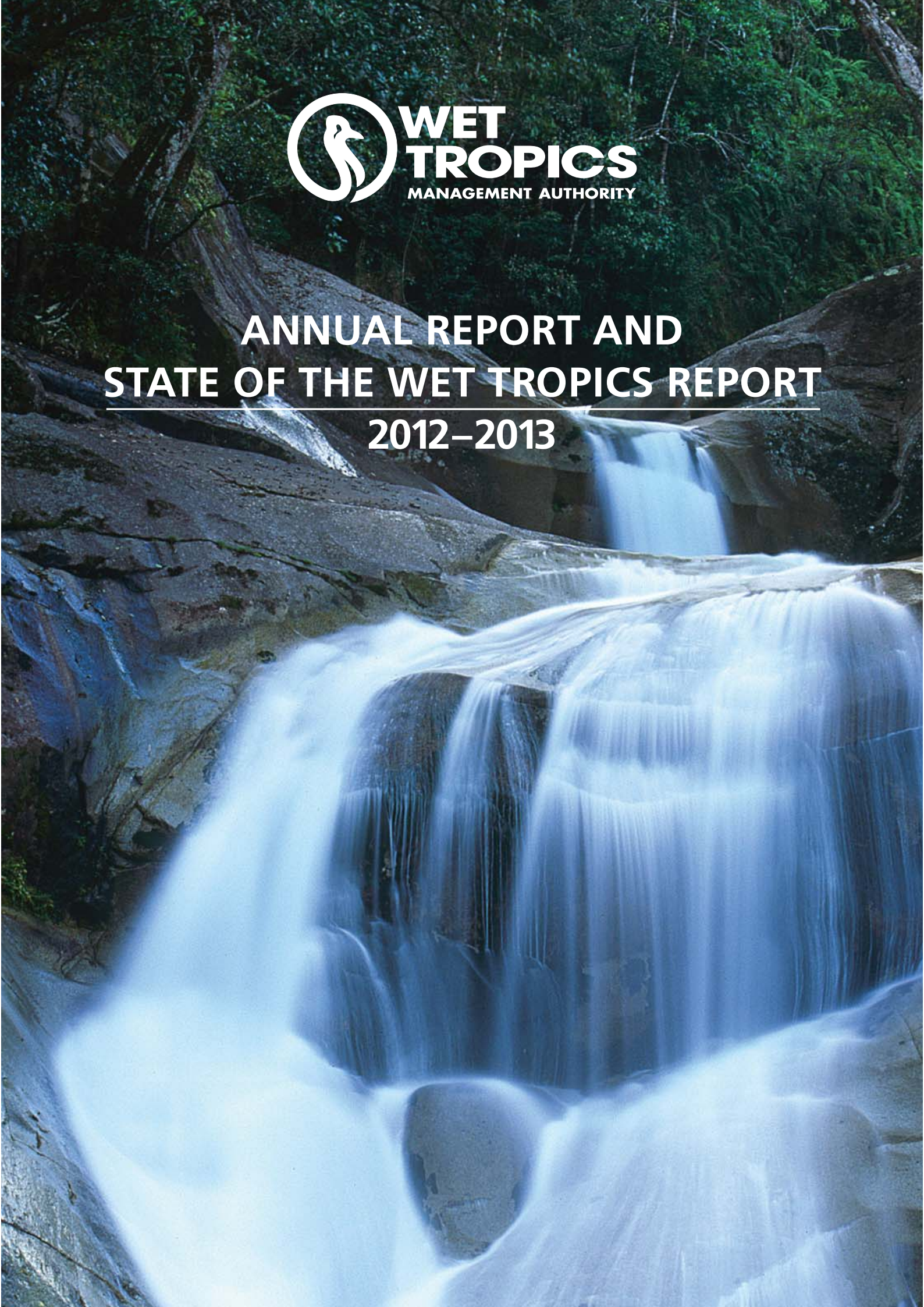
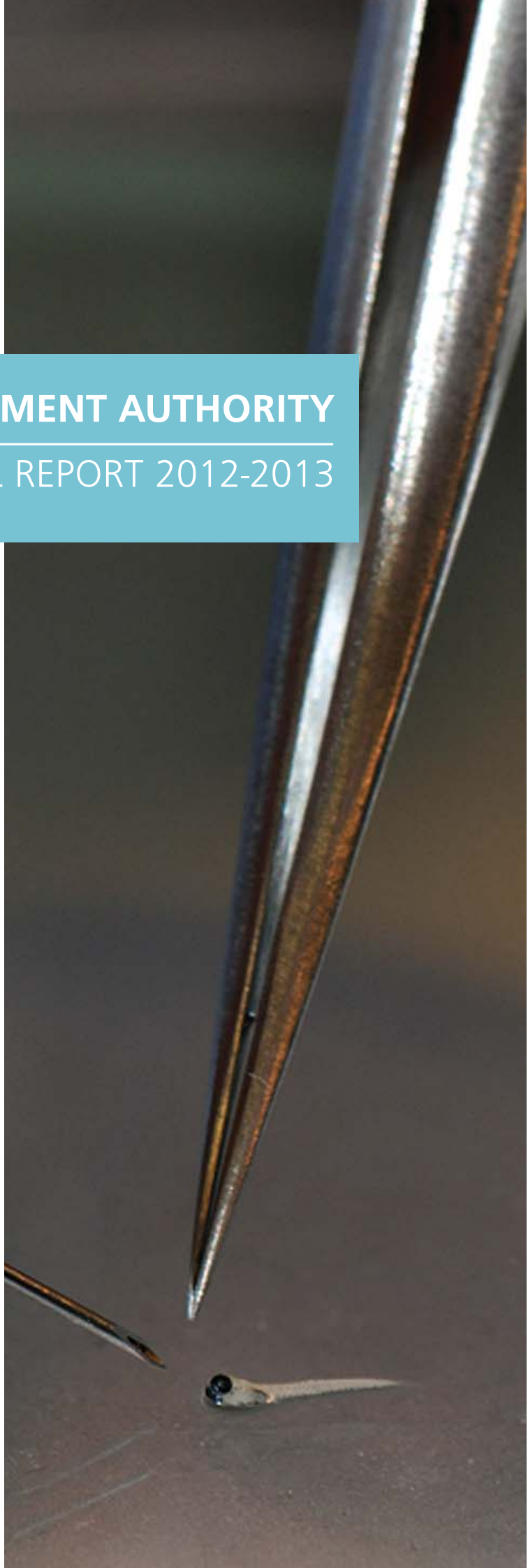


WET TROPICS
MANAGEMENT AUTHORITY

ANNUAL REPORT AND STATE OF THE WET TROPICS REPORT 2012–2013

WET TROPICS MANAGEMENT AUTHORITY

ANNUAL REPORT 2012-2013



Purpose of the report

This annual report details the financial and non-financial performance of the Wet Tropics Management Authority from 1 July 2012 to 30 June 2013. It highlights the work, achievements, activities and strategic initiatives of the Authority, and satisfies the requirements of Queensland's Wet Tropics World Heritage Protection and Management Act 1993 and Financial Accountability Act 2009; and the Commonwealth's Wet Tropics of Queensland World Heritage Conservation Act 1994. It also includes a report on the state of the Wet Tropics World Heritage Area, as required under section 63(1) of the Queensland Act and section 10 of the Commonwealth Act.

Your feedback

The annual report is an important document representing communication and accountability. The Authority values comments and welcomes feedback from readers.

This publication can be accessed and downloaded from our website at www.wettropics.gov.au

Copyright

Wet Tropics Management Authority
PO Box 2050
Cairns QLD 4870
Phone: (07) 4052 0555
Email: wettropics@wtma.qld.gov.au
ISBN 978-1-921591-67-9

Licence

Attribution

Content from this annual report should be attributed as: Wet Tropics Management Authority Annual Report and State of Wet Tropics Report 2012-13.

Disclaimer

This document has been prepared with all due diligence and care, based on the best available information at the time of publication. The Authority holds no responsibility for any errors or omissions within this document. Any decisions made by other parties based on this document are solely the responsibility of those parties.

The Wet Tropics Management Authority is committed to providing accessible services to people from all culturally and linguistically diverse backgrounds. If you have difficulty in understanding the annual report and need to access this document in a language other than English, please call the Translating and Interpreting Service (TIS National) on 131 450 and ask them to telephone the Queensland Government Library Services on +61 7 3224 8412.

This publication can be made available in an alternative format (e.g. large print or audiotape) on request for people with vision impairment; phone +61 7 3224 8412 or email library@eph.qld.gov.au

This report is printed on Monza Satin 55% Recycled, FSC Mixed Sources product group from well-managed forests, controlled sources and recycled wood or fiber. www.fsc.org

WET TROPICS
MANAGEMENT AUTHORITY

WET TROPICS
MANAGEMENT AUTHORITY

27 September 2013
The Honourable Greg Hunt MP
Minister for the Environment
PO Box 6022
House of Representatives
Parliament House
CANBERRA ACT 2600

Dear Minister,

I am pleased to present the Annual Report and State of the Wet Tropics Report 2012-2013 for the Wet Tropics Management Authority.

Under the *Wet Tropics World Heritage Conservation Act 1994*, section 10 (1) 'annual report' means a report given to the Australian Government under section 63 of the *Wet Tropics World Heritage Protection and Management Act 1993* (Qld).

Section 10 (2) requires you, as the Minister, to cause a copy of the annual report to be laid before each House of Parliament within 15 sitting days after the report is given to the Australian Government.

In submitting this report to you today the Authority is fulfilling its responsibilities under Australian Government legislation.

Yours sincerely

Andrew Maclean
Executive Director

Contents

Wet Tropics Management Authority Annual Report 2012-2013

State of Wet Tropics Report 2012-13

Highlights from the Executive Director

Andrew Maclean, Executive Director © Wet Tropics Images

The Wet Tropics of Queensland World Heritage Area is one of the world's outstanding natural landscapes. Inscribed on the World Heritage List in 1988, the Wet Tropics is an area of extraordinary scenery and biodiversity, and of great scientific significance.

The Wet Tropics Management Authority was established to assist the Australian and Queensland Governments to fulfil Australia's obligations under the World Heritage Convention in relation to the Wet Tropics are met. The Authority is jointly accountable to the Commonwealth and State environment and heritage Ministers.

