surface water run-off is confined to the wet season (December to March) in relatively short, spring fed streams (Grimes 2001). The dominant water resource on the island, and the source of water for the Hosnies Spring Ramsar site, is groundwater.

There are three hydrogeological units on Christmas Island (EWL Sciences and Tallegalla Consultants 2005):

- residual soils;
- fractured, unconfined and semi-confined aquifers within the limestone; and
- relatively impermeable volcanic basement rocks.

Soils are highly permeable and rates of infiltration are very high. This coupled with the presence of limestone underlying these soils results in rapid drainage and no water stored at the surface or within the soil profile (EWL Sciences and Tallegalla Consultants 2005). The plateau (middle area of the island) contains some dolines or sinkholes, where infiltration of rainfall into underling groundwater aquifers is very rapid (Grimes 2001).

The fractured aquifers within the limestone are predominantly unconfined, except for small areas where overlying impermeable rocks are found (EWL Sciences and Tallegalla Consultants 2005). Falkland (1999; as cited in EWL Sciences and Tallegalla Consultants 2005) indicated that there was a perched freshwater aquifer that underlies much of Christmas Island and a basal aquifer below this. The lower, basal aquifer is fresh in its upper layers, but grades into saline water at depth where it intersects with the sea (Figure 15). The water at Hosnies Spring is from the fresh, perched aquifer.

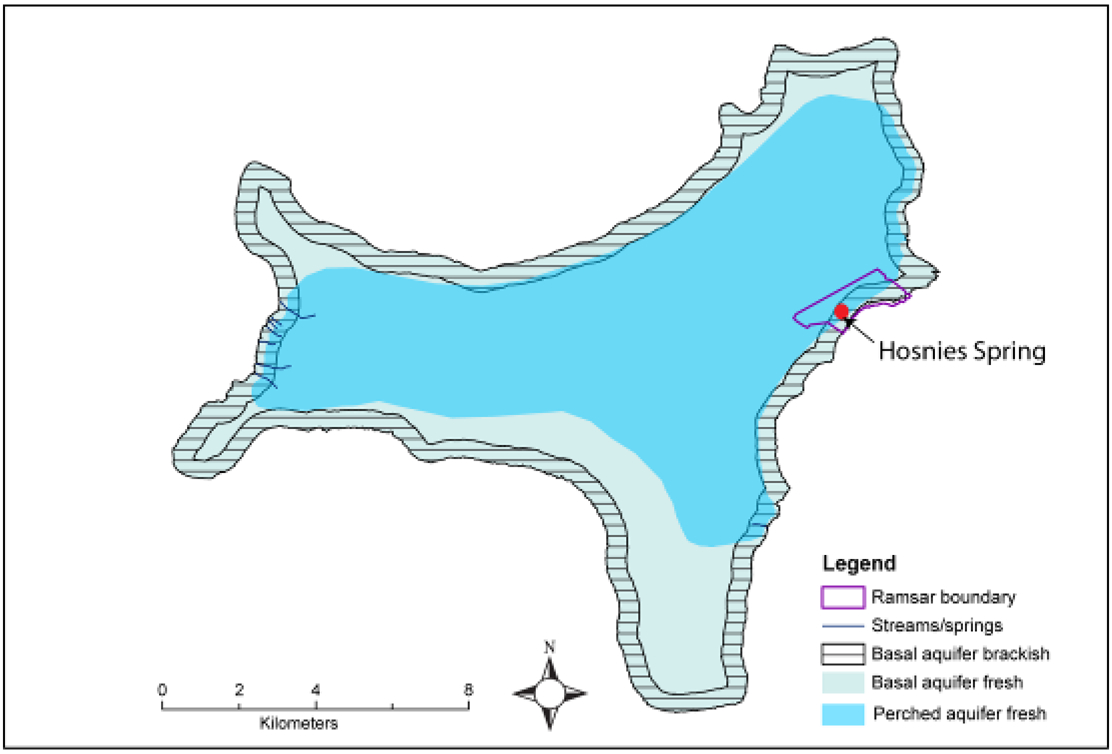



**Figure 15: Aquifers of Christmas Island (data supplied by Parks Australia).**

The water cycle at Christmas Island is relatively simple (Figure 16). Recharge of groundwater occurs via rainfall with about half of incident rainfall entering the aquifers. The remainder is lost via evaporation / evapotranspiration. The permeable soil and rapid infiltration result in seasonality of groundwater flow, with higher flow rates following the wet season, and slower rates at the end of the dry (Grimes 2001). Rates of flow at the Hosnies Spring Ramsar site are not known, but anecdotally are considered to be very low (Parks Australia 1998).

Once infiltrated water flows under hydraulic pressure along the limestone / volcanic rock interface. Discharges occur at springs where volcanic rocks are close to the surface both along the margins of the islands and at sea (EWL Sciences and Tallegalla Consultants 2005).

Hosnies Spring in an example of a land based spring discharge of the perched aquifer. Water discharges from a number of discrete locations and saturates the soil for an area of approximately 3300 square metres (Parks Australia 1998). Although flow rates are not known, the spring is a permanent water source and remains flowing through the dry season.

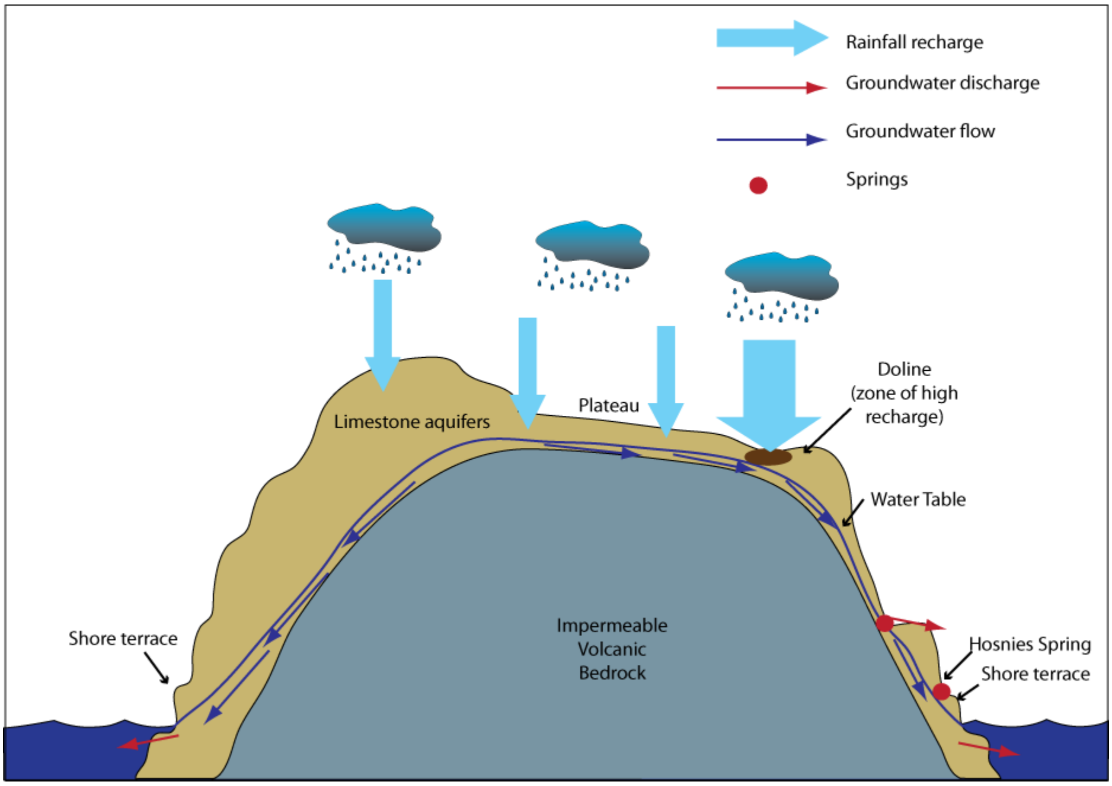



**Figure 16: Conceptual diagram of water cycle at Christmas Island (adapted from Grimes 2001 and EWL Sciences and Tallegalla Consultants 2005).**

### *3.3.2 Mangroves*

Hosnies Spring Ramsar site contains a unique inland stand of mangroves from the genus *Bruguiera*. Investigations in the 1970s and 1980s identified two species of mangrove at the site *Bruguiera gymnorhiza* and *B. sexangula* (van Steenis 1984 in Woodroffe 1988). However, the two species are morphologically very similar and very difficult to distinguish. Woodroffe (1988) reported no evidence that there were two species present and all specimens collected from the 1988 survey were of *B. gymnorhiza*.

The mangroves cover almost the entire area of freshwater wetland (Figure 17) and there is a range of age classes present on the site, indicating active regeneration. The size structure of the trees within the stand shows a bimodal distribution (Figure 18) and Woodroffe (1988) reported that young trees were most common where gaps in the canopy were present (from falling older trees). Woodroffe (1988) also reported extensive flowering and large numbers of propagules within the stand.

The stand includes several large specimens, the largest measuring 82 centimetres (diameter at breast height) and exceeding 40 metres in height (Figure 19). This is larger than is typical for the species, which is commonly recorded at between 15 to 35 centimetres (diameter at breast height) and seven to twenty metres in height (Allen and Duke 2006).

The density of the site at the time of listing was between 10 and 20 trees per 100 metres squared (trees greater than 2.5 centimetres diameter at breast height) and contained between 300 and 600 mature trees (Woodroffe 1988). Six to ten large fallen trees were also recorded in the 1988 survey.

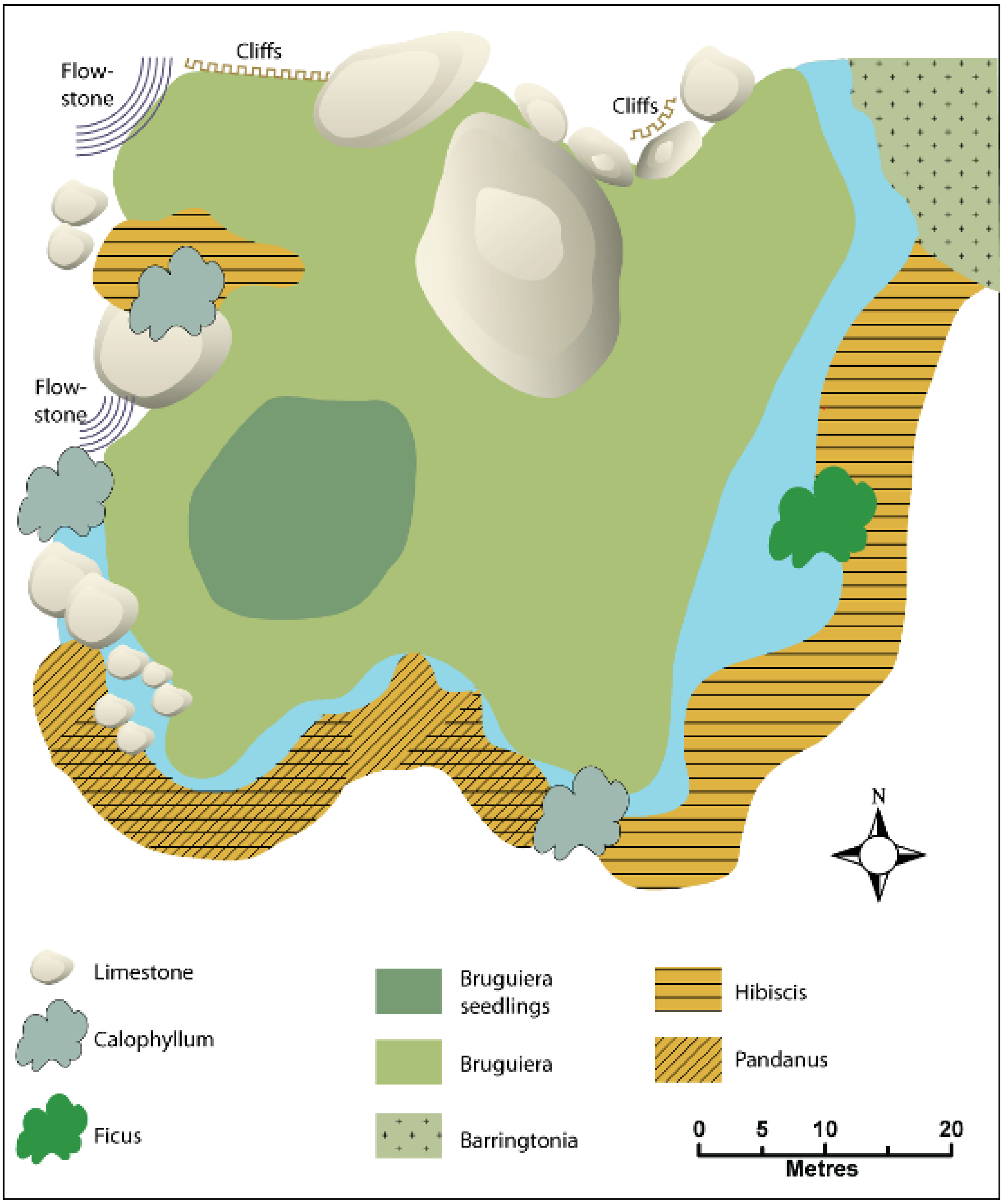



**Figure 17: Vegetation map of Hosnies Spring (adapted from Woodroffe 1988).**

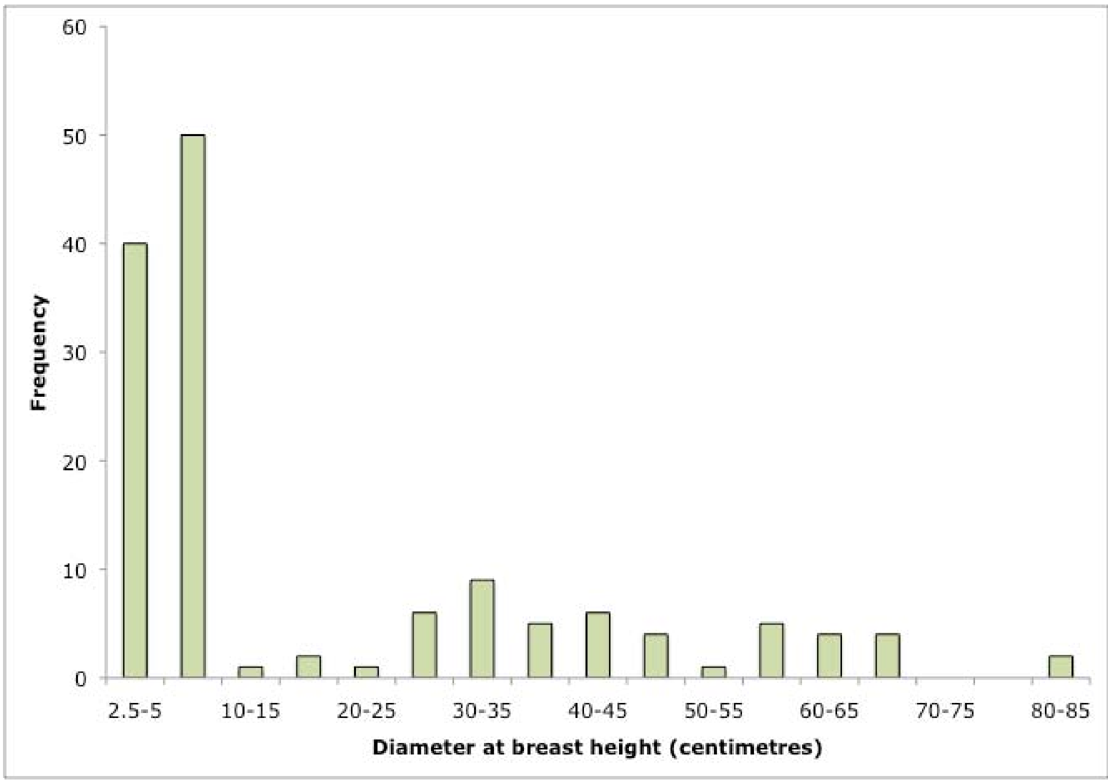



**Figure 18: Size structure of mangroves in the Ramsar site (adapted from Woodroffe 1988; sample size of 137).**

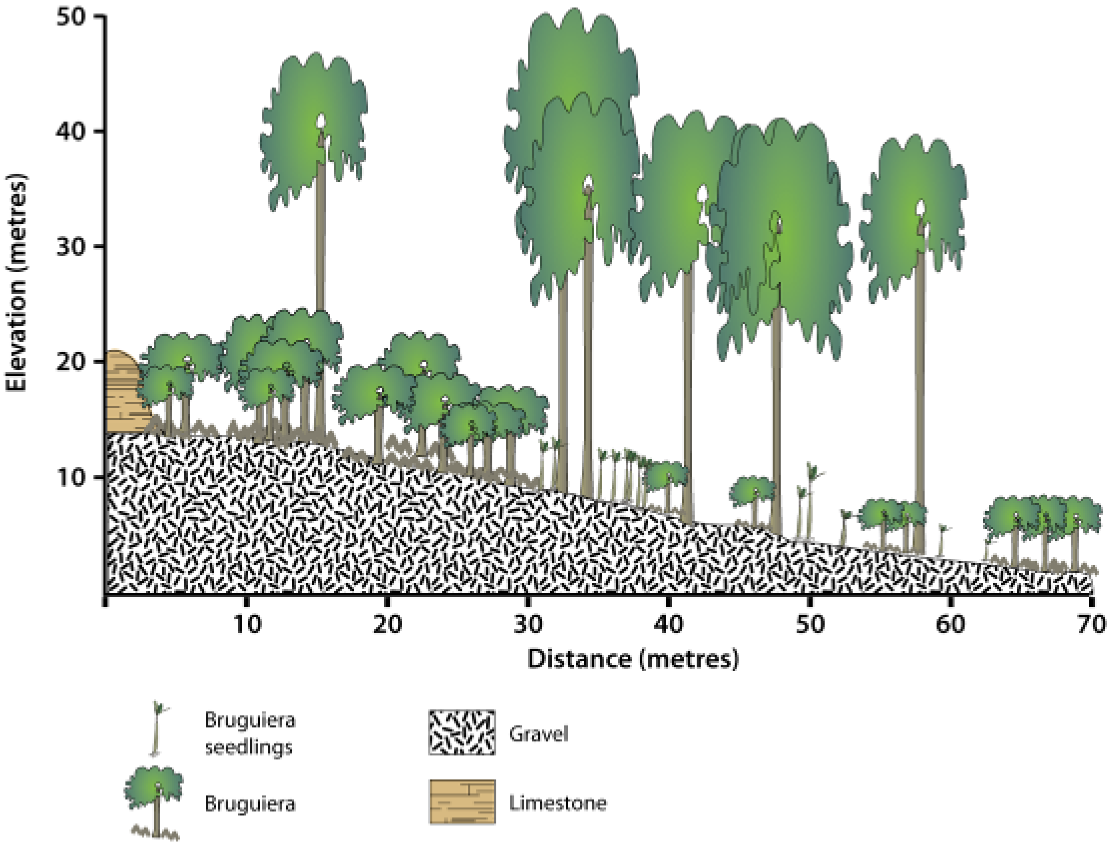



**Figure 19: Transect through the mangrove stand at Hosnies Spring (adapted from Woodroffe 1988).**

**Mangrove seedlings at Hosnies Spring (photograph by Daniel Simon).**

### *3.3.3 Land Crabs*

The Hosnies Spring Ramsar site supports a large number of land crabs. Woodroffe (1988) observed large numbers of three species at the spring site:

- red crabs (*Gecarcoidea natalis*) – which were the most abundant at the site;
- robber crabs (*Birgus latro*) – which were considered common; and
- blue crabs (*Discoplax hirtipes*) – which were described as restricted to the freshwater wetland (and other freshwater areas on the Island). Although widespread, this species occurs in its blue form only on Christmas Island.

The baseline for the current site boundary is 2010, and there is some quantitative data for red crab burrow density from the 2009 island wide survey that represents baseline conditions[4] (). Although the data does not allow for a definitive population of red crabs to be determined for the site, it illustrates that occupied burrows occur at a greater density on the plateau than the shore terrace. In addition, if similar monitoring (50 metre transects) is included in future surveys this could inform against change in character.

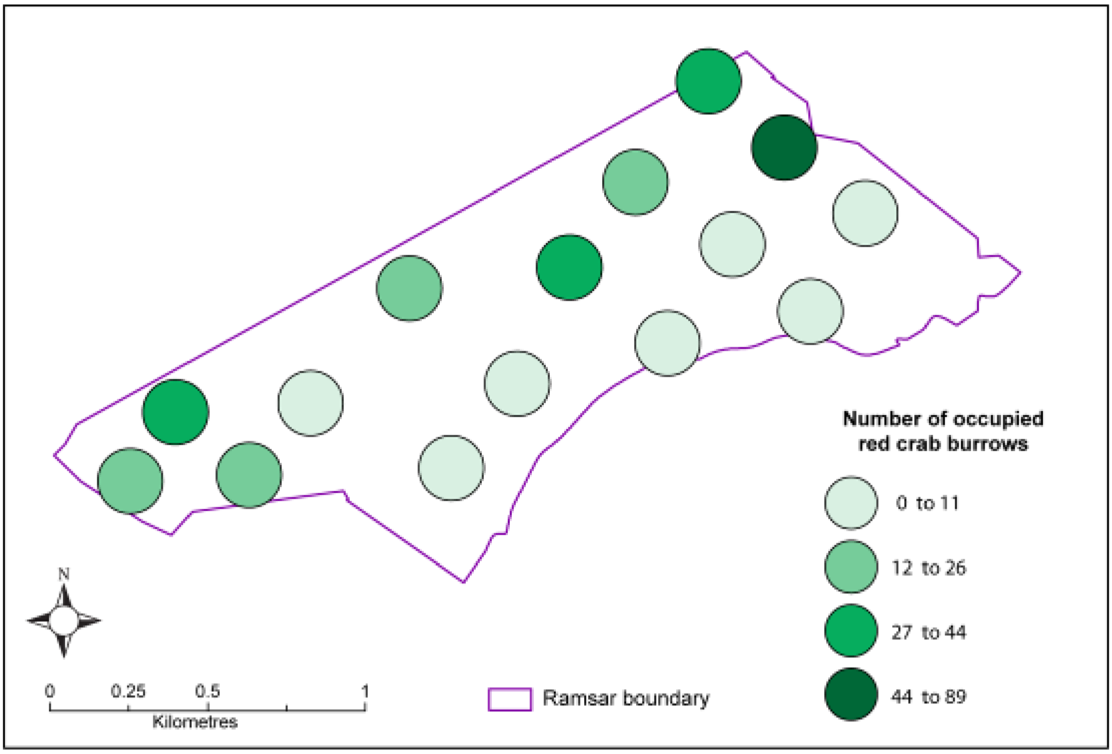



**Figure 20: Red crab burrow density per 50 metre transect within the Hosnies Spring Ramsar site (2009 island wide survey, data provided by Parks Australia).**

There are a number of other land crab species that occur on Christmas Island. However, there are no records specific to the Ramsar site. There is no quantitative information on the numbers of robber or blue crabs within the Hosnies Spring wetland or wider Ramsar site, nor any indication of population variability either seasonally or inter-annually. Descriptions of the interactions that support these crabs at the site during various stages of their lifecycles are provided in the services section (section 4).