The Authority has diverse roles. As well as ensuring protection through administration of the statutory *Wet Tropics Management Plan 1988*, the Authority builds partnerships within the community, with Rainforest Aboriginal people, with the research community, with the tourism industry and with government departments and agencies to advance the conservation, presentation and transmission to future generations of the Wet Tropics.

2012-2013 represents another year of achievement for the Authority and its partners in World Heritage management. Some highlights of the year are summarised below.

National Heritage Listing for Indigenous Cultural Values

The Authority was delighted with the decision of the Minister for Sustainability, Environment, Water, Population and Communities to include the cultural heritage values of the Wet Tropics on the National Heritage List. National Heritage listing helps to overcome the concern Rainforest Aboriginal people felt when the Wet Tropics was listed as World Heritage for

Rainforest Aboriginal nut cracking rock © Wet Tropics Images

natural values only. The Authority is eager to support Rainforest Aboriginal people in their aspirations for managing their cultural heritage. The Authority has engaged with the Department of Sustainability, Environment, Water Population and Communities and the Rainforest Aboriginal Peoples Alliance to determine appropriate planning and management regimes in response to the listing.

World Heritage symposium

As a contribution towards celebrating the 40th anniversary of the World Heritage Convention in 2012, the Authority partnered with the Australian Committee for IUCN and the Australian Conservation Foundation to organise a national symposium on Australian World Heritage – *Keeping the Outstanding Exceptional*. Held in Cairns in August 2012, the symposium attracted in excess of 100 delegates from all over Australia. Speakers included the Hon Tony Burke MP, Minister for Sustainability, Environment, Water, Population and Communities and the Hon Andrew Powell MP, Minister for Environment and Heritage Protection. The Australian Committee for IUCN has published proceedings of the symposium, including a consensus statement about the future of Australian World Heritage – *the Cairns Communique*.

Developing sustainable Wet Tropics tourism

The Authority has continued to develop a program of support for tour guides in the Wet Tropics. These front line experts play a major role in presenting the values of the Wet Tropics to thousands of visitors each year. Through this program, the Authority supports tour guides through training and networking to ensure they have access to the best available information to deliver a world class experience to visitors.

National Landscapes Program

The Authority has been pleased to continue providing a regional coordination role for this important Commonwealth program, building partnerships between tourism and conservation in the region and helping to ensure the Wet Tropics is appropriately promoted in Australia's international tourism marketing programs. The Authority's work with the tourism industry represents an important contribution it makes to the Queensland Government's tourism pillar as a basis for economic development of Queensland.

New Strategic Plan

The Authority developed and adopted a new strategic plan for 2013-2018 that will guide its work for the next five years. Grounded in the goals of the World Heritage Convention, the plan includes new goals relating to tourism, research and partnership development while continuing to give priority to protecting natural values, ensuring community engagement and supporting Rainforest Aboriginal people. This annual report is structured around the goals of the new strategic plan.

Wet Tropics on the web

In August 2012, the Authority launched a new website. Designed to build interest and excitement about the special values of the Wet Tropics World Heritage Area, the site is a wealth of information. Importantly, shifting to modern website content management arrangements means that the site is now a much more flexible communication tool for the Authority. The Authority also established a Facebook page that is helping maintain connections with an online community of Wet Tropics World Heritage Area supporters.

Making connections

2012-2013 marked the completion of the Making Connections project on the southern Atherton Tablelands. This project helped address the risk of climate change in the Wet Tropics by connecting and building resilience of high altitude climate refugia that will likely become increasingly important as the temperature of the region rise as a consequence of global warming. While this particular project has come to an end, the broader task of building Wet Tropics rainforest resilience through rehabilitation, connectivity and pest management remains an important priority for the Authority.

Searching for tramp ants

In partnership with Conservation Volunteers and Biosecurity Queensland, the Authority completed a program of surveillance and community awareness in relation to yellow crazy ant and electric ant infestations in the vicinity of Cairns. Collectively known as tramp ants, these species create potentially severe risks to the value of the Wet Tropics World Heritage Area and the amenity of surrounding urban and rural areas. Through the project, the Authority and its partners have been able to better document the extent of infestations threatening the Wet Tropics World Heritage Area and to demonstrate the feasibility of eradication from the Area.

Research e-bulletin

The Authority has a goal of establishing the Wet Tropics World Heritage Area as a learning landscape: a globally significant focus for research and learning about tropical rainforests and their management. In support of this goal, the Authority published the first edition of its research e-bulletin in early 2013. The bulletin highlighted some of the outcomes of research in the Wet Tropics with an emphasis on its relevance to management of the World Heritage Area.

Funding round

2012-2013 was the final of a four year funding round for the Authority from the Commonwealth Government. The Authority acknowledges with thanks the support the Commonwealth has provided for the Authority's work through this contribution.

Board appointments

The term of appointment of Authority Chairperson, Associate Professor Peter Valentine ended in February 2013. Peter has a profound knowledge of World Heritage management and policy including in particular knowledge of the Wet Tropics of Queensland. Directors and staff of the Authority are grateful for the leadership and support Peter demonstrated during his term of appointment.

Milla Milla Falls © Tourism Queensland

In June 2013, the terms of appointment of Directors Dr Alastair Birtles, and Cr Julia Leu ended. Alastair's knowledge of the ecotourism industry and his passion for Rainforest Aboriginal culture was a great asset for the Authority. Julia's strong knowledge of local government and governance and her extensive community network in the north of the World Heritage Area were also highly valued by the Authority.

At the time of drafting, the process for appointment to these vacancies was underway.

Thanks

The Authority cannot succeed without supportive partnerships, so I take this opportunity to collectively thank the many people and organisations that assisted in the conservation and management of the Wet Tropics World Heritage Area during 2012-2013. Prominent among these are the volunteers on our Community Consultative Committee and Scientific Advisory Committee; Rainforest Aboriginal people; the many hundreds of volunteers in community conservation organisations; the tourism industry, in particular the tour guides who present the Area to thousands of visitors each year; and the research community. The Authority is also grateful for the support and guidance of its partners in the Australian, Queensland and local governments and their agencies.

Andrew Maclean
Executive Director

Introduction

World Heritage and National Heritage listing

The World Heritage List includes 981 properties forming part of the cultural and natural heritage which the World Heritage Committee considers as having outstanding universal value. These include 759 cultural, 193 natural and 29 mixed properties in 160 State Parties. As of September 2012, 190 State Parties have ratified the World Heritage Convention.

Australia became a signatory in 1974 and at 30 June 2012 there were 19 Australian properties on the World Heritage list. World Heritage listing is recognition by the international community that a place is such an outstanding example of the world's natural or cultural heritage that its conservation is of value to all people.

The Wet Tropics of Queensland World Heritage Area ('the World Heritage Area' or 'the Area') has outstanding natural values, meeting all four natural criteria for World Heritage listing and fulfilling the necessary conditions of integrity. The Wet Tropics of Queensland is considered to:

- contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance – *Criterion (vii)*
- be an outstanding example representing the major stages of Earth's history, including the record of life, and significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features – *Criterion (viii)*
- be an outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals – *Criterion (ix)*
- contain the most important significant natural habitats for *in situ* conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation – *Criterion (x)*.

In May 2007 the Area was also listed on Australia's National Heritage List. The Area was listed for the five National Heritage criteria that correspond to its World Heritage (natural) criteria. The National Heritage criteria include:

- the place's importance in the course, or pattern, of Australia's natural or cultural history – *Criterion (a)*
- the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history – *Criterion (b)*
- the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history – *Criterion (c)*
- the place's importance in demonstrating the principal characteristics of (i) a class of Australia's natural or cultural places; or (ii) a class of Australia's natural or cultural environments – *Criterion (d)*

Wet Tropics Rainforest Aboriginal people celebrate the Australian Government inclusion of national Indigenous heritage values as part of the existing National Heritage Listing for the Wet Tropics of Queensland, 9 November 2012 © K Beattie

- the place's importance in exhibiting particular aesthetic characteristics valued by a community or cultural group – *Criterion (e)*.

On 9 November 2012, the Australian Government announced the inclusion of the national Indigenous heritage values as part of the existing National Heritage listing for the Wet Tropics World Heritage Area. The Aboriginal Rainforest people of the Wet Tropics of Queensland have lived continuously in the rainforest environment for at least 5,000 years and this is the only place in Australia where Aboriginal people have permanently inhabited a tropical rainforest environment. The criteria for are:

- the place has outstanding heritage value to the nation because of the place's importance in demonstrating a high degree of creative or technical achievement at a particular period – *Criterion (f)*
- the place has outstanding heritage value to the nation because of the place's importance as part of indigenous tradition – *Criterion (i)*.

National Heritage listing provides protection under the *Environment Protection and Biodiversity Conservation Act 1999* and that the Commonwealth must use its best endeavours to ensure a management plan that is consistent with the management principles is prepared and implemented in cooperation with the State.

Administration of the Act

Enabling legislation

The Wet Tropics of Queensland World Heritage Area is managed under the *Wet Tropics World Heritage Protection and Management Act 1993* (the Queensland Act) and the *Wet Tropics of Queensland World Heritage Area Conservation Act 1994* (the Commonwealth Act). These Acts implement Australia's international duty for the protection, conservation, presentation, rehabilitation and transmission to future generations of the World Heritage Area.

The Queensland Act establishes the Wet Tropics Management Authority and provides the legal basis for the Wet Tropics Management Plan 1998 (the Plan) that regulates land use activities in the Area through a zoning and permit system. The *Wet Tropics World Heritage Area Management Scheme* is an intergovernmental agreement signed by the Prime Minister of Australia and the Premier of Queensland in 1990. It sets out broad structural and funding arrangements for the management of the Area. The agreement is incorporated as Schedule 1 to the Queensland Act and given effect by section 3 of the Commonwealth Act. An amended version of the Agreement was adopted in 2011.

The Wet Tropics Management Authority

The Wet Tropics Management Authority was set up to ensure Australia's obligation under the World Heritage Convention is met in relation to the World Heritage Area.

The Authority's functions, as defined under section 10 of the Queensland Act, are to:

- develop and implement policies and programs for management of the Area
- formulate performance indicators for the implementation of approved policies and programs
- advise and make recommendations to the Minister and the Ministerial Council
- prepare and implement management plans for the Area
- administer funding arrangements
- facilitate and enter into Cooperative Management Agreements
- rehabilitate and restore the Area
- gather, research, analyse and disseminate information on the Area
- develop public and community education programs
- promote the Area locally, nationally and internationally
- liaise with the Australian and Queensland Governments, agencies and international organisations
- monitor the state of the Area
- advise and report to the Minister and the Ministerial Council on the state of the Area.

Subject to performing its functions in a way which is consistent with the protection of the natural heritage values of the Area, the Authority must, as far as practicable, also perform its functions in a way that is consistent with the objectives and principles of the National Strategy for Ecologically Sustainable Development and with the Intergovernmental Agreement on the Environment.

Statutory reporting obligations

Each year the Wet Tropics Management Authority prepares a report on the administration of the Act during the year, financial statements for the year, and a report on the state of the Area, as required under section 63(1) of the Queensland Act and section 10 of the Commonwealth Act.

Management structure

The intergovernmental agreement provides for, *inter alia*, the establishment of the Wet Tropics Ministerial Council, consisting of Commonwealth and State Ministers. Its function is to coordinate policy and funding for the Area.

In August 2011 the intergovernmental agreement was updated to reflect the decision of the Council of Australian Governments to abolish property specific Ministerial Councils, including the Wet Tropics Ministerial Council, and to make other minor amendments required to ensure the Agreement remains current and relevant. It recognises that both the Commonwealth Government and Queensland Government have joint interests in and responsibilities for the Wet Tropics of Queensland World Heritage Area.

Subject to amendment of the Queensland Act, several of the functions of Ministerial Council will be re-allocated to the Commonwealth and Queensland Environment Ministers acting in cooperation. Other functions will be directly discharged by either the Commonwealth or Queensland Minister.

A board of directors is set up under the Queensland Act and consists of seven directors, six of whom serve in a part time capacity. Two directors are nominated by the Australian Government and two by the Queensland Government. The Chair and a designated Aboriginal director are nominated by the Wet Tropics Ministerial Council. The executive director of the Authority is a non-voting board director. The Board's key function is to implement programs to meet Australia's international obligations for the Area under the World Heritage Convention.

The Authority operates as an administrative unit within the Queensland Government Department of Environment and Heritage Protection. As part of the Queensland public sector, the Authority is subject to public sector legislation, regulations, standards and guidelines governing administrative functions and arrangements. The Director-General of the Department of Environment and Heritage Protection is the accountable officer for the Authority under the *Financial and Performance Management Standard 2009*. The Authority is responsible to the Director-General regarding compliance with State Government administrative and financial standards.

The Authority has two statutory advisory committees appointed by the Board under the Queensland Act. They are the Community Consultative Committee and the Scientific Advisory Committee. These committees meet quarterly prior to Board meetings and advise the Authority on programs and research for the management of the Area.

The Authority is a small organisation and works in partnership with other agencies, stakeholders and the wider community. The

Authority has produced a range of strategic policy and planning documents which guide management of the World Heritage Area, consistent with its legislative responsibilities. **Figure 1** provides an overview of the Authority's legislative and strategic planning framework.

While the Authority is the lead agency responsible for policy, planning and the coordination of management in the Area, it is not directly responsible for on-ground management. Day-to-day management activities such as infrastructure maintenance and pest control are the responsibility of the relevant land managers which include the Department of National Parks, Recreation, Sport and Racing; the Department of Environment and Heritage Protection; the Department of Agriculture, Fisheries and Forestry; and community infrastructure service providers for power, water and roads and nine local governments.

An annual partnership agreement is developed each year between the Authority and Queensland Parks and Wildlife Service (QPWS, Department of National Parks, Recreation, Sport and Racing) to prioritise and coordinate management activities in the protected area estate within the World Heritage Area. The partnership agreement outlines products and services to be delivered by QPWS under funding provided by the Queensland Government for World Heritage management.

The Authority also works in partnership with the regional community as a means of building a sense of ownership and sharing both the benefits and burdens of best practice management. In particular, the Authority consults with the community, both through its committees and directly and extensively on matters with significant community impact, such as management plans.

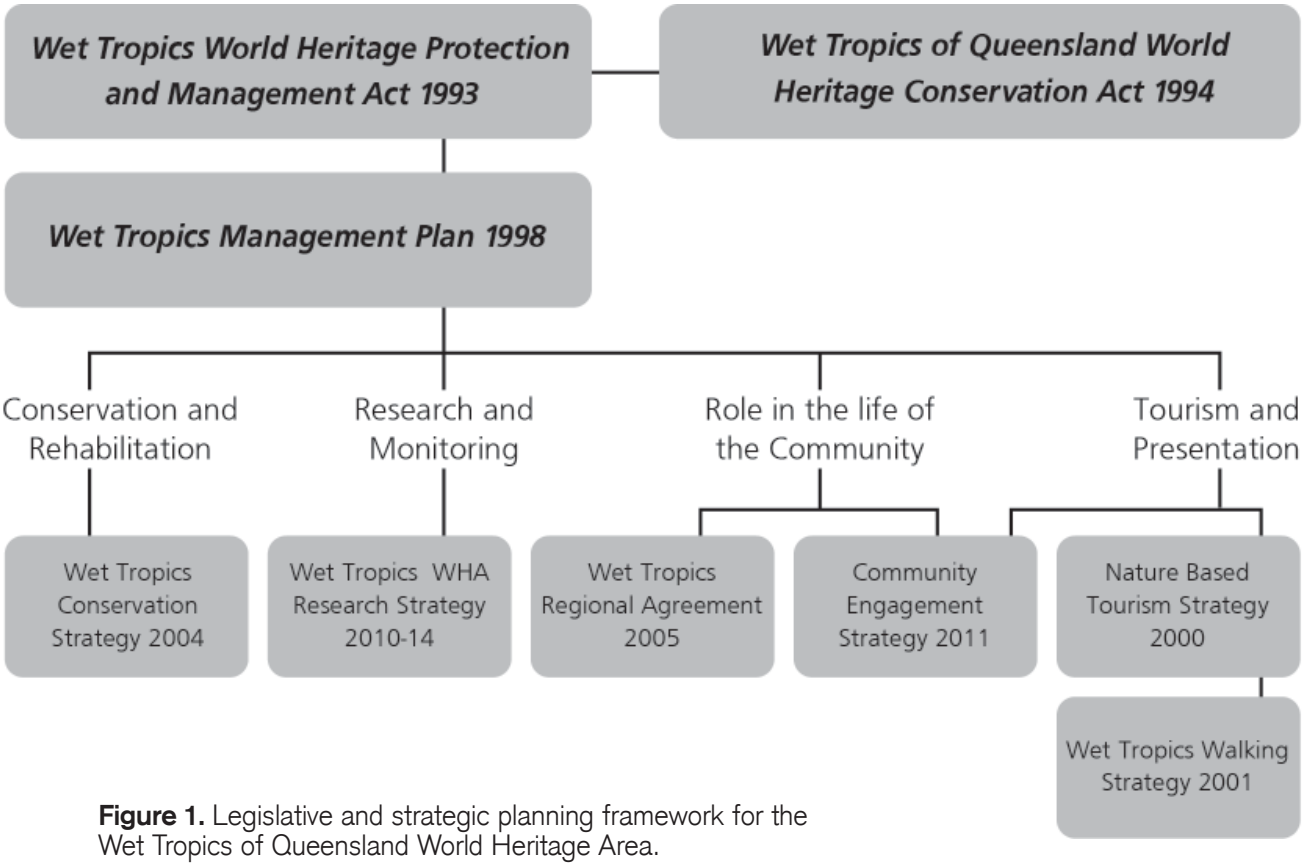
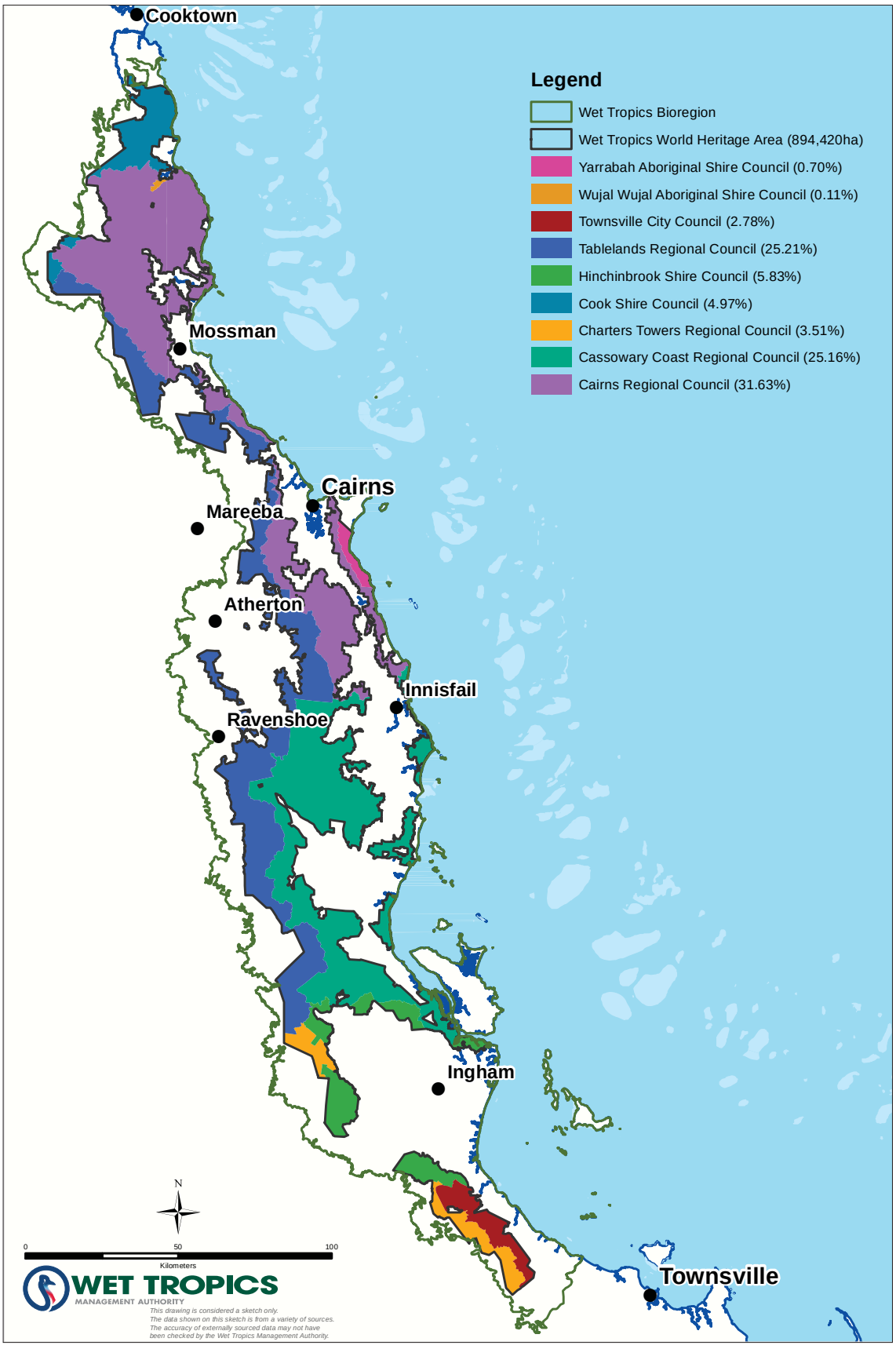