[4] Note that baseline is not synonymous with natural and that the populations of red crabs within the Ramsar site at 2010 were impacted by yellow crazy ants (see section 5).


**Blue crab burrow at Hosnies Spring (photograph by Daniel Simon).**


**Robber crab on limestone at Hosnies Spring (photograph by Daniel Simon).**

# 4 Ecosystem services

## 4.1 Overview of benefits and services

Ecosystem benefits and services are defined under the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems" (Ramsar Convention 2005, Resolution IX.1 Annex A). This includes benefits that directly affect people such as the provision of food or water resources as well as indirect ecological benefits. The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005) defines four main categories of ecosystem services:

1. **Provisioning services** - the products obtained from the ecosystem such as food, fuel and fresh water;
2. **Regulating services** – the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation;
3. **Cultural services** – the benefits people obtain through spiritual enrichment, recreation, education and aesthetics; and
4. **Supporting services** – the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.

There is no evidence to substantiate a case for provisioning or regulating services within the Hosnies Spring Ramsar site. The site is wholly contained within a national park and the site is protected from resource harvesting. In addition, the small size of the site and its remote location makes it unlikely to play a substantial role in regulating the surrounding environment. The cultural and supporting ecosystem benefits and services of the Hosnies Spring Ramsar site are outlined in Table 6.

**Table 6: Ecosystem services and benefits provided by the Hosnies Spring Ramsar site (critical services are shaded).**

| Category | Description |
|---|---|
| **Cultural services** | |
| Recreation and tourism | While the site is open to the public, tourism is not promoted at the site. Rather, the site is managed to provide a limited number of visitors an opportunity to visit a unique wetland that is largely undisturbed by humans. |
| Scientific and educational | The unique nature of the site and the pristine condition, provide excellent opportunities for research. |
| **Supporting services** | |
| Supports near-natural wetland types | The spring at the Ramsar site is in near-natural condition and significant within the bioregion. |
| Food webs | Interactions between land crabs and mangroves form an important food web at the site. |
| Distinct wetland species | Blue crabs are reliant on the few permanent freshwater sites on Christmas Island (including Hosnies Spring) for reproduction, and for survival in the dry season. |
| Biodiversity | Supports a variety of wetland species, communities and habitats including marine, terrestrial and freshwater dependent species. |
| Ecological connectivity | Red crabs migrate from the plateau to the ocean to breed each year. |

## 4.2 Identifying critical ecosystem services and benefits

The critical ecologically based ecosystem services and benefits of a Ramsar site have been identified using the same criteria provided by DEWHA (2008a) used as a guide for selecting critical components and processes; i.e. services that at a minimum:

1. are important determinants of the site's unique character
2. are important for supporting the Ramsar criteria under which the site was listed
3. for which change is reasonably likely to occur over short or medium time scales (less than 100 years), and / or
4. that will cause significant negative consequences if change occurs.

Using these criteria it was considered that the following services could be considered "critical":

- Supports near-natural wetland types
- Food webs
- Distinct wetland species
- Biodiversity

Recreation and tourism were not considered critical to the ecological character of the site, as the site is not actively promoted for tourism and visitor access is limited. While the site is undoubtedly beneficial in terms of providing opportunities for scientific research this was not considered a "critical" service in that a reduction in research interest would not necessarily indicate a change in ecological character.

Finally, there is no evidence to suggest that the site is significant in terms of red crab migration. Red crabs migrate from the plateau to the ocean across the entire Island, and as Hosnies Spring Ramsar site connects the plateau and the ocean, it is presumed that crabs migrate across the site. However, it is not known if the site represents a significant migratory route. Therefore, while not identified as a critical ecological service, the service (ecological connectivity) is described briefly below in the event that information collected in the future indicates that this is a critical service of the site.

## 4.3 Critical services

### *4.3.1 Supports near natural wetland types*

Hosnies Spring, by virtue of its remote location and difficulty of access, has had little impact by human activities and remains in near-natural condition. The simple conceptual model (Figure 21) provides an overview of how components and processes interact to provide critical services at the site. The combination of climate, geomorphology and groundwater hydrology at the site provides a permanent expression of surface water. This is rare on Christmas Island and is essential for maintaining the populations of Bruguiera spp. mangroves and the blue crab at the site. Blue crabs rely on the freshwater in the spring to maintain respiratory function. This is particularly important during the dry season when the surrounding landscape is dry (see section 4.4.3 below). Land crabs (predominantly blue crabs and red crabs) feed on the mangrove leaves and propagules, forming the basis of an important food web at the site (see section 4.4.2).

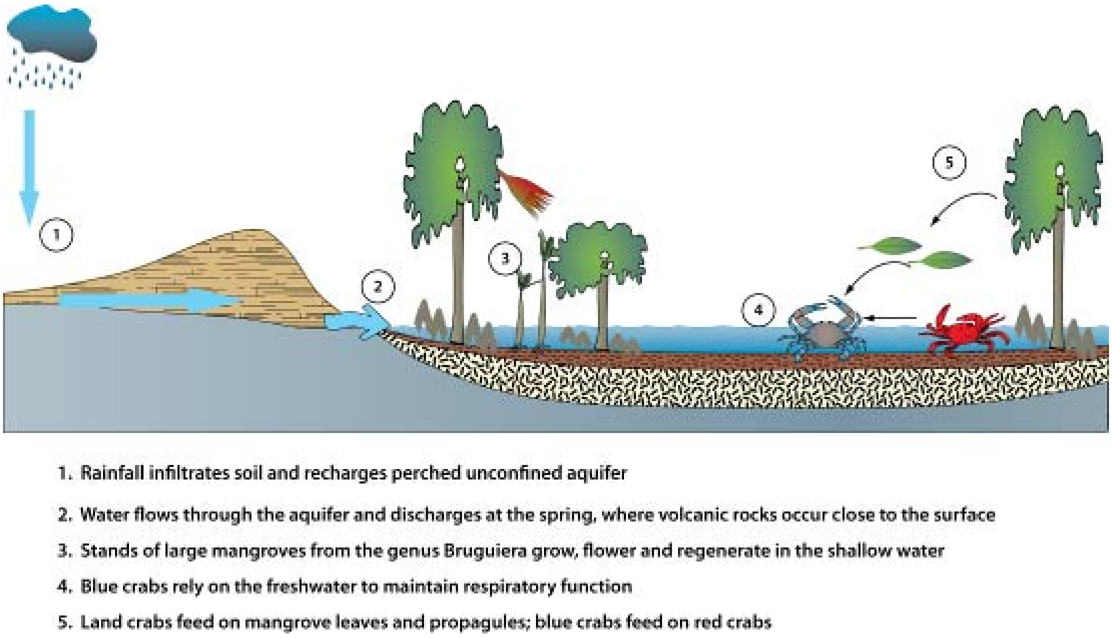



**Figure 21: Simple conceptual model of the freshwater spring at the Hosnies Spring Ramsar site showing major interactions between components, processes and services.**

### *4.3.2 Food webs*

The Christmas Island red crab is recognised as being important in maintaining terrestrial forest structure on the island (Hicks et al. 1984; Green et al. 1997). Elsewhere, crabs are known to be important in mangrove food webs (Smith et al. 1991; Sheaves and Molony 2000) and field observations indicate that this may also be true for the mangrove community at Hosnies Spring (Green et al. 2008). Woodroffe noted that red and blue crabs had burrows in or near the site and that both species were seen “attacking” leaves and propagules.

Decomposition (in the absence of detritivores) is slow in permanent aquatic ecosystems. However, by consuming the leaf litter and other biomass of mangroves at or near the site, crabs speed up the process of nutrient cycling, providing important sources of nutrients in a form available for plant uptake and growth.

Land crabs are opportunistic feeders that will consume plant material, detritus and other animals. Blue crabs are somewhat more aggressive than red crabs and have been observed predating on both live and dead red crabs (Hicks et al. 1984).

### *4.3.3 Distinct wetland species (land crabs)*

Christmas Island is renowned for its diverse and numerous land crabs. However, a large number of these are either ubiquitous across the island (such as the red crab) or restricted to habitats that are not provided by Hosnies Spring. Hosnies Spring does, however, provide significant habitat for blue crabs as a dry season refuge.

Blue crabs (similar to all land crabs of the Gecarcinidae family) have both gills and lungs for respiration. The former do not require surface water, but gills need to be kept moist to function properly. Urine is passed over the gills to maintain moister levels for respiratory function and for the renal (kidney) function of removing salts (Greenaway 1989). It has been suggested that while gas exchange could be maintained in the absence of surface water, blue crabs need to immerse in freshwater at least once a week to remove excess nitrogen from gill surfaces (Turner 2007).

During the wet season there is sufficient surface water in forests to maintain gill functioning in blue crabs and they can range over large areas of Christmas Island. However, during the dry season they are restricted to permanent freshwater sources, such as that provided by Hosnies Spring (Hicks et al. 1984). Their burrows at Hosnies intersect the water table, with the bottom part of the burrow underwater (Hicks et al. 1984).

Little is known about blue crab reproduction, juvenile recruitment and inland dispersal. Hicks et al. (1984) suggest that blue crabs require a freshwater connection to the sea to facilitate juvenile migration. As this habitat is not provided at Hosnies Spring, it would suggest that the site does not provide habitat to fulfil all lifecycle stages. However, there is anecdotal evidence that juvenile blue crabs occur at the Hosnies Spring Ramsar site (Peter Green pers. comm.) contradicting the observations of Hicks et al. (1984). This highlights the paucity of knowledge on this topic and the significance of this knowledge gap.

### *4.3.4 Biodiversity*

Island biodiversity values are quite different to mainland biodiversity values with the biogeography of isolated oceanic islands playing an important role. Key features of island biodiversity exhibited on Christmas Island are summarised in (Table 7).

**Table 7: Biodiversity characteristics of Christmas Island (modified from EWL Sciences and Tallegalla 2005).**

| Island biodiversity characteristics | Examples from Christmas Island (list not exhaustive) |
|---|---|
| The biota is usually relatively simple and species depauperate compared to corresponding areas on continental or 'island-chain' landmasses. | Flora and fauna are depauperate reflecting isolation from potential sources of colonists. |
| Endemic species are usually more abundant and comprise a greater proportion of the total biota. | Island wide the plant endemic species is not as high (18 species of 242) but may reflect a stable environment. However vertebrate endemism is very high. Endemism in the invertebrate fauna is not known. |
| Many species and species groups fill atypical ecological roles and or occupy habitats that would be dominated by very different groups of organisms on larger more interconnected landmasses. | Mangrove stand at Hosnies Spring. Red crabs are keystone consumers. |
| Individual species may dominate a trophic level that elsewhere would be occupied by many species. | Red crabs as keystone consumers. |
| Biological invasions are a pervasive feature and represent a fundamental long-term change in the dynamics and population structure of the biota. | Yellow crazy ant – scale insect infestations leading to supercolonies; giant African land snail, wolf snake. Introduced plant species constitute 42 percent of plant species. |
| Island species, especially endemics, are more vulnerable to extinction as a consequence of biological invasions and anthropogenic changes than are the more 'resilient' populations of biota of continental and interconnected landmasses. | Endemic species are particularly vulnerable as there is no possibility of immigration. The Christmas Island pipistrelle (*Pipistrellus murrayi*), which is considered to be extinct, is a prime example. |

Christmas Island, incorporating Hosnies Spring, biodiversity value does not arise from high species richness, but rather from a unique combination of species and ecosystems, in particular the crab – forest community and the mangrove stand (Expert Working Group 2009). The habitat template for the island, and Hosnies Spring is complex ranging from terrestrial rain forest, freshwater wetlands and fringing coral reefs. This diversity of habitat sets the stage for some truly unique associations and biodiversity values. For example there are a high number of endemic species present on the island, unusual associations such as supporting the unique mangrove stand and blue crabs, the marine bioregion may be a potential centre of hybridisation for fish species, and the island is home to the world renowned migration of the red crab.