Figure 1. Legislative and strategic planning framework for the Wet Tropics of Queensland World Heritage Area.

Map 1. Local Government Areas which include the Wet Tropics of Queensland World Heritage Area.



Wet Tropics Ministerial Council

At June 2013 Ministerial Council comprised:

- The Hon Andrew Powell MP, Queensland Minister for Environment and Heritage Protection (*Chair*)
- The Hon Mark Butler MP, Australian Minister for the Environment, Heritage and Water.

Ministerial Council did not meet face to face between 1 July 2012 and 30 June 2013. In December 2012 it approved (out of session) zoning amendments for the realignment of an Ingham to Tully powerline at Sunday Creek south of Cardwell and approved community services infrastructure for the Wujal Wujal community.

The board of directors is set up under the Queensland Act and consists of seven directors. Two directors are nominated by the Australian Government and two by the Queensland Government. The Chair and a designated Aboriginal director are nominated by the Wet Tropics Ministerial Council.

The term of appointment of Authority Chairperson, Associate Professor Peter Valentine ended on 24 February 2013. On 9 June 2013, the terms of appointment of Directors Dr Alastair Birtles, and Cr Julia Leu ended. As at June 2013 the process for appointments to these vacancies, as well as one (indigenous) directorship was underway.

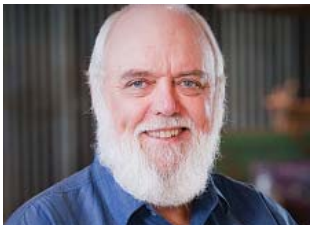
As at June 2013 the board of directors comprised:

Wet Tropics Management Authority Board of Directors

Associate Professor Peter Valentine (Chair)

Mr Andrew Maclean

Dr Ro Hill



Dr Alastair Birtles

Cr Julia Leu

Ms Leah Talbot

- Mr Andrew Maclean *(Executive Director)*
- Dr Rosemary Hill
- Ms Leah Talbot

The Authority's Board met quarterly or as required. Four Board meetings were held during the year on: 20-21 August 2012; 2 November 2012 including a field trip to Edmonton, south of Cairns, to inspect a yellow crazy ant infestation inside the World Heritage Area; 18-19 February 2013; and 5-6 June 2013 at Mission Beach including a field trip.

The overall cost of the Board in 2012-2013 was $55,425. This included meeting fees, special assignment fees, all necessary and reasonable travel expenses, venue hire, catering and other general operating costs.

Committees and liaison groups

Community Consultative Committee

The Community Consultative Committee (CCC) is established under s 40 (1) (a) (ii) of the Queensland Act. The CCC has the function of advising the authority on the views of the community on the authority's policies and programs in relation to the wet tropics area.

The members of the CCC are selected as individuals to represent a broad range of community views and expertise from throughout the Wet Tropics region. Committee members represent a broad range of expertise and skills including conservation, education, tourism, recreation, local government, Aboriginal culture, science and primary industries.

During the reporting year a new Chairperson was selected and approved by the Board. Two members resigned and four new members were selected to replace those who had resigned in the previous and current reporting periods. In addition, the Board approved the membership of another Rainforest Aboriginal representative. Topics covered during the year included access to the World Heritage Area, education opportunities, community forums, branding of the Authority and presentation of the World Heritage Area. At 30 June 2013 membership of the CCC included:

- Ms Rhonda Sorensen (*Chair*)
- Ms Bryony Barnett (*Deputy Chair*)
- Mrs Pam Birkett
- Mr Greg Bruce
- Mr Pino Giandomenico
- Ms Ellie Bock
- Ms Maree Grenfell
- Mr Ross Rogers
- Mr Chris Cameron
- Ms Darlene Irvine
- Mr Warren Singleton
- Ms Joann Schmider
- Ms Doon McCool, Manager, Community Engagement, Great Barrier Reef Marine Park Authority, (*Observer)*
- Ms Claire Grant, Manager, Technical Support, QPWS, Department of National Parks, Recreation, Sport and Racing (*Observer*).

The CCC met on: 27 August 2012; 18 October 2012; 15 February 2013; and 3 May 2013. The Community Consultative Committee cost $4,365 to operate, mostly for catering, venue hire and reimbursement for out-of-pocket expenses and travel expenses. Members do not receive sitting fees.

Scientific Advisory Committee

The Scientific Advisory Committee (SAC) is established under s 40 (1) (a) (i) of the Queensland Act. Members of the SAC come from a broad range of disciplines including the natural, ecological, socio–cultural and economic sciences. Most are actively involved in tropical research programs in the Wet Tropics region and northern Australia.

During the year major issues where SAC advice was sought included the development of the Wet Tropics Learning Landscape initiative, biosecurity issues, amendments to guidelines and policies associated with the review of the Wet Tropics Management Plan, Caring for Our Country and Biodiversity Fund submissions, connectivity conservation priorities and development of a Wet Tropics Research e-bulletin.

The current SAC was appointed in May 2011 for a three-year term. At 30 June 2013 the members included:

- Professor Steve Williams, Centre for Tropical Biology and Climate Change, James Cook University (*Chair*)
- Dr Susan Laurance, Tropical Leader in Rainforest Ecology, James Cook University (*Deputy Chair*)
- Dr Damien Burrows, Director TropWater, Tropical Water and Aquatic Ecosystem Research
- Professor Carla Catterall, Theme Leader, Environmental Restoration and Management, Environmental Futures Centre, Griffith University
- Professor Darren Crayn, Director Australian Tropical Herbarium, Centre of Tropical Environment and Sustainability Services
- Dr Miriam Goosem, Principal Research Fellow, James Cook University
- Dr Alex Kutt, Adjunct Associate Professor, James Cook University
- Ms Henrietta Marrie, Adjunct Professor, United Nations University
- Dr Dan Metcalfe, Program Leader, Ecology Program, Ecosystem Services, CSIRO
- Dr Lea Scherl, Adjunct Associate Professor, Discipline of Environmental Sciences and Geography, James Cook University
- Professor Jeff Sayer, Professor of Conservation and Development Practice, James Cook University
- Mr Gerry Turpin, Queensland Herbarium, Department of Environment and Heritage Protection
- Dr Christine Williams, Assistant Director General, Department of Science, Information Technology, Innovation and the Arts
- Dr David Westcott, Principal Research Scientist, Tropical Landscapes Program, CSIRO
- Ms Claire Grant, Manager, Technical Support, Department of National Parks, Recreation, Sport and Racing (*Observer)*.

Members of the Scientific Advisory Committee met on: 2 August 2012; 25 October 2012; 28 February 2013; and 6 May 2012. The SAC cost $9,793 to operate, mostly for catering, venue hire and reimbursements for out of pocket and travel expenses. Members do not receive sitting fees.

Conservation Sector Liaison Group

The Conservation Sector Liaison Group (CSLG) is established under s 40 (1) (b) of the Queensland Act. The function of the CSLG is to provide conservation sector input to the Authority in relation to key conservation challenges associated with the Wet Tropics World Heritage Area; to channel information and opinion between the conservation sector and the Authority; and to facilitate and support implementation of the Authority's conservation agenda. In turn, the conservation sector, through the CSLG, has the opportunity to be effectively engaged in providing timely input into the development of policies and strategies to address these key challenges.

The CSLG met three times during the year on: 17 September 2012; 3 December 2012; and 8 April 2013. The Authority provides secretariat support for the CSLG, including provision of meeting facilities, catering, and out-of-pocket travel expenses for members whose organisations or community conservation groups cannot cover those costs.

The current CSLG was appointed in August 2011 for a three-year term. At 30 June 2013 members included:

- Ms Anna McGuire, Cairns and Far North Environment Centre (*Chair*)
- Mr Peter Smith, Wildlife Preservation Society Qld (*Deputy Chair*)
- Dr Alice Crabtree, Conservation Volunteers Australia
- Dr Sigrid Heise-Pavlov, Tree Kangaroo and Mammal Group
- Mr Tony Jurgensen, Johnstone Ecological Society
- Mr Jeremy Little, the Wilderness Society
- Ms Margaret Moorhouse, North Queensland Conservation Council and the Alliance to Save Hinchinbrook
- Mr Fergus Power, Environmental Defender's Office
- Ms Deborah Pergolotti, Frog Decline Reversal Project
- Mr Peter Rowles, Community for Coastal and Cassowary Conservation
- Ms Rowena Grace, Terrain NRM (*Observer*)
- Ms Claire Grant, Manager, Technical Support, Department of National Parks, Recreation, Sport and Racing (*Observer*)
- Mr Travis Sydes, FNQ Regional Organisation of Councils (*Observer*)
- Mr Michael Graham, Biosecurity Queensland – DAFF (*Observer*)

In 2012-13, the cost for convening the CSLG meetings was $2,905. Costs incurred were primarily for catering purposes and out-of-pocket travel expenses of members. Members do not receive sitting fees.

Wet Tropics Tourism Network

The Wet Tropics Tourism Network (WTTN) provides a key point of contact between the Wet Tropics Management Authority and tourism operators who utilise the World Heritage Area. Meetings provide a formal channel of communication where participants advise and provide comment to Wet Tropics on policy directions, projects and strategies that specifically regard tourism.

The focus of the WTTN is to facilitate partnerships to present World Heritage values, and as a result, further strengthening and developing the Wet Tropics tourism industry. The Tourism Network comprises representatives from the tourism industry, local operators, local and state government agencies, local conservation groups and Rainforest Aboriginal people. Over 100 individuals and organisations have registered to participate at meetings, and participants choose to attend meetings that are of interest to them.

At 30 June 2013 the Wet Tropics Tourism Network organisational membership included 100 tourism businesses, local and state government organisations, Indigenous organisations, individuals and private tour operator businesses.

2013-2018 Strategic Plan Goals

The Wet Tropics Management Authority is organised around the seven strategic goals that describe the ultimate outcomes the Authority aspires to (**Figure 2**). The goals are:

1. The Outstanding Universal Value of the Wet Tropics World Heritage Area is protected and maintained consistent with Australia's obligation under the World Heritage Convention
2. Communities derive benefit and value from the World Heritage Area, are effectively involved in planning and management and their stewardship of the World Heritage Area is recognised and supported
3. Rainforest Aboriginal people are supported in expressing their knowledge, culture and management practices on country
4. The Wet Tropics World Heritage Area is used, enjoyed and celebrated as the world's finest learning landscape for tropical rainforest and its sustainable management
5. World Heritage Area values are supported and presented through sustainable tourism
6. Enduring partnerships enhance the integrity of the Wet Tropics World Heritage Area, its presentation and its function in the life of the community
7. The Wet Tropics Management Authority is an accountable and capable organisation.

Progress towards the goals, objectives and milestones in the 2013-2018 Strategic Plan provide the framework for 2012-13 annual reporting.

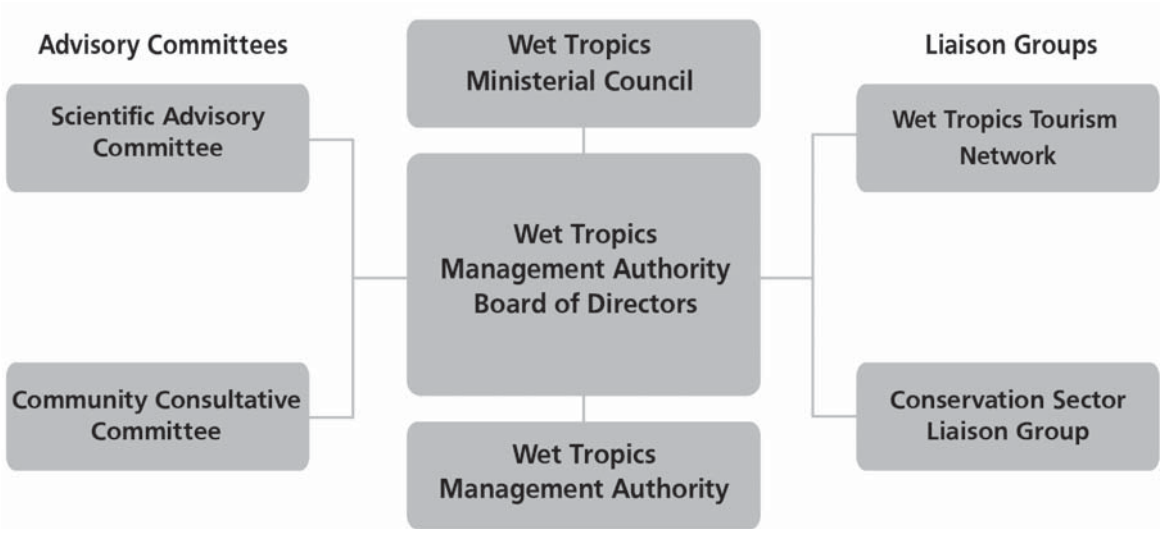


Figure 2. Wet Tropics Organisation and management structure

Strategic Goal 1

The outstanding universal value of the Wet Tropics World Heritage Area is protected and maintained consistent with Australia's obligation under the World Heritage Convention.

The Outstanding Universal Value of the Wet Tropics World Heritage Area lies at the heart of its governance and management regime. The protection and conservation of the value of the Area requires an effective management and regulatory regime. The Authority has an important role in coordinating the contribution of others in support of the Area. Pests, weeds, disease and climate change are identified as currently posing the greatest threat to the integrity of the World Heritage Area.

Administration of the Wet Tropics Management Plan

The *Wet Tropics Management Plan 1998* (the Plan) regulates activities in the Wet Tropics World Heritage Area (the Area) which have the potential to impact on the integrity of the Area. This Plan includes criteria for the assessment of permit applications for construction and maintenance of roads, powerlines, water supplies and communication facilities.

Avoiding impacts on World Heritage integrity – advice and assistance to stakeholders

Community services infrastructure providers

Authority staff undertook regular liaison with staff and contractors working on the planning, building and maintenance of community services infrastructure in the World Heritage Area (WHA or 'Area'). Major service providers included Queensland Department of Transport and Main Roads (DTMR), local governments, Powerlink Queensland, Stanwell Pty Ltd and Ergon Energy as well as agencies providing telecommunication facilities. Maintenance and upgrade procedures were reviewed to determine whether the scope of works being proposed is covered by existing permits or may require revised conditions or a new permit. In many cases the need for new permits was not necessary due to work methodologies being negotiated that minimise or avoid impacts on the Area.

Authority staff collaborated with DTMR personnel to help update the Road Maintenance Code of Practice. Staff also provided advice on revising the Queensland Electricity Supply Industry Code of Practice for the maintenance of electricity supply assets in national parks and state forests.

A powerline traversing the World Heritage Area © B Jennison

These documents help staff and contractors to understand the relevant environmental issues and the best practical techniques to employ when working on road and electricity supply assets in environmentally significant areas.

Land managers

Authority personnel regularly liaised with local government staff regarding road building and maintenance activities, and the maintenance and upgrade of Council water supply assets. The Authority also participated in cross agency activities associated with the management of natural resources including NRM bodies, QPWS, and the Cairns Hillslopes Fire Management Committee.

Rainforest Aboriginal people

Advice and support to Aboriginal organisations and councils to support their management of natural resources and mitigate threats to the integrity of their country. Staff facilitated consultation between agencies undertaking construction and maintenance activities in the Area and relevant Traditional Owner groups. These discussions help all parties better understand the potential impact of projects and maintenance activities on cultural and natural heritage values.

Minor and inconsequential activities

Activities deemed to be of minor and inconsequential impact under the Plan do not require a Wet Tropics permit to be issued. Staff reviewed and provided advice regarding the following proposals that were deemed to have only minor and inconsequential impacts on the Area:

- GBR Helicopters undertaking intermittent landings at a tourist facility in Wangetti
- Upgrade of Armstrong Road (western access to Mona Mona); an addition to the Tablelands Regional Council infrastructure maintenance permit
- Cassowary Coast Regional Council contractors constructing gabion retaining walls on Cardstone Road and Alexander Drive near Clump Point.

Assessment of Wet Tropics permit applications

Authority staff assessed and issued permits under the Plan to the following agencies:

- WTMA12006 – Department of Transport and Main Roads – for slope stabilisation works, Captain Cook Highway
- WTMA13001 – Hidden Valley Cabin and Tours – for permit to operate motor vehicle on management road, Benhams Track
- WTMA13002 – Cairns Regional Council – for bridge over Woobadda River crossing of Bloomfield Track.

A number of agencies were issued with new permits to allow them to continue to maintain their infrastructure in the World Heritage Area including:

- WTMA12005 – Southedge Road maintenance
- WTMA12007 – Queensland Rail maintenance
- WTMA12008 – Townsville Water infrastructure maintenance.

Permits were issued with appropriate conditions to prevent, minimise, rehabilitate or monitor any adverse impacts on the Area's outstanding universal value or its integrity.

Ten Mile Station

Ten Mile Station is a grazing lease in the upper Bloomfield Valley within the WHA. The lessee was a party to Eastern Kuku Yalanji Indigenous Land Use Agreement (EKY ILUA), and was granted a lease extension with conditions including the requirement to enter a natural resource management agreement with the Authority

to protect the natural values of the lease from grazing impacts. As part of this agreement, the Authority assisted the landholder to repair the fence line to improve cattle management. Fencing materials have been purchased and the fence-line has been re-cleared. The Authority has established monitoring plots at sites subjected to heavier grazing pressure and sites with lower grazing impacts, and will monitor these periodically as part of the agreement.

Terrestrial Ecosystem Research Network FNQ supersite

The Authority entered into a Cooperative Management Agreement with James Cook University regarding the construction of a 40 metre steel lattice tower at Robson Creek, near Atherton, in the Danbulla National Park within the WHA. The tower is part of an intensive ecosystem observatory which has been set up to collect, examine and monitor vegetative, faunal and biophysical measurements in tropical rainforest environment. It also includes ecosystem monitoring, carbon and water balance experiments, in stream water quantity and quality measurements and OzFlux energy, carbon and water monitoring.

Rezoning amendments

On 8 February 2013 the Queensland Government approved two amendments to the Wet Tropics Management Plan 1998 zoning maps. The first amendment provided for the use of a cleared area adjacent to the Wujal Wujal community for community services infrastructure. The second allowed for the realignment of the Ingham to Tully powerline at Sunday Creek south of Cardwell.

Compliance and enforcement

Training of Conservation Officers

All conservation officers under the Nature Conservation Act 1992 have, by virtue of their office, the power to undertake investigation and enforcement activities in relation to the Plan. Staff from the Authority updated the training package that was provided to QPWS officers on their responsibilities as authorised officers under the provisions of the Plan.

Infringements

Authority staff investigated potential infringements at East Russell, near Babinda; Wangetti, north of Cairns; and Pebbly Beach, south of Port Douglas. In each case there was insufficient information to pursue prosecution.