It has been postulated that given the high level of endemism in the higher taxa that it is probably that there is also a high level of endemism in the lower fauna of the island as well (Expert Working Group 2009).

## 4.4 Non-critical services

### *4.4.1 Red crab migration (ecological connectivity)*

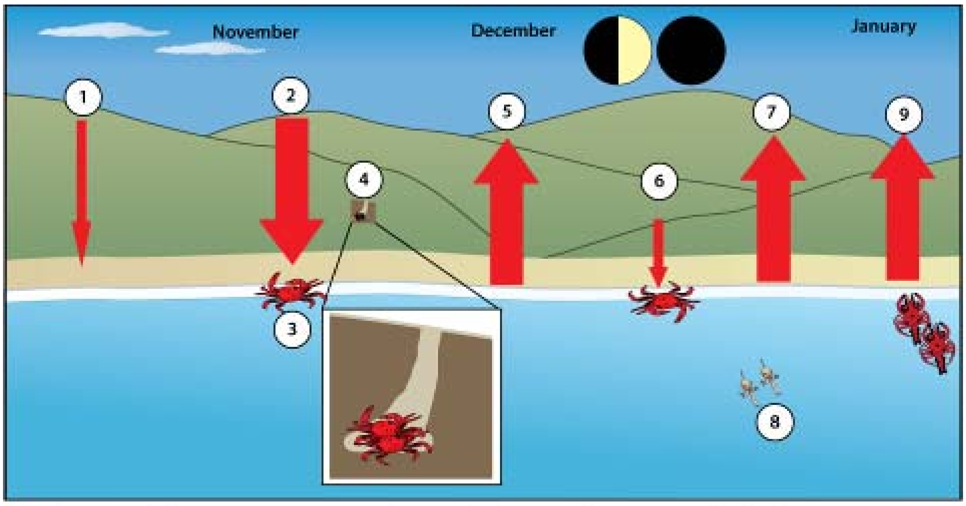
The annual red crab migration is a biological wonder, with tens of millions of crabs moving across the island during their breeding migration. Estimates of the number of red crabs on the island vary, with reports of 40 to 50 million crabs. The primary habitat for the red crab is the rain forest where densities can range from 0.4 – 1.8 crabs per metre squared with biomass estimates of up to 1519 kilogram per hectare (O'Dowd and Lake 1991; Green 1997).

They feed on fallen leaf litter, fruit and seeds removing large amounts of litter from the forest floor, removing between 39 and 87 per cent of the annual fall from the forest floor (Green et al. 1999). In some places the forest floor can appear completely clear of plant matter (O'Dowd and Lake 1989, 1991), which has been attributed to their high biomass compared to other litter invertebrates (Green et al. 1999). The red crab is considered a keystone species on the island for its role as an ecosystem engineer and consumer (Green et al. 1999; Green et al. 2008). Red crabs not only consume leaf litter, they also redistribute it across with the forest floor, moving leaf litter into and around their burrows resulting in areas with localised higher concentrations of organic matter and nutrients (O'Dowd and Lake 1989).

The key phases of the migration are presented below and illustrated in Figure 22. The breeding season lasts between three to six weeks, is usually synchronised island wide, with adult red crabs entering the migration once they reach three or more years of age and moving en masse from the forest to the ocean. Males depart first followed by the females. Early onset of the rainy season can act as a trigger for early migration; however the actual spawning is set by the lunar phase (Adamczewska and Morris 2001). On arrival at the coast both sexes dip in the ocean with large males arriving first followed by smaller males and females two to three days later. By day four to five females outnumber the males on the shorelines (Hicks et al. 1984). After dipping males retreat back to the shore terrace to excavate burrows for mating. Dipping also occurs before the males return to the higher terraces and prior to the females returning inland after spawning (Hicks 1984). Fighting over burrows occurs in the shore terrace. After mating the males return to the higher terraces, whilst the females retreat to the burrow to produce the eggs.

The females produce eggs within three days of mating and remain in the breeding burrows for 12-13 days while the eggs develop. A single female can brood up to 100 000 eggs. Spawning is tied to the lunar phase and corresponds to a low volume neap tide with females releasing their eggs toward dawn, around the turn of the high tide. Release of eggs may occur on five to six consecutive nights during the main breeding migration. After the first two days, egg-less females may be seen crossing plateau roads, kilometres from the shore (http://www.environment.gov.au/parks/christmas/nature-science/fauna/red-crabs.html).

Eggs hatch into megalopae on release into the ocean and are carried off by the tide, returning after 17 to 28 days. Megalopae accumulate at the tide line for several days before during which time they metamorphose into baby crabs. The baby crabs then begin their migration inland, joining the adult population after three years.




1. Early onset of the wet season can result in early downward migration of red crabs
2. Main migration starts in mid to late November when the wet season has commenced
3. Crabs "dip" in the ocean to take in water
4. Crabs retreat to the shore terrace to dig burrows, where they mate
5. Males return to the plateau following mating, and often another "dip" in the ocean
6. Females travel to the shore and release their eggs into the ocean, this occurs between the last quarter and new moon in December
7. Females return to the plateau following release of eggs
8. Eggs hatch at sea and pass through several larval stages (17 to 30 days)
9. In years of successful reproduction, baby crabs (megalopae) return and migrate up from the ocean in late January

**Figure 22: Conceptual model of red crab migration (modified from Hicks et al. 1984).**

**Female red crab releasing eggs into the ocean (photograph by Daniel Simon).**

# 5. Threats to Ecological Character

Wetlands are complex systems and an understanding of components and processes and the interactions or linkages between them is necessary to describe ecological character. Similarly threats to ecological character need to be described not just in terms of their potential effects, but the interactions between them. One mechanism for exploring these relationships is the use of stressor models (Gross 2003). The use of stressor models in ecological character descriptions has been suggested by a number of authors to describe ecological character (Phillips and Muller, 2006; Hale and Butcher 2008) and to aid in the determination of limits of acceptable change (Davis and Brock 2008).

Stressors are defined as (Barrett et al. 1976):

"*physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level*"

In evaluating threats it is useful (in terms of management) to separate the threatening activity from the stressor. In this manner, the causes of impacts to natural assets are made clear, which provides clarity for the management of natural resources by focussing management actions on tangible threatening activities. For example, increased macroalgae may be identified as a threat for coral communities in the reef. However, management actions cannot be targeted at increased macroalgae without some understanding of why the increase is taking place. By identifying the threatening activities that could contribute to increased macroalgae (e.g. selective fishing, removing grazers, pollution resulting in increased nutrients) management actions can be targeted at these threatening activities and reduce the impact to the wetland.

There are a number of potential and actual threats that may impact on the ecological character of Hosnies Spring Ramsar site. The stressor model (Figure 23) illustrates the major threatening activities, stressors and resulting ecological effects in Hosnies Spring Ramsar site. A description of these major threats is provided below.

**Christmas Island settlement (photograph by Daniel Simon).**

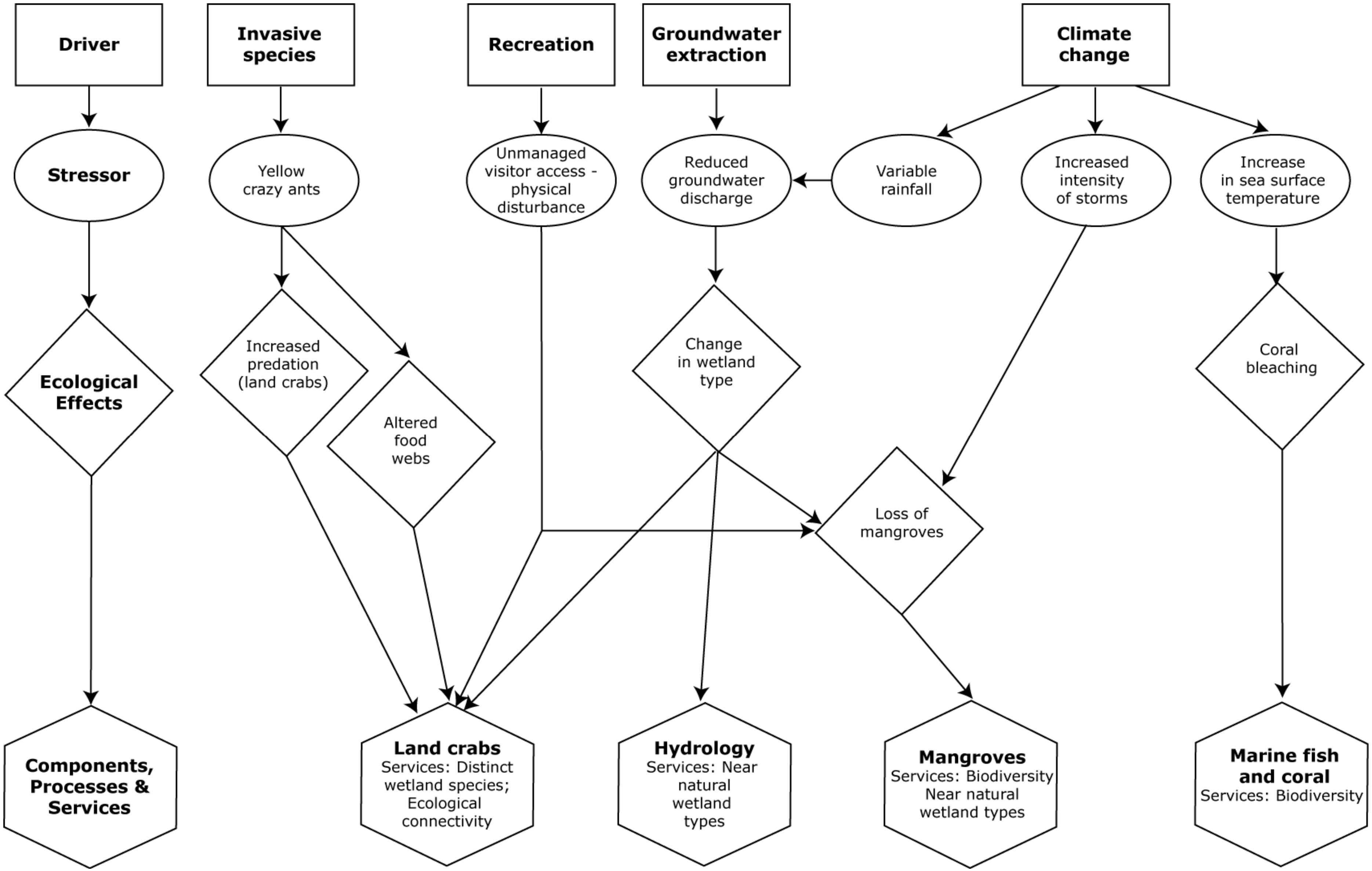



**Figure 23: Stressor model of the Hosnies Spring Ramsar site (after Gross 2003 and Davis and Brock 2008).**

## 5.1 Groundwater extraction

There is little permanent surface water on Christmas Island, and water for consumptive uses is extracted from the unconfined aquifers. The main water supply for the settlement is from the Grant's Well Karst system. However at any one time, water could be sourced from a variety of sites including Jedda Cave, Jane-up, Waterfall Spring and Ross Hill Gardens Spring (EWL Sciences and Tallegalla Consultants 2005). The system of pipe lines and storages that runs across the eastern side of the island (Figure 24) indicates the spatial extent of water resource utilisation on Christmas Island.

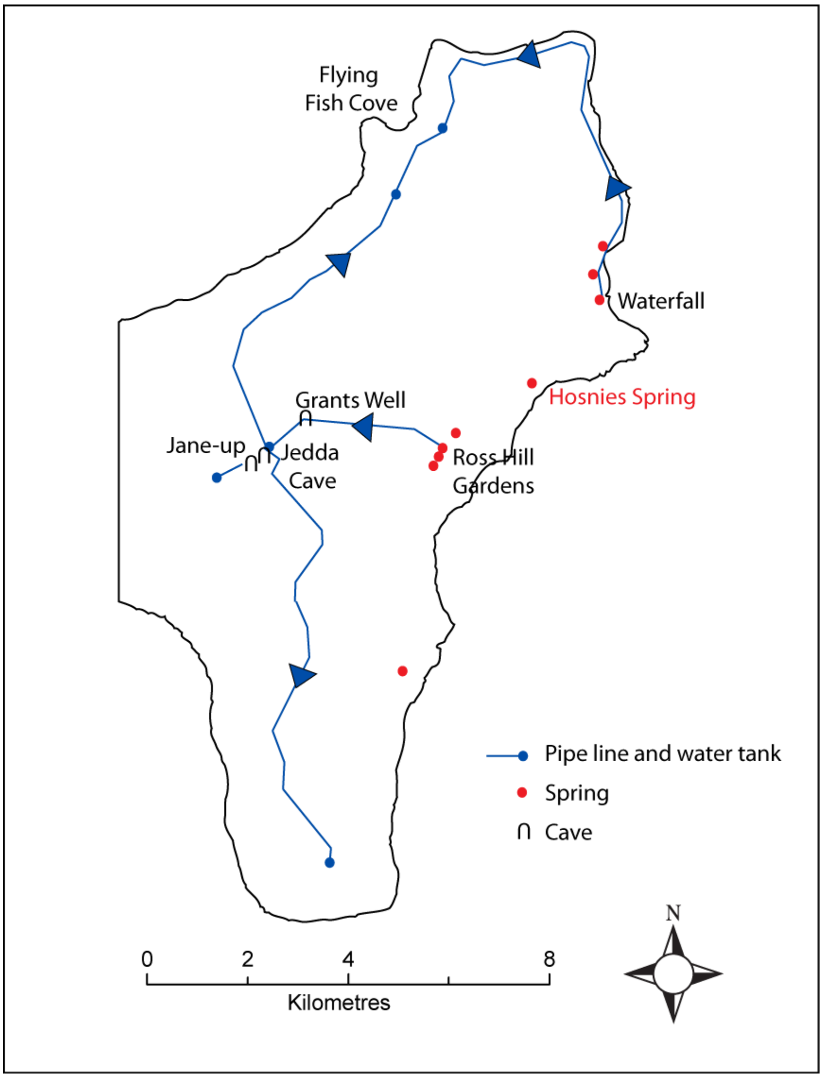



**Figure 24: Water sources and pipelines on the eastern side of Christmas Island (Barrett 2001).**

There is no information on the quantity of water extracted for consumptive purposes. However, trends in water use can be considered in terms of population fluctuations and major industrial uses on the island.

The population on Christmas Island fluctuates in response to construction and mining activities, but in 2009, was considered to be close to that at the time of listing (Figure 25). However, it should be noted that the population figures do not include fly-in fly-out workers, nor do they include residents at the immigration detention facility, which has the capacity to accommodate over 1000 people; effectively doubling the resident population (ACIL Tasman 2009). In addition, water is utilised in phosphate mining operations on the island.

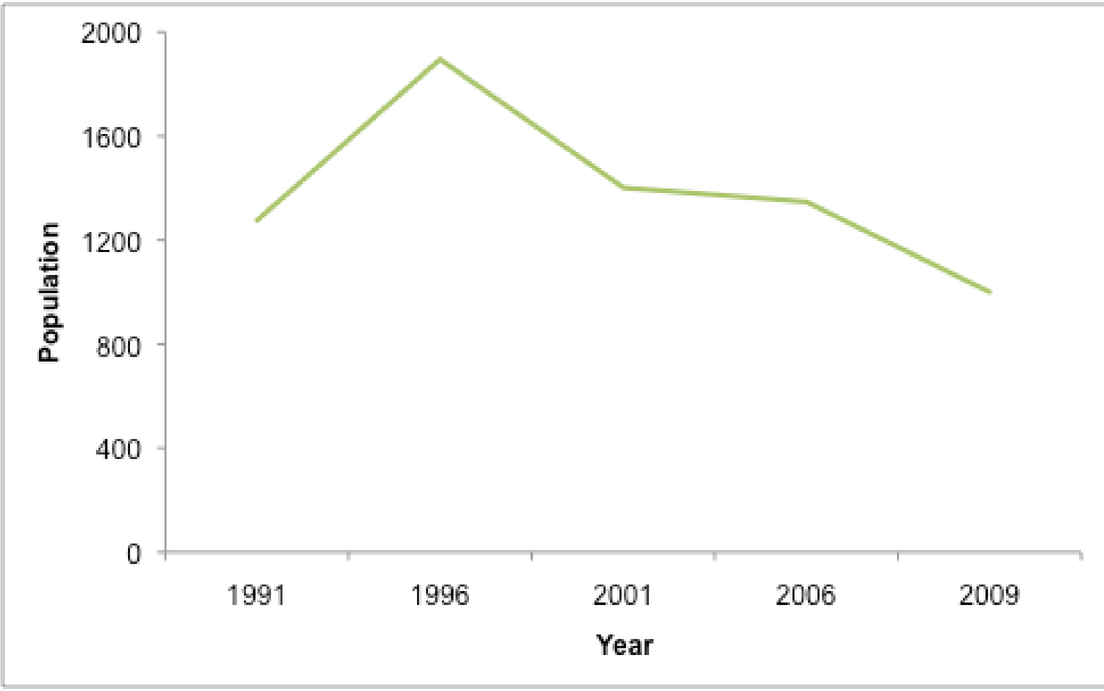



**Figure 25:Resident population of Christmas Island (ACIL Tasman 2009).**

Although water is not extracted from Hosnies Spring directly, Grimes (2001) described the groundwater resources of the island as interconnected. This suggests that extraction from water on the plateau at Grants Well or Jane-up, could impact on the discharge volumes and rates at coastal springs on the shore terrace. A significant reduction in flow, or a loss of permanent water at the Hosnies Spring Ramsar site has the potential to result in dramatic effects to the ecological character of the site, with the potential loss of the mangrove stand and severe impacts to blue crabs, both of which are reliant on permanent water.

However, the connectivity between Hosnies Spring and the aquifers from which groundwater is extracted is not understood. In addition, there is neither quantitative information on flows at the Ramsar site, nor any indication if groundwater extraction on the plateau is having effects on hydrology in the Ramsar site. This remains a significant knowledge gap.

## 5.2 Invasive species (yellow crazy ants)

Yellow crazy ants (*Anoplolepis gracilipes*) are thought to have been introduced to Christmas Island between 1915 and 1934 (O'Dowd et al. 1999). Listed as one of the top 100 worst invasive alien species in the world by the Global Invasive Species Database (2009), they have caused wide scale impacts to tropical ecosystems on Christmas Island, Hawaii and the Seychelles. Yellow crazy ants forage over a large range of habitats, including forest floor and canopy and are scavengers feeding on a range of invertebrates. They also form mutualistic associations with scale insects, harvesting carbohydrate rich honeydew. On Christmas Island the relationship between yellow crazy ants and high densities of scale insects has resulted in the formation of multi-queen "super colonies" which result in high population densities (Abbott 2005). There are nine species of scale insects on Christmas Island (Abbott and Green 2007), however two main species were involved with the advent of the super colonies, the lac scale**,** *Tachardina aurantiaca* (Kerriidae), and *Coccus celatus* (Coccidae) (Hemiptera, Homoptera, Coccoidea) (Abbott 2003; O'Dowd 2003).

The spread of the scale insects have been influenced by positive interactions with the yellow crazy ant, as indicated by experiments where crashes in scale densities corresponded with the exclusion of the yellow crazy ant (Abbott and Green 2007). Boundaries of supercolonies exhibit abrupt declines in ant densities over tens of metres, declines which are matched by in scale density on understory saplings over the same distance (Abbott and Green 2007). Whilst this association between supercolonies and high scale densities is most obvious on the forest floor, large numbers of ants also move into the canopy of the rainforest indicating that most of the ant-scale interaction occurs in the canopy (Abbott and Green 2007). In the forest canopy the ant-scale interactions leads to the development of honeydew dependent sooty moulds, declines in shoot growth, and canopy dieback (O'Dowd et al. 2003). Canopy trees appear to be variable in their susceptibility to scale infestations, with *Inocarpus fagifer* being especially hard hit by the lac scale *Tachardina aurantiaca*, leading to lower rates of seed production in adult trees, slower rates of growth in adult and juvenile trees, and higher rates of mortality in all size classes (O'Dowd et al 2003; P. Green, LaTrobe University, pers. comm.). The monospecific stands of *Inocarpus fagifer* in The Dales appears to be less susceptible than trees elsewhere in the forest, although the reason for this is unclear at present (P. Green, LaTrobe University, pers. comm.).

It has been suggested that the ants could cause chick death in nesting Abbott's booby, but there has been no observations of this occurring (Commonwealth of Australia 2001), however some evidence exists that shows no detectable impact on the number or success of breeding pairs in areas with supercolonies (P. Green unpublished data). Christmas Island frigatebirds are considered to be especially at risk from yellow crazy ants as they have limited nesting sites which all occur within the shore terrace, the forest type in which the majority of supercolonies are found (Hill and Dunn 2004). Davis et al. (2008) also noted declines in two endemic landbirds reflecting direct interference by ants and altered resource availability and habitat structure caused indirectly by ant invasion. The ants have a severe impact on all ground dwelling fauna including reptiles and invertebrates including the red, blue and robber crabs.

In invaded areas, yellow crazy ants swarm over all surfaces; and in addition to harvesting honey dew they kill and feed on, amongst other things, large numbers of red crabs. The ants have a severe impact on all ground dwelling fauna, however the most notable is the impact on the red crabs. It is estimated that 10 – 15 million red crabs (over one-third of the entire population) have been killed by the yellow crazy ant (O'Dowd et al. 2003). Crazy ants spray formic acid in the eyes and mouth parts of the crabs, killing them within 48 hours. The super colonies then spread occupying red crab burrows, consuming resident crabs and using the burrows as nest sites (O'Dowd et al. 2003).

The red crab is considered a keystone species on the island playing an important role in maintaining forest structure. The foraging of red crabs on seedlings and leaf litter results in open understorey structure and bare soils with littler leaf litter. In areas where yellow crazy ants have invaded, and red crab numbers are diminished, forest structure is changed with dense seedling cover and a thick layer of leaf litter (O'Dowd et al. 2003). There is evidence that this has a further effect in facilitating the increase in the populations of two additional introduced species the giant African land snail (*Achatina fulica*) and the giant centipede (*Scolopendra morsitans*). The increased litter on the forest floor provides habitat for these invasive invertebrates, which coupled by a lack of predation by red crabs, results in increased populations of both invasive species (O'Dowd and Green 2010). These processes are illustrated conceptually in Figure 26.