Land dealings

The Authority provided advice on development proposals, including those outside the Area that may affect the cultural and World Heritage natural values.

Authority staff provided formal advice on eight occasions to the State Land Asset Management group within the Department of Natural Resources and Mines regarding land dealings including proposed lease renewals, free holding applications and proposed road closures. Staff also responded to five inquiries concerning the location of particular properties relative to the Area.

Other Government planning

Cape Tribulation Road Link – Road Management Plan

The Authority worked closely with Cairns Regional Council to develop a 20-year road management plan for the Cape Tribulation Link Road (from the Mossman to Daintree Road to the Mulligan Highway near Cooktown). The link road traverses the Wet Tropics World Heritage Area in numerous locations in the Daintree and Bloomfield areas.

The road management plan fulfils the Authority's previous requirement for a planning study about the use and impact of the road.

Local government planning

The Authority provided general advice and formal comments on numerous local government planning schemes during 2012-13, particularly for Tablelands Regional Council, Cassowary Coast Regional Council and Wujal Wujal Aboriginal Community Council. The primary issues for the Authority were to ensure that the plans were consistent with World Heritage legislation and promoted habitat connectivity in and around the World Heritage Area. A review of the Wujal Wujal planning scheme also initiated an application for rezoning of land in the community (see rezoning amendments).

The Authority also contributed to the Cairns Regional Council Biodiversity Strategy 2012-22 and biodiversity assessments for the proposed planning scheme.

World Heritage conservation and rehabilitation

Conservation covenants

A covenant on title was signed between the Authority and a landholder to provide for the protection of the significant native vegetation on their property in the Daintree lowlands.

'Making Connections' project

From 2011 to 2013 the Wet Tropics Management Authority worked with local landholders and numerous land managers, conservation groups and researchers to create wildlife corridors in the Upper Barron and East Evelyn areas. The project was funded with $600,000 from the Australian Government's Caring for Our Country program.

The restoration project joins a 1000ha complex notophyll rainforest outlier (privately managed for conservation) to the Herberton Range in the World Heritage Area and provides connectivity across the East Evelyn Highway where underpasses have already been incorporated into road design. It provides habitat for numerous endemic upland rainforest species including Lumholtz tree-kangaroos, lemuroid ringtail possums, green ringtail possums, golden bowerbirds, tooth-billed bowerbirds, mountain thornbills, Victoria's riflebirds, Atherton scrubwrens, the endangered southern cassowaries and several endangered frog species.

Making Connections: creating wildlife corridors © C Clarke

Tramp Ants surveillance and detection project

The Authority secured $260,000 via the Commonwealth Caring for Our Country project for Conservation Volunteers (CVA) and Biosecurity Queensland to undertake surveillance for the existence of any infestations of yellow crazy ants or electric ants from Palm Cove to Edmonton and in the Bingil Bay area. The project was also designed to raise community awareness about the impacts of these tramp ants. The project work was completed in June 2013. While some further infestations of yellow crazy ant were detected in the Edmonton area, it appears the tramp ants have otherwise been contained within known sites of infestation. Outcomes of this project provide a good basis for any future program of eradication.

Strategic Goal 2

Communities derive benefit and value from the World Heritage Area, are effectively involved in planning and management and their stewardship of the World Heritage Area is recognised and supported.

Community support for the World Heritage Area (the Area) and engagement in its stewardship is vital to ensuring the Area is protected and that it remains a valued global asset. Community groups in and around the Area actively participate in enhancing the natural and cultural values of the Area and need to be recognised and appreciated. Landholders and neighbours of the Area have an important role in monitoring threats and are important partners to management agencies.

Working with the Wet Tropics community

Community forums and events

The Authority aims to inspire the community to actively engage and participate in conservation and presentation of the Wet Tropics World Heritage Area and to educate the community to appreciate the diverse environmental and socioeconomic benefits of the Area. To understand what the communities are concerned about around the region and to gauge the level of interest in the Area, the Authority held a community forum in Malanda on 20 April 2012 and another at Port Douglas on 11 May 2012.

The Authority gained valuable feedback about issues that really matter to communities and clarified the Authority's role in working with its partners in managing the Area. They also provided an opportunity for community members to gain an insight into Rainforest Aboriginal people's interests in the Area and to reflect on the 25th anniversary of the World Heritage listing of the Wet Tropics

Participants identified many positive attributes about living close to the Area, hence protection of its natural values was considered of critical importance. Participants at both forums demonstrated a deep appreciation of its intrinsic values and innate beauty and the role of its natural landscape on lifestyles in North Queensland. There was also a great appreciation for the role of water in the Area. Maintaining clean waterways and biodiversity was strongly linked to human health.

Pests and weeds were considered the most serious threats to the natural values of the Area. Participants strongly voiced their concerns about tropical weeds and animals such as pigs, wild dogs, tramp ants, and introduced fish species threatening the Area's biodiversity, aesthetics, access and surrounding land use and production.

The Authority participated in Townsville's Ecofiesta and the Cairns *Sustainability Expo* in May 2013 with an information stall at both events. The Townsville Ecofiesta allowed the Authority to reach southern audiences of the Wet Tropics, while the Sustainability Expo in Cairns reached the wide variety of audiences in the city at that time of the year.

Community Consultative Committee

The Community Consultative Committee held meetings every quarter, discussing topical issues around the Wet Tropics region. Topics covered during the year included access, education opportunities, community forums, branding of the Authority and presentation of the Area.

Cassowary Recovery Team

The Authority Chairs and provides secretariat support for the Cassowary Recovery Team which oversees the implementation of the Recovery Plan for the endangered southern cassowary

under the Commonwealth's *Environment Protection and Biodiversity* Conservation Act 1999 (EPBC Act). Membership includes a broad range of government agencies, organisations and individuals who are working for cassowary conservation in the Wet Tropics.

Recognising community contribution to conservation

Some of the Wet Tropics World Heritage Area's most inspirational people were acknowledged at the 14th annual Wet Tropics Management Authority's Cassowary Awards on 3 November 2012. The awards shone a light on those individuals and groups who are making a real difference in and around the Area. Ms Rhonda Brim, Mr Keith Smith, Mr Dave Hudson and Ms Helen Underwood were awarded Cassowary Awards, while Gordonvale State School and Gordonvale State High School received the Young Cassowary Award.

The Awards were presented by Board Chair Associate Professor Peter Valentine; Senator the Hon Jan McLucas, Senator for Queensland; and Mr Michael Trout MP, Member for Barron River. Eight nominations were acknowledged with four of those receiving Cassowary Awards. A total of 149 guests attended the ceremony.

Education

Rainforest Explorer

The Authority facilitated a workshop to undertake an initial review of the Rainforest Explorer with the aim of aligning the contents to the Australian Curriculum and to reflect contemporary methods of communication. Teachers, partners and education specialists including previous authors were invited to provide their views on the existing content and areas which need strengthening. The Authority engaged an external contractor familiar with the Australian Curriculum to facilitate the workshop who has provided recommendations in redevelopment of Rainforest Explorer.

Newspapers in Education

The Authority sponsored the Newspapers in Education (NiE) section of The Cairns Post newspaper for the ninth year. As part of its sponsorship the Authority provided four pages of stories and small activities. This year's NiE articles promoted the Young Cassowary Awards and Keep It Wild poster competition.

Keep it Wild poster competition

The Authority launched its Keep it Wild poster competition in September 2012. The competition was held at the Cairns Regional

Children enjoying Wet Tropics wildlife © Wet Tropics Images

Art Gallery. Over 300 entries were received, with young artists from primary schools around the region expressing messages through their artwork about protecting our reef and rainforests. Winning posters were exhibited at the Cairns Regional Gallery. The winners' artwork was also made into an electronic calendar for 2013 that was hosted on the Wet Tropics website.

Communications

News and media

The Authority continued to promote its work and the Area to the media and the wider community. The 25th anniversary of its listing was well promoted particularly during Australian Heritage Week. Media around yellow crazy ants generated much interest with feature stories being run in the Cairns Post and interviews highlighting the threat to the World Heritage Area aired on several radio stations. The Authority's tour operator program was also promoted across the region through newspaper, web and radio. The Cassowary Awards provided an opportunity to promote the Area and the contributions of communities in most of the regional newspapers. The news and events section of the Wet Tropics website was regularly updated ensuring the public were aware of issues relevant to the Area.

Wet Tropics eNews

Publication of the Authority's quarterly eNews continued during the year, with the objective to ensure the Wet Tropics community is well informed about the World Heritage Area and the work of the Authority and its partners.

Interpretation, website, digital media and on-line engagement

During the year the Authority has focused on developing messages that celebrate the 25th anniversary of the World Heritage Area and its outstanding universal value. A 25th anniversary logo was designed and used across various media and distributed to tour operators and businesses who wished to draw attention to the anniversary. A 25th anniversary portal was created on the front page of the Wet Tropics website which allowed visitors to access information about the anniversary events and other information about the significance of the listing.

Wet Tropics website

The Authority renewed the Wet Tropics website which went live in August 2012. Favourable feedback and suggestions for further improving the website have been received since its launch. According to website statistics for 2012-13 there was an average of 2.63 pages viewed per visit, with 64,375 people visiting the website and 169,073 page views recorded throughout the year.

Social media

The Wet Tropics World Heritage Area Facebook page continued to promote World Heritage Area experiences, and communicate updates on issues and events from around the region. It has also been a valuable tool in distributing messages such as those relating to yellow crazy ants and wildlife conservation. The Facebook page received 497 'likes' throughout the year, highlighting the increasing reach it is having. The most popular posts are those that reflect the outstanding natural features of the Area.

Since its inception in June 2011, the Authority's Facebook 'friend' engagement has grown steadily. About two thirds of the Facebook friends are Australians, of which half are from local Wet Tropics communities. Engagement peaked at New Year 2013 with interest in the 25 year anniversary of listing being shared 'virally' and reaching 1,900 Facebook users.

Strategic Goal 3

Aboriginal people are supported in expressing their knowledge, culture and management practices on country.

As the original owners and custodians who shaped the landscape to its current World Heritage significance, the Authority values the significant contribution Rainforest Aboriginal people also make to contemporary management. The Authority works closely with Rainforest Aboriginal people, respecting their traditional lore and cultural knowledge, rights, interests and aspirations regarding best practice management of the World Heritage Area.

A proactive and conciliatory partnership approach to supporting Traditional Owners' equitable and culturally respectful participation requires adequate capabilities and capacities at all levels of engagement and development. The capacity of Traditional Owners to express their knowledge, cultures and 'looking after country' practices is critical to their well-being and yields social and economic dividends for the broader community as well as environmental and cultural benefits.

Appropriate recognition and support provides a platform for improved leadership, governance and operational competencies through capacity growth, education, and equitable participation in decision-making, corporate development and employment.

This partnership approach includes working with Rainforest Aboriginal peoples and their organisations, including Native Title representative bodies, registered Native Title Bodies Corporates (RNTBC), land trusts and land/sea management corporations, Commonwealth and State government agencies, local government councils, research institutions, NRM bodies and other non-government organisations.

The Authority's enterprise with Rainforest Aboriginal people is summarised below.

Relationships and partnerships

The Authority builds sustainable relationships at local, sub-regional, regional and national levels based on mutual trust engagement pathways developed through dedicated and strategic resource allocation. In 2012-13 the Authority:

- worked closely with the Rainforest Aboriginal Peoples Alliance (RAPA), the leadership representative body for Rainforest Aboriginal people across the Wet Tropics region, to establish a representative framework for involvement and collaboration at the regional scale
- developed an information package and engaged with Rainforest Aboriginal people regarding recommendations for the vacant Aboriginal Director position on the Authority Board
- maintained and extended a database of contacts and communication protocols across the region
- developed a 'Welcome to Country' internal operating guideline that provides place specific procedures and information for the numerous meetings, forums, conferences or other public events convened or facilitated by the Authority, complementing the Australian and Queensland Government's policies and protocols
- conducted 'Engaging the Mob' – a cross-cultural awareness training workshop for all staff which was facilitated by Traditional Owners
- supported Rainforest Aboriginal people and staff to attend the inaugural World Indigenous Network Conference in Darwin and the National Native Title Conference in Alice Springs.

Supporting effective capacity

Building the human, social and institutional competencies and capabilities of Traditional Owners is critical to realising linkages between, and the well-being of, the environment and communities. Long term success relies on the degree to which people owning, living with, and dependent on our natural environment are able to make informed decisions that result in a sustainable environment and socio-economic viability.

Traditional Owner small grants scheme

The Authority provided six small grants totalling nearly $60,000 to support bio-cultural activities by Rainforest Aboriginal people that will benefit Wet Tropics World Heritage Area management, policy development or operational decision making.

This program supported Traditional Owners to express or enhance their knowledge, culture and management practices through planning, management, monitoring and research on their traditional country.

Successful recipients and their projects include:

- Djiru – enabling traditional management of Country through weed eradication and revegetation
- Wadjanbarra Tablelands Yidinji – procure cultural heritage database management system to build capacity and record data
- Dulabed Malanburra Aboriginal Corporation – developing a Country based management plan for land acquired through the Protected Area Indigenous Land Use Agreement
- Eastern Kuku Yalanji – for seed collection and propagation of Duwar (Black Palm)
- Kuku Nyungkal – interpretative sign at existing shelter at Bana Yarralji Ranger Base
- Wanyurr Majay – procure cultural heritage database management system to build capacity and record data.

Catching up with the mob - Bana Yarraliji Ranger Base © A Bolan

Rainforest Aboriginal Peoples Alliance

The Authority provided a grant to the Rainforest Aboriginal Peoples Alliance (RAPA) to formalise a Partnership Agreement with the Authority detailing clear lines and principles of the Authority's communication, engagement and commitments to an annual Action Plan. The grant agreement also supported engagement with the Authority to progress key strategic policies, plans and programs; preparation of operational guidelines for RAPA; holding and reporting on a Regional Summit of Rainforest Aboriginal people; planning for and participation in the National Heritage List declaration; and development of a website and logo for RAPA.

Support for Traditional Owner organisations to prepare and/or partner grant applications

The Authority provided in-kind support for a number of bio-cultural grant applications which would enhance the capacity of Traditional Owners to look after their traditional lands. Some of these organisations, granting bodies and their projects included:

– Choorechillum (Ngadjon-Jii) – for mapping, tourism walking tracks and land protection

– Gunggandji – Indigenous Sea Country Management Grants: Implement Land and Sea Management Plan and Indigenous Carbon Farming Fund: Feasibility Study

- Mandingalbay Yidinji – Wellbeing Research and Biodiversity Fund: Weeds and Land Rehabilitation
- Dawul Wuru Indigenous Corporation – Indigenous Sea Country Management Grants: Yirrganydji Gulbul Maningal sea country management plan and Caring for our Country (CFOC): Invasive pest management and littoral rainforest management
- Gimuy Walubara Yidinji – Biodiversity Fund: protect native habitats and connect up ecological networks
- Jabalbina Yalanji Aboriginal Corporation RNTBC – Indigenous Sea Country Management Grants: Eastern Kuku Yalanji Building Capacity to Care for Sea Country
- Wanyurr-Majay Aboriginal Corporation – Indigenous Sea Country Management Grants: Sea Country Management Plan.

Assisting Traditional Owner organisations with their on-ground projects

The Authority provided staff support, resources and training for a number of Traditional Owner organisations to increase their capacity to look after their traditional lands including:

- provision of Wooroonooran NP aerial photo maps and Walking Plan for 'On Country' walking tracks for Choorechillum (Ngadjon Jii)
- provision of two-day GIS training for Djunbunji rangers and member of their recruitment panel for rangers
- provision of mapping for Mandingalbay Yidinji Indigenous Protected Area (IPA) consultative forum and GIS data for land claim
- provision of GIS mapping and data for Girringun Aboriginal Corporation
- GIS data provision, advice and services to Bana Yarralji.

Improving wellbeing

As a partner to the National Environment Research Program (NERP) Tropical Ecosystems Hub 'Indigenous Co-management and Biodiversity Protection' project, the Authority participated in project co-research team meetings and workshops. The overall goal of the project is to identify

the means for effective engagement of Indigenous knowledge and co-management for biodiversity and cultural protection in the region. It is envisaged the project will deliver tested mechanisms for co-governance and collaboration between Traditional Owners, government managers, natural resource managers, non-government organisations, and other key partners for biodiversity and cultural conservation in the Wet Tropics region.

The Authority supported Rainforest Aboriginal people and the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities to formally announce the listing of the Wet Tropics World Heritage Area on the National Heritage List for its Aboriginal cultural values.

Native Title, Indigenous Land Use and other agreements

The Authority engaged as a party to negotiations and implementation arrangements for Native Title determinations and associated ILUAs and the development and dedication of Indigenous Protected Areas (IPAs). This reconciles the Authority's responsibility to appropriately balance World Heritage values with the well-being of Rainforest Aboriginal people, their cultural obligations to protect and manage lands and waters, and their aspirations for land use, community development and socio-economic recovery, in 2012-13 the Authority:

- signed two Protected Area ILUAs: Tablelands Yidinji and Mamu in July 2012. In addition to the Native Title parties agreeing to exercise their native title rights and interests in a manner consistent with the protection and management of the World Heritage Area, these ILUAs commit the Authority to participate in Working Groups to develop and agree on an Implementation Plan, Activity Guidelines and further agreements for on-ground management (e.g. fire, pests, cultural heritage, employment and commercial enterprise, cultural awareness programs and permits)
- worked with the Mandingalbay Yidinji Aboriginal Corporation and other partners of the IPA Steering Committee to progress implementation of the IPA Management Plan and ex-ILUA arrangements
- supported Jabalbina Yalanji Aboriginal Corporation with development of their IPA Management Plan and celebrated the formal dedication ceremony at Cape Tribulation by the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities. The IPA sets out how Eastern Kuku Yalanji people will look after their bubu (land) and jalun (sea) into the future according to their culture, law/lore and custom
- signed a Memorandum of Understanding (MoU) between the Authority and Girringun Aboriginal Corporation outlining our mutual working relationship for supporting the IPA and its implementation
- participated in a cross-agency working group to give effect to the on-going aspirations of the Mona Mona community for access, use and management of the Mona Mona reserve. The Department of Aboriginal and Torres Strait Islander and Multicultural Affairs, as the trustee, is responsible for a 30 year lease of the reserve to the Mona Mona Bulmba Aboriginal Corporation (members of Mona Mona families) issued in 2010 for cultural, historical, heritage, environmental and Aboriginal purposes. A Land Management Plan under the *Land Act 1994* (QLD) has been approved by the Department of Natural Resources and Mines.

Strategic Goal 4

The Wet Tropics World Heritage Area is used, enjoyed and celebrated as the World's finest learning landscape for tropical rainforest and its sustainable management.

Accumulated knowledge about the values of the Wet Tropics World Heritage Area and its governance and management represents a major asset. There is an opportunity to better capitalise on this to contribute to the future management of the Wet Tropics and to other natural landscapes. While the knowledge generated and shared by formal research organisations is a key focus in these strategies, the knowledge held and shared by communities, including Rainforest Aboriginal people is also important.

Wet Tropics Learning Landscape

The Authority recognises that scientific research plays a critical role in providing the knowledge for evidence-based informed decision making and for the community to understand and appreciate the importance of the World Heritage Area. The Authority seeks to support continued research, to build on the legacy of past research investment and to ensure knowledge generated in the Wet Tropics is accessible to rainforest and protected area managers elsewhere. In order to support this, the Authority is promoting the Wet Tropics World Heritage Area as an international 'learning landscape'. The outstanding universal value of the Area, together with the favourable research environment found within the region, provides outstanding opportunities for collaborative research across a range of disciplines such as ecology, climatology, tourism, sociology and economics based on tropical ecosystems. Some of the key objectives of the learning landscape project include:

- the Wet Tropics World Heritage Area is recognised as a globally significant site for research into rainforest ecology, management and societies
- research investment is directed to research questions that are relevant to the management and policy needs of the Wet Tropics World Heritage Area
- research findings are presented and communicated in ways that maximise uptake and impact for management and policy
- knowledge from a wide variety of formal and informal sources is respected and shared for the benefit of the World Heritage Area and its communities
- land managers and communities are active participants in research and learning processes.