Results of island wide surveys (Parks Australia unpublished) indicate that yellow crazy ant super colonies are present within the Hosnies Spring Ramsar site and that this has resulted in decreases in red crabs. Yellow crazy ants were observed within the mangrove stand in the 1990s. However, the mangrove may not be a good host for the scale insect and the ants have not significantly impacted on the mangrove stand at the site (Peter Green, pers. comm.). In addition, blue crabs appear to be less affected by the ants, perhaps due to the water within their burrows diluting the formic acid.

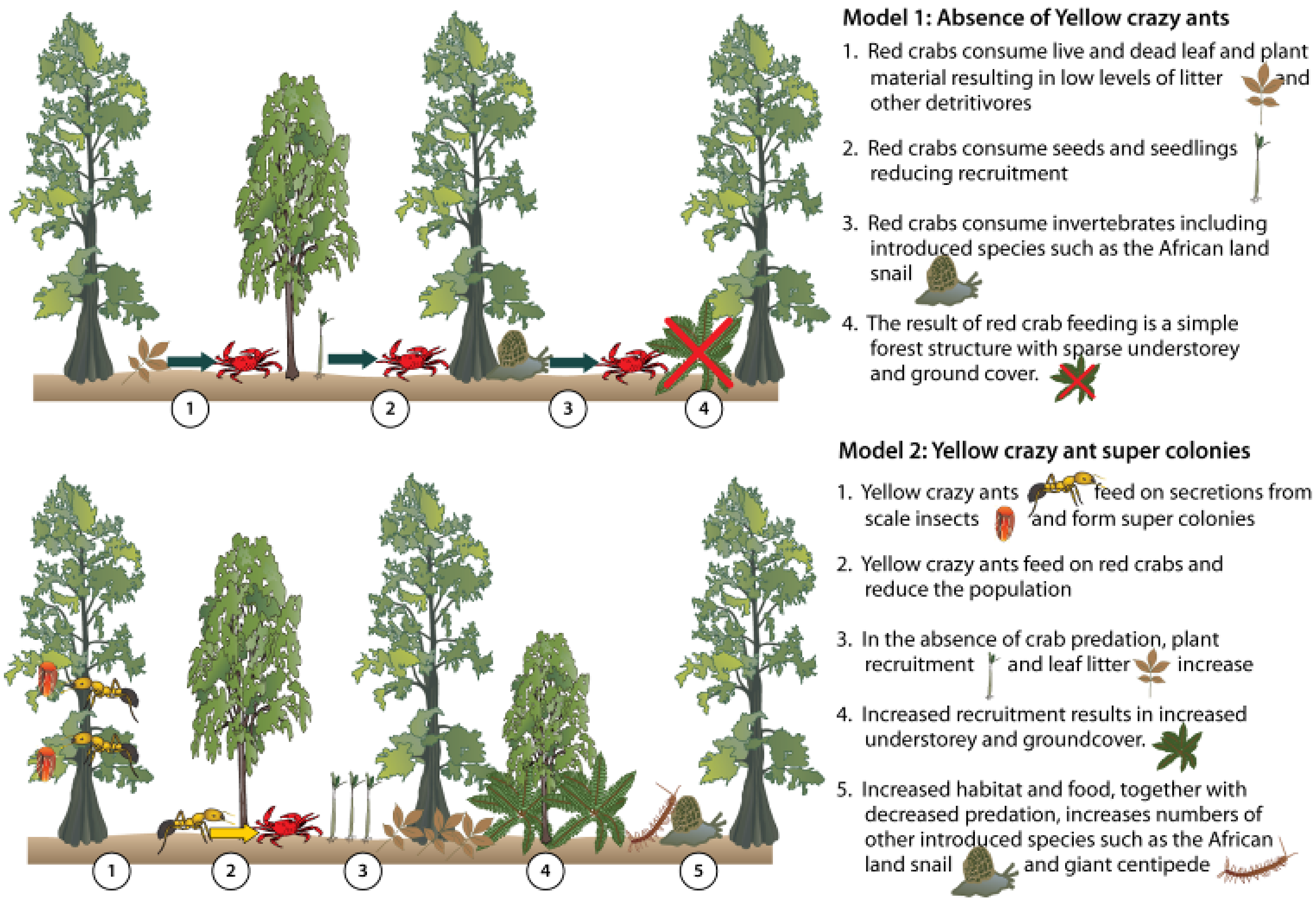



**Figure 26: Conceptual diagram of effects on yellow crazy ants on red crabs and vegetation.**

## 5.3 Recreation

Although tourism at the Hosnies Spring Ramsar site is not activity promoted, the site is not closed to the public. To maintain the natural state of the site, there is no infrastructure or formed walking track access. This may deter casual visitors from entering the site, but does not prevent determined visitors.

Visitor access of small, interest groups such as bird watchers, or scientific teams is managed by Parks Australia to conserve the ecological character of the site. The increase in the population of Christmas Island has resulted in more people seeking recreational activities during non-work hours. Unmanaged site visitation by large numbers of visitors has the potential to negatively impact on the freshwater spring through physical disturbance and trampling of vegetation and seedlings.

## 5.4 Climate change

There are a variety of climate change predictions for Christmas Island (McInnes et al. 2008), those of direct relevance to the Hosnies Spring Ramsar site are related to rainfall, tropical storms and sea temperature. In general it is thought that the intensity (if not the frequency) of tropical storms could increase and sea surface temperatures will rise by up to 2.5 degrees Celsius by 2070 (McInnes et al. 2008).

There is uncertainty in the predicted change in climate for Christmas Island, and it is not known if rainfall will decrease or increase by a small amount. However, the consequences of a potential decrease in rainfall are significant and will exacerbate any increases in groundwater extraction for consumptive uses (described in section 5.2). The water source for Hosnies Spring is an unconfined aquifer that is recharged each wet season by rainfall (see section 3.3.1 above). A significant reduction in rainfall could result in reduced groundwater flow and a reduction in the extent and duration of surface water at the site. The mangroves at Hosnies Spring are reliant on the permanent freshwater for regeneration and survival. A loss of permanent water could result in a complete loss of the mangrove stand. Loss of permanent water would also affect the survival of the blue crab, which is reliant on freshwater springs such as Hosnies to survive during the dry season (Hick et al. 1984).

Tropical storms, with strong winds, have the potential to cause direct physical damage to the mangroves at the site. The isolated nature of the mangrove stand makes them vulnerable to storm impacts, as there would be little or no opportunity for recovery in the event that the small stand was to be cleared by an intense storm. The recent warming of annual average sea surface temperatures in the vicinity of Christmas Island is likely to continue and accelerate in the future (McInnes et al. 2008). Annual average sea surface temperatures are likely to increase by 0.4 to 0.9 degrees Celsius by 2030 and by 1.7 to 2.5 degrees Celsius by 2070, with increases across all seasons of a similar magnitude of warming (McInnes et al. 2008). The predicted increases in sea temperature are likely to impact on the marine communities of Christmas Island in a number of ways. Firstly, outbreaks of coral disease, particularly White Syndrome, have been linked to increased water temperatures. There was an outbreak of this destructive disease at Christmas Island in February 2008 when water temperatures were high. This outbreak was specific to plate corals and infected 13 percent of these corals around the island and up to 43 percent at some locations (Hobbs and Frisch, 2010). The disease resulted in widespread mortality of plate corals, and the loss of this habitat and food source caused significant declines in abundance of some fishes (Hobbs unpublished data).

Arguably the biggest threat to coral reefs from increasing sea temperature is coral bleaching. The heat-induced stress causes a breakdown in the relationship between corals and their symbiotic algae that can lead to widespread coral mortality. Coral bleaching caused significant mortality at Christmas Island in 1997, 1988 and also during March and April 2010 (Jean-Paul Hobbs, pers. comm.; Figure 27). Initial surveys of the 2010 event indicate eight percent of corals have bleached so far, with 29 percent affected in some locations. In addition, 70 percent of *Cryptodendrum adhaesivum* anemones were bleached and this threatens the future of the anemone fish (*Amphiprion clarkii*) that relies on its host anemone.

Species that rely on specific habitats will be affected the most by changes in coral reefs associated with warming oceans. This is already evident at Christmas Island, where the longnose filefish (*Oxymonacanthus longirostris*) appears to have recently gone extinct due to the loss of its habitat (Hobbs et al. in press). Fishes and many calcareous organisms such as corals will also be negatively affected by the increasing acidity of the oceans associated with global warming (Hoegh-Guldberg et al. 2007; Munday et al. 2008)

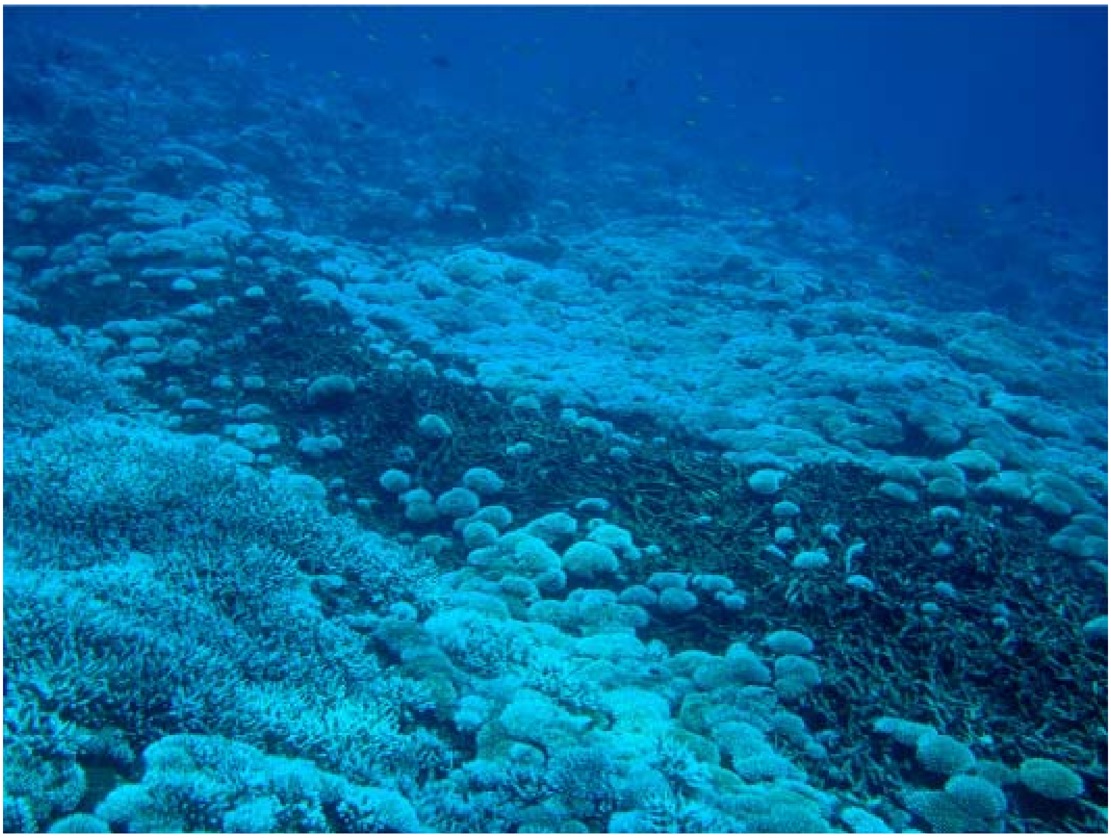


**Figure 27: Example of bleached corals at Christmas Island (photograph by Jean-Paul Hobbs)**

## 5.5 Summary of threats

Although a risk assessment is beyond the scope of an ECD, the DEWHA (2008a) framework states that an indication of the impacts of threats to ecological character, likelihood and timing of threats should be included. The major threats considered in the previous sections have been summarised for each location within the Ramsar site in accordance with the DEWHA (2008a) framework Table 8.

**Table 8: Summary of the main threats to the Hosnies Spring Ramsar site.**

| Actual or likely threat | Potential impact(s) to wetland components, processes and/or service | Likelihood[1] | Timing |
|---|---|---|---|
| Groundwater extraction | Decrease in flow and loss of permanent surface water. This would result in a loss of mangroves and blue crabs. | Medium | Current |
| Invasive species: yellow crazy ants | Predation on crabs, resulting in alteration to the forest ecosystems and consequent increase in other invasive species. | Certain | Current |
| Recreation | Unmanaged visitor access may reduce mangrove condition and reduce recruitment success. | Medium | Medium to long term |
| Climate change – potentially reduced rainfall | Reduced recharge of aquifer and loss of freshwater. Corresponding loss of habitat for mangroves and blue crabs. | Medium | Medium to long term |
| Climate change – increased storms | Direct physical damage to mangroves, potential loss of entire stand. | Medium | Medium to long term |
| Climate change – increased sea surface temperature | Increase in coral bleaching and disease. | Medium | Long-term |

[1] Where Certain is defined as known to occur at the site or has occurred in the past Medium is defined as not known from the site but occurs at similar sites; and Low is defined as theoretically possible, but not recorded at this or similar sites.

# 6. Limits of Acceptable Change

## 6.1 Process for setting Limits of Acceptable Change (LAC)

Limits of acceptable change (LAC) are defined by Phillips (2006) as:

*"…the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameter, etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character that could lead to a reduction or loss of the values for which the site was Ramsar listed. In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed".*

LAC and the natural variability in the parameters for which limits are set are inextricably linked. Phillips (2006) suggested that LAC should be beyond the levels of natural variation. Setting limits in consideration with natural variability is an important, but complex concept. Wetlands are complex systems and there is both spatial and temporal variability associated with all components and processes. Defining this variability such that trends away from "natural" can be reliably detected is far from straight forward.

Hale and Butcher (2008b) considered that it is not sufficient to simply define the extreme measures of a given parameter and to set LAC beyond those limits. What is required is a method of detecting change in pattern and setting limits that indicate a distinct shift from natural variability (be that positive or negative). This may mean accounting for changes in the frequency and magnitude of extreme events, changes in the temporal or seasonal patterns and changes in spatial variability as well as changes in the mean or median conditions.

It should be noted that LAC are not synonymous with management values or "trigger levels". The LAC described here represents what would be considered a change in ecological character at the site in absolute terms with no regard for detecting change prior to irrevocable changes in wetland ecology. Detecting change with sufficient time to instigate management actions to prevent an irrevocable change in ecological character is the role of wetland management and the management plan for a site must develop and implement a set of management triggers with this aim.

## 6.2 LAC for the Hosnies Spring Ramsar site

LAC have been set for the Hosnies Spring Ramsar site based on conditions at the time of listing (Table 9). Where possible, site specific information has been used to determine quantitative LAC. In the absence of sufficient site specific data, LAC are based on recognised standards or information in the scientific literature that is relevant to the site. In all these cases, the source of the information upon which the LAC has been determined is provided. However, it should be noted that there is very limited data for this site and in the most part, qualitative LAC based on the precautionary principle have been recommended and will require careful review with increased information gained from future monitoring.

LAC are required for all identified critical components, processes, benefits and services. However, due to the interrelated nature of components, processes and services a single LAC may in fact account for multiple components, process and services. For example, the LAC that addresses the mangroves and hydrology at Hosnies Springs also covers the critical service of near natural wetland types. If either the mangroves and/or hydrology were significantly altered this would lead to a loss of the service. In order to limit repetition in the LAC for Hosnies Spring a hierarchical approach has been adopted where LAC have been set for components, which in this case has also covered critical services.

The columns in Table 9 contain the following information:

| | |
|---|---|
| **Primary critical Component / Process for the LAC** | The component or processes that the LAC is a direct measure of. |
| **Baseline / supporting evidence** | Relevant baseline information (relevant to the time of listing) and any additional supporting evidence from the scientific literature and / or local knowledge. |
| **Limit of Acceptable Change** | The LAC stated as it is to be assessed against. |
| **Confidence level** | The degree to which the authors are confident that the LAC represents the point at which a change in character has occurred. Assigned as follows:<br><br>High – Quantitative site specific data; good understanding linking the indicator to the ecological character of the site; LAC is objectively measurable.<br><br>Medium – Some site specific data or strong evidence for similar systems elsewhere derived from the scientific literature; or informed expert opinion; LAC is objectively measurable.<br><br>Low – no site specific data or reliable evidence from the scientific literature or expert opinion, LAC may not be objectively measurable and / or the importance of the indicator to the ecological character of the site is unknown. |
| **Secondary critical components/ processes/services addressed through this LAC** | These are other critical components, processes or services that are protected indirectly by the LAC. |

**Table 9: Proposed Limits of Acceptable Change for the Hosnies Spring Ramsar site.**

| Primary critical Component / Process for the LAC | Baseline/Supporting Evidence | Limit of Acceptable Change | Confidence level | Secondary critical components/ processes/services addressed through this LAC |
|---|---|---|---|---|
| Hydrology | Hosnies Spring in an example of a land based spring discharge of the perched aquifer. Water discharges from a number of discrete locations and saturates the soil for an area of approximately 3300 square metres (Parks Australia 1998). Although flow rates are not known, the spring is a permanent water source and remains flowing through the dry season (Woodroffe 1988). | *No loss of permanence of the spring and extent of surface water to remain greater than 0.3 hectares.* | High | Service:<br>• Near natural wetland types |
| Mangroves | Stand of mangroves from the genus Bruguiera covers the majority of the wetland.<br>Comprises a range of size classes with evidence of active regeneration.<br>A number of very large trees (large than typical for the species), with the largest tree measuring 82 centimetres dbh and exceeding 40 metres.<br>Between 300 and 600 trees in total (greater than 2.5 centimetres dbh) and a density of between 10 and 20 trees per 100 square metres (Woodroffe 1988). | • *Tree density (trees greater than 2.5 centimetres diameter at breast height) to be at least 10 trees per 100 square metres.*<br>• *Seedlings and saplings present as indicators of active regeneration.* | High | Services:<br>• Near natural wetland types<br>• Biodiversity |
| Land crabs | Supports large at least three species (Woodroffe 1988):<br>• Red crabs (*Gecarcoidea natalis*);<br>• Robber crabs (*Birgus latro*); and<br>• Blue crabs (*Discoplax hirtipes*)<br>There is information on red crab burrow density within the Ramsar site from the Island wide survey in 2009 (data provided by Parks Australia). Although this does not allow for population calculations, it could be used as a baseline against which future change in red crab densities could be assessed | • *Blue crabs present at the site during the dry season*<br>• *Red crabs and robber crabs present at the site for at least part of their lifecycle.* | Low | Services:<br>• Food webs<br>• Distinct wetland species<br>• Biodiversity |

# 7. Current Ecological Character and Changes Since Designation

In 2010 the boundary of Hosnies Spring was expanded from 0.33 hectares to 202 hectares. This extension increased the boundary of the Ramsar site to match that of the national park boundary on the eastern side of Christmas Island. This additional area around the original 0.33 hectares gives greater protection to the unique and ancient freshwater mangrove stand.

There is no evidence that there has been any change to the hydrology, geomorphology or biota at Hosnies Spring since listing. The threats of groundwater extraction and yellow crazy ants were present at the time of listing and there is no evidence that there have been significant changes since. There is insufficient site specific information to assess the original Ramsar site against the LAC contained in Table 9, but anecdotally there has been no change in ecological character at the site.

# 8. Knowledge Gaps

Throughout the Ecological Character Description for the Hosnies Spring Ramsar site, mention has been made of knowledge gaps and data deficiencies for the site. While it is tempting to produce an infinite list of research and monitoring needs for this wetland system, it is important to focus on the purpose of an ecological character description and identify and prioritise knowledge gaps that are important for describing and maintaining the ecological character of the system.

Knowledge gaps that are required to fully describe the ecological character of this site and enable rigorous and defensible limits of acceptable change to be met are relatively few and listed in Table 10. Collection of information at Hosnies Spring Ramsar site is difficult due to the remote location and difficulty of access. In recognition of this, recommended actions are aimed at developing indicators of ecological character that could fill knowledge gas and help in the design of on going monitoring.

**Table 10: Knowledge Gaps for Hosnies Spring Ramsar site**

| Component / process | Knowledge Gap | Recommended Action |
|---|---|---|
| Hydrology | • Flow rates at the spring including seasonal variability.<br>• Extent and duration of inundation at the site. | • Monitor flow rates at the spring on a monthly basis.<br>• Measure the extent and depth of inundation in wet and dry season. |
| | Connectivity between groundwater source for Hosnies Spring and the groundwater resources used for human consumption. | • Ongoing groundwater monitoring and investigations. An assessment of the sustainable extraction volumes from groundwater. |
| Mangroves | Changes in community composition, age classes and regeneration since the initial survey of Woodroffe in 1988. | Repeat survey of mangrove extent, age classes and regeneration every 5 to 10 years. |
| Land crabs | • Quantitative information on crab densities and the importance of the site for different crab species (including breeding migrations).<br>• The lifecycle dynamics of blue crabs and the significance of the Ramsar site for reproduction. | • Survey of crab burrow density within the Ramsar site.<br>• Scientific studies on blue crab reproduction on juvenile dispersal. |
| Waterbirds | The importance of the expanded site for waterbird species – breeding in terrestrial forest, or on sea cliffs; feeding in the marine areas. | Surveys of waterbirds within the Ramsar site, including the sea cliffs. |
| Marine environment | Complete knowledge gap, there is no site specific information on any marine features in the site, including the number of species, types of habitat and any special ecological features. | Surveys of marine habitat and fauna, within the Ramsar site boundary. |
| Site use | Quantitative information on visitors to the site and the impact they may be having to the spring portion of the expanded Ramsar site. | Assessment of visitor numbers. |

# 9. Monitoring needs

As a signatory to the Ramsar Convention, Australia has made a commitment to protect the ecological character of its Wetlands of International Importance. Under Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* a person must not take an action that has, will have or is likely to have a significant impact on the ecological character of a declared Ramsar wetland. While there is no explicit requirement for monitoring the site, in order to ascertain if the ecological character of the wetland site is being protected a monitoring program is required.

A comprehensive monitoring program is beyond the scope of an ECD. What is provided is an identification of monitoring needs required to both set baselines for key components and processes and to assess against limits of acceptable change. It should be noted that the focus of the monitoring recommended in an ECD is an assessment against LAC and determination of changes in ecological character. This monitoring is not designed as an early warning system whereby trends in data are assessed to detect changes in components and processes prior to a change in ecological character of the site. This must be included in the management plan for the site.

The recommended monitoring to meet the obligations under the Ramsar and the EPBC Act with respect to Hosnies Spring Ramsar site are provided in Table 11.

**Table 11: Monitoring needs for Hosnies Spring Ramsar site**

| Component/Process | Purpose | Indicator | Locations | Frequency | Priority |
|---|---|---|---|---|---|
| Hydrology | Set baseline, refinement of LAC, assessment against LAC | Flow | Hosnies Spring | Monthly | High |
| | Set baseline, refinement of LAC, assessment against LAC | Extent and duration of inundation | Hosnies Spring | Seasonally | High |
| Vegetation - mangroves | Establishment of variability detection of change, refinement of LAC | Species composition, age-classes, tree density (as per methods of Woodroffe 1988) | Hosnies Spring | Every five to ten years | High |
| Land crabs | Establishment of variability detection of change, refinement of LAC | Crab burrow density – blue crab | Hosnies Spring | Every two years | Medium |
| | Establishment of variability detection of change, assessment of threats (yellow crazy ants) refinement of LAC | Crab burrow density – red crabs | Entire Ramsar site | Every two years | Medium |
| Yellow crazy ants | Assessment of threat | Super colony presence and location | Entire Ramsar site | Every two years | High |
| Marine environment | Establishment of baseline, informing the development of LAC, detection of change | Benthic habitat, fish and invertebrate diversity and abundance | Marine portion of the site | Every two to five years | Medium |
| Waterbirds (including sea birds) | Establishment of baseline | Survey of habitats: spring, terrestrial forest, sea cliffs | Entire Ramsar site | Every two to five years | Low |
| Visitors | Assessment of threat | Survey of visitor numbers | Hosnies Spring | Continuous | Medium |

# 10. Communication and Education Messages

Under the Ramsar Convention a Program of Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. At the Conference of Contracting Parties in Korea in 2008, a resolution was made to continue the CEPA program in its third iteration for the next two triennia (2009 – 2015).

The vision of the Ramsar Convention's CEPA Program is: "People taking action for the wise use of wetlands." To achieve this vision, three guiding principles have been developed:

a) The CEPA Program offers tools to help people understand the values of wetlands so that they are motivated to become advocates for wetland conservation and wise use and may act to become involved in relevant policy formulation, planning and management.
b) The CEPA Program fosters the production of effective CEPA tools and expertise to engage major stakeholders' participation in the wise use of wetlands and to convey appropriate messages in order to promote the wise use principle throughout society.
c) The Ramsar Convention believes that CEPA should form a central part of implementing the Convention by each Contracting Party. Investment in CEPA will increase the number of informed advocates, actors and networks involved in wetland issues and build an informed decision-making and public constituency.

The Ramsar Convention encourages that communication, education, participation and awareness are used effectively at all levels, from local to international, to promote the value of wetlands.

A comprehensive CEPA program for an individual Ramsar site is beyond the scope of an ECD, but key communication messages and CEPA actions, such as a community education program, can be used as a component of a management plan.

The management plan for the Christmas Island National Park contains a number of key communication messages and a program for implementing community education. Key CEPA messages for Hosnies Spring Ramsar site arising from this ECD, which should be promoted through this program, include:

- the fragility of the unique 120 000 year old mangrove stand that, although contained within a National Park, is still vulnerable to external threats both natural (storms) and human induced (water resource use and groundwater extraction);

- the connectivity between groundwater resources on the island and the potential effects of over extraction on the flora and fauna dependant on freshwater at the site;

- the dependence of the blue crab on this freshwater resources; and

- the importance of low impact tourist activities at this remote site.

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# Appendix A: Methods

## A.1 Approach

The method for compiling this ECD comprised of the following tasks:

**Project Inception:**
Consultant team leader Jennifer Hale met with the Department of Sustainability, Environment, Water, Population and Communities(DSEWPaC) project manager to confirm the scope of works and timelines as well as identifying relevant stakeholders that would be consulted.

**Task 1: Review and compilation of available data**
The consultant team undertook a thorough desktop review of existing information on the ecology of the Hosnies Spring Ramsar site. In addition, data was provided by Parks Australia, Peter Green (Latrobe University) and Jean-Paul Hobbs (James Cook University).

**Task 2: Stakeholder engagement and consultation**
A Steering Committee was formed for Hosnies Spring Ramsar site ECD. This group was comprised of the stakeholders with an interest in the ECD and management planning process and included representatives of the following organisations:

Department of Sustainability, Environment, Water, Population and Communities

- Parks Australia, Planning, Tourism and National Landscapes Section
- Parks Australia, Christmas Island National Park
- Water Reform Division, Wetlands Section

Members of the Steering Committee provided verbal and written comments on drafts of the ECD.

**Task 3: Development of a draft ECD**
Consistent with the national guidance and framework (2008) the following steps were undertaken to describe the ecological character of the Hosnies Spring Ramsar site.

| Steps from the national draft (2008) framework | Activities |
|---|---|
| 1. Document introductory details | Prepare basic details: site details, purpose, legislation |
| 2. Describe the site | Based on the Ramsar RIS and the above literature review describe the site in terms of: location, land tenure, Ramsar criteria, wetland types (using Ramsar classification). |
| 3. Identify and describe the critical components, processes and services | • Identify all possible components, services and benefits.<br>• Identify and describe the critical components, services and benefits responsible for determining ecological character. |
| 4. Develop a conceptual model of the system. | Two types of models were developed for the system:<br>• A series of control models that describe important aspects of the ecology of the site, including feedback loops. Aiding in the understanding of the system and its ecological functions.<br>• A stressor model that highlights the threats and their effects on ecological components and processes. Aiding in understanding management of the system. |
| 5. Set Limits of Acceptable Change | For each critical component process and service, establish the limits of acceptable change. |
| 6. Identify threats to the site | This process identified both actual and potential future threats to the ecological character of the wetland system. |
| 7. Describe changes to ecological character since the | This section describes in quantitative terms (where possible) changes to the wetlands since the initial listing in |

| Steps from the national draft (2008) framework | Activities |
|---|---|
| time of listing | 1990. |
| 8. Summarise knowledge gaps | This identifies the knowledge gaps for not only the ecological character description, but also for its management. |
| 9. Identify site monitoring needs | Based on the identification of knowledge gaps above, recommendations for future monitoring are described. |
| 10. Identify communication, education and public awareness messages | Following the identification of threats, management actions and incorporating stakeholder comments, a general description of the broad communication / education messages are described. |

**Task 4: Revision of the Ramsar Information Sheet (RIS)**
The information collated during Task 1, together with the draft Ecological Character Description was used to produce a revised RIS in the standard format provided by Ramsar.

**Task 5 Finalising the ECD and RIS**
The draft ECD and RIS were submitted to DSEWPaC, and the Steering Committee for review. Comments from agencies and stakeholders were incorporated to produce revised ECD and RIS documents.

## A.2 Consultant Team

***Jennifer Hale (team leader)***
Jennifer has over twenty years experience in the water industry having started her career with the State Water Laboratory in Victoria. Jennifer is an aquatic ecologist with expertise in freshwater, estuarine and near-shore marine systems. She is qualified with a Bachelor of Science (Natural Resource Management) and a Masters of Business Administration. Jennifer is an aquatic ecologist with specialist fields of expertise including phytoplankton dynamics, aquatic macrophytes, sediment water interactions and nutrient dynamics. She has a broad understanding of the ecology of aquatic macrophytes, fish, waterbirds, macroinvertebrates and floodplain vegetation as well as geomorphic processes. She has a solid knowledge of the development of ecological character descriptions and has been involved in the development of ECDs for Port Phillip Bay and Bellarine Peninsula, the Peel-Yalgorup, the Ord River Floodplain, Eighty-mile Beach, the Coorong and Lakes Alexandrina and Albert, Lake MacLeod, Elizabeth and Middleton Reefs, Ashmore Reef and the Coral Seas Ramsar sites.

***Rhonda Butcher***
Rhonda is considered an expert in wetland ecology and assessment. She has a BSc (hons) and a PhD in Wetland Ecology together with over twenty years of experience in the field of aquatic science. She has extensive experience in biological monitoring, biodiversity assessment, invertebrate ecology as well as wetland and river ecology having worked for CSIRO/Murray Darling Freshwater Research Centre, Monash University/CRC for Freshwater Ecology, Museum of Victoria, Victorian EPA and the State Water Laboratories of Victoria. Rhonda has worked on numerous Ramsar related projects over the past eight years, including the first pilot studies into describing ecological character. She has subsequently co-authored, provided technical input, and peer reviewed a number of Ecological Character Descriptions. She was project managed the preparation of Ramsar nomination documents for Piccaninnie Ponds Karst Wetlands in South Australia, which included preparation of the ECD, RIS and Ramsar Management Plan and managed the ECD for Banrock Station Wetland Complex. Other ECD project's Rhonda has had technical input to include the Coorong and Lakes Alexandrina and Albert, Lake MacLeod, Peel-Yalgorup, Eighty-mile Beach, Port Phillip Bay and Lake Albacutya.

***Halina Kobryn***
Dr Halina Kobryn has over fifteen years of experience in applications of GIS and remote sensing in environmental applications. She is a GIS and remote sensing expert, specialising in natural resource assessment. Dr Kobryn has a BSc in Physical Geography and Cartography, Graduate Diploma in Surveying and Mapping and a PhD which explored impacts of stormwater

on an urban wetland and explored GIS methods for such applications. She has worked at a university as a lecturer for over 15 years and taught many subjects including GIS, remote sensing, environmental monitoring and management of aquatic systems. She has developed the first course in Australia (at a graduate level) on Environmental Monitoring. She has been involved in many research and consulting projects and her cv outlines the breadth of her expertise. She has also supervised over 20 research students (honours, Masters and PhD). She has worked in Indonesia, Malaysia (Sarawak) and East Timor on projects related to water quality and river health.

***Peter Green***
Dr Peter Green is an ecologist with a broad range of interests, including forest ecology, plant-animal interactions, seed and seedling ecology, invasion biology, and the ecological strategies of plants. Peter is a senior lecturer in the Department of Botany at Latrobe University. Peter has been involved in the study of red land crabs, invasive yellow crazy ants and scale insects as biotic filters to the local assembly of rainforest seedling communities on Christmas Island for over a decade.

***Jean-Paul Hobbs***
Jean-Paul is a marine ecologists specialising in the ecology of tropical coral reefs and in particular isolated island systems. He is a member of the ARC Centre of Excellence for Coral Reef Studies and a lecturer at James Cook University in Queensland. He has undertaken extensive surveys and research into the marine environments at Christmas Island and Cocos Island. He is currently finishing a report to Parks Australia on the status of North Keeling Ramsar site at Cocos and the loss of marine diversity and local extinctions that have recently occurred in this wetland following the closure of the lagoon.

***Bill Humphreys***
Dr Humphreys is currently Senior Curator at the Western Australian Museum. He has experience of marine, freshwater and terrestrial fauna, both as a researcher and teacher, and has published widely on both invertebrate and vertebrate taxa. To date, he has edited 4 books, and authored 36 chapters, over 100 peer-reviewed papers, 36 consultancy reports and in excess of 40 other publications. Dr Humphreys is a board member of the Centre for Groundwater Studies and serves on the Editorial Board of the Records of the Western Australian Museum and the international journal Subterranean Biology. He is also Vice-President of the International Society of Subterranean Biology. Dr Humphreys is currently a member of the Western Australian Scientific Advisory Committee for Threatened Ecological Communities and also serves on a number of other Western Australian-based advisory groups and recovery teams.

# Appendix B: Wetland birds recorded in the Hosnies Spring Ramsar Site

Species list compiled from Birds Australia Bird Atlas

| Order | Scientific Name | Family Name | EPBC Listing |
|---|---|---|---|
| Ardeiformes | *Egretta sacra* | Eastern reef egret | Marine; Migratory (CAMBA) |
| | *Nycticorax caledonicus* | Nankeen night heron | Marine |
| Pelecaniformes | *Papasula abbotti* | Abbott's booby | Endangered; Migratory (JAMBA, ROKAMBA) |
| | *Fregata andrewsi* | Christmas island frigatebird, | Vulnerable; Marine; Migratory (CAMBA) |
| | *Fregata ariel* | Lesser frigatebird | Marine; Migratory (CAMBA, JAMBA, ROKAMBA) |
| | *Fregata minor* | Greater frigatebird | Marine; Migratory (CAMBA, JAMBA) |
| | *Phaethon lepturus fulvus* | White-tailed tropicbird | Marine |
| | *Phaethon rubricauda* | Red-tailed tropicbird | Marine |

Note that there is insufficient site specific information to compile species lists for any other fauna group or flora within the Ramsar site boundary.