Over the past year, several workshops were held with the Scientific Advisory Committee to refine and develop the concept further. In addition a number of projects were initiated including the launch of a research e-bulletin, providing support to post-graduate research students through a competitive grants scheme, supporting and partnering in research grant proposals, supporting training courses and gathering support to establish a Wet Tropics Research Alliance.

Student Research Grant scheme

This was the second year that the Authority offered a competitive small grants scheme to Australian post graduate students. Funding of up to $4,000 was made available for PhD and Masters research projects and up to $1,500 for Honours projects to support environmental, social and cultural research which will benefit Wet Tropics World Heritage Area management, policy development and operational decision making. Many well-conceived projects, meeting the priorities identified in the *Wet Tropics Management Authority 2010-2014 Research Strategy* and demonstrating scientific rigour and innovative research

were received. Twelve post-graduate students from four Australian universities were successful grant recipients. The student, their affiliated research institution and projects include:

- Mohammed Alamgir, PhD candidate, JCU for *Forest Ecosystem services in Queensland Wet Tropics: climate change impacts, vulnerability, resilience and adaptation options*
- Alice Bhurich, PhD candidate, JCU for *Investigating the preservation and culturally appropriate management of carved trees in the central Tableland of Wet Tropics World Heritage Area*
- Amelia Tulsi Elgar, Honours student, Griffith University for *Rainforest Restoration by seedling recruitment in disused pastureland*
- Kate Hughes, PhD candidate, Griffith University/Australian Rivers Institute for *Understanding how rivers respond to climate change in the Wet Tropics: Past evidence for future predictions*
- Andrew Hunter, Masters candidate, JCU for *Investigating Rope Canopy Bridge and Faunal Underpass Use of Rainforest Fauna*
- Ana Cristina Palma Gartner, PhD candidate, JCU for *Recruitment limitation and seedling success in regrowth forests*
- Claudia Pandolfo Paz, PhD candidate, JCU for *Arbuscular Mycorrhizal Fungi in Secondary Forests: diversity and soil organic carbon concentration*
- Sachin Sridhara, PhD candidate, JCU *for Investigating the potential of feral deer as effective dispersers of Wet Tropics native and invasive fruits*
- Rochelle Steven, PhD candidate, Griffith University for *Avitourism in Australian Important Bird Areas: Relationships with Avian Conservation*
- David Tng, PhD candidate University of Tasmania for *Why can't Far North Queensland's iconic Rose Gums (Eucalyptus grandis) regenerate in rain forest? – examining the regeneration niche of a tropical giant eucalypt*
- Tegan Whitehead, Honours student, JCU for *Small terrestrial mammal and reptile recolonisation and succession within different aged ecological restorations on the Atherton Tablelands*
- Rainer Wunderlich, Masters candidate, JCU for *Edge-effects of grazing and intensive agriculture on reptile communities in rainforest fragments on the Atherton Tablelands*.

Wet Tropics Research e-bulletin

The Authority's first edition of its Wet Tropics research e-bulletin was produced during the year. The purpose of the e-bulletin is to promote science for management; help identify management issues and scientific solutions; emphasise application and relevance of research; and translate, interpret, synthesise and convey research findings to better inform decision making.

JCU Doctoral candidate Katrien Geurtz surveying rainforest mammals © K Geurtz

The first edition was distributed to over 1000 individuals, Commonwealth, State and local government bodies, managers of other Australian World Heritage properties, research bodies organisations, conservation organisations and Indigenous organisations. Readership of the e-bulletin extended into 12 countries within one week of its launch, and was 'opened' over 2,500 times.

The research e-bulletin strengthens our engagement between researchers and research users in ways that helps to ensure research is more directly relevant to current information needs and that findings more directly influence behaviour change.

In producing the e-bulletin, the Authority also aims to clearly establish the Wet Tropics World Heritage Area as an important locus for research synthesis and establish the Authority as an important contributor to knowledge brokering. The

National Environmental Research Program

The Australian Government's National Environmental Research Program (NERP) funds a portfolio of public good environmental research throughout Australia.

The NERP Tropical Ecosystems Hub (NERP TE Hub) is focused on addressing issues of concern for the management, conservation and sustainable use of tropical rainforests including the Wet Tropics World Heritage Area, the Great Barrier Reef and its catchments, and the Torres Strait, through the generation and transfer of research and knowledge. The Authority was represented on the NERP TE Hub Steering Committee and also chairs and is represented on the NERP TE Hub Rainforest Implementation Group.

The NERP TE Hub annual conference (7 - 10 May 2013) provided a forum for researchers to present an update and share knowledge of the management relevance of their NERP funded research. The Authority's executive director chaired one of the three rainforest focussed conference sessions.

Terrestrial Ecosystem Research Network

The Terrestrial Ecosystem Research Network (TERN) is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy and the Super Science Initiative. TERN provides the research infrastructure and standardised procedures through which a wide array of ecosystem research data and knowledge can be stored, accessed and analysed.

TERN is establishing two Rainforest Super Sites in the Wet Tropics; one on the Atherton Tableland centred on a 25ha instrumented monitoring plot at Robson Creek; and one in the Daintree lowlands centred on JCU's Daintree Rainforest Observatory and canopy crane site. The Rainforest Super Sites are providing information on rainforest dynamics and in changes in biodiversity focusing on the influence of climate change and climate drivers such as carbon dioxide.

Running alongside the biodiversity monitoring has been the establishment of a biophysical monitoring program which includes automatic weather stations, soil moisture sensor systems and instrumented soil pits. A 40m tower with an OzFlux station was constructed within the WHA in December 2012 adjacent to the 25ha plant dynamics plot to monitor energy, water and carbon balance. A Wet Tropics Cooperative Management Agreement and Environment Protection and Biodiversity Conservation Act 1999 approval were necessary to allow for the construction of the tower within the Area.

The Authority and the NPRSR have entered into a Memorandum of Understanding with the TERN Rainforest Super Site research consortium to jointly support their various projects and to facilitate, enable and encourage collaboration of effort between the parties for mutual benefit.

Authority staff attends regular meetings of the TERN Rainforest Supersite group to discuss research progress and project management issues. A TERN Rainforest Supersite User Group was established during the year to discuss how to optimise the research relevance and data accessibility from the Robson Creek and Daintree Rainforest Observatory monitoring nodes of the TERN Rainforest Supersites.

Australian Research Council Linkage Grant

In December 2011 the Authority entered into a three year partnership agreement with JCU, the Queensland Herbarium, the University of Queensland and Biome5 Pty Ltd in an Australian Research Council (ARC) Linkage project: *Accelerating species richness gains and carbon sequestration in secondary regrowth in north Queensland*. The aim of the project is to devise strategies to accelerate rainforest recovery and regrowth on degraded land.

Secondary forests often regenerate on previously cleared land but are a poor substitute for the original forest, lacking both their high species richness and exceptional carbon storage. This project is investigating the barriers to rainforest regeneration to determine how we can accelerate the restoration of these forests to increase their carbon sequestration and biological diversity. The research sites are located on private land on the Atherton Tablelands and involve the cooperation and support of many landholders. The Authority's contribution to the project involves the allocation of staff time and access to digital spatial coverages and data sets.

Tropical Rainforest Plant Identification Courses

In partnership with the Authority and CSIRO Plant Industries, the Australian Tropical Herbarium (ATH) has developed a series of plant identification workshops that provide hands-on training to learn and develop skills in identifying the flora of the Wet Tropics. The workshops introduce participants to the skills and resources needed for rainforest plant identification; teach the use of interactive plant identification keys and are designed to improve participants understanding of identification, distribution and ecology of Wet Tropics native and invasive plant species.

The workshops are based on the *Interactive Key to Australian Tropical Rain Forest Plants* (RFK) which is the largest interactive key in the world and covers 10% of the Australian vascular flora (over 2,530 species). Workshop materials were developed in a module format, to enable them to be presented 'stand-alone' or be combined with others on an as-needed basis. During 2012-13, 48 participants enrolled for either basic training (two days) or completed advance modules in plant identification techniques (four days), depending on their skill level and requirements. The workshops were also open to the public.

Geographic Information Services

The Authority provided geographic information services and products to a varied client base during the year. Clients included Commonwealth, State and local government departments, universities, research organisations, consulting companies, Traditional Owner groups and organisations, tourism organisations, community groups and individuals.

Strategic Goal 5

The Wet Tropics World Heritage Area is used, enjoyed and celebrated as the World's finest learning landscape for tropical rainforest and its sustainable management.

Tourism and presentation of the Wet Tropics World Heritage Area and associated values are critical areas of activity for the Authority. They contribute to the Queensland Government's plan of objectives for the community, to grow a four pillar economy and deliver better infrastructure and planning.

National landscapes Program

The Wet Tropics National Landscape was launched on 8 August 2012 by the Hon Tony Burke MP, Minister for Sustainability, Environment, Water, Population and Communities. The Authority was centrally involved both in the establishment of the National Landscapes Steering Committee and is supporting a number of its key projects about building tourism experiences and strengthening interpretation and presentation in the Wet Tropics.

The Wet Tropics National Landscape Steering Committee was singled out by Commonwealth program managers at both the 2012 and 2013 National Landscape Forums for its leadership in working with diverse stakeholders to develop new tourism products recognising and promoting World Heritage values and assisting tour operators incorporate landscape positioning into their business.

The National Landscape Steering Committee considered and made progress on other important issues over the course of 2012-13. These included overview and support of the Wet Tropics Tour Guide program and a facilitation role in supporting coordinating voluntourism in the Wet Tropics.

Another key activity was the *Best of Nature – Product Criteria Project*. The Authority worked with Tourism Australia and Parks Australia to lay down the criteria for the identification of current and developing signature products and experiences that will later be applied to all National Landscapes. This was an opportunity to strengthen the World Heritage Area as an essential part of the tourism experience in the Wet Tropics. Other achievements included the development of media and publicity assets which included media kits, wildlife calendar and preparations for the *Nature-Wise* film shoot for the Wet Tropics.

Tour guide accreditation and training

The Authority has made a strong contribution to the tourism industry through developing an on-line training scheme for Wet Tropics tour guides. 2012-13 marked the successful completion of the first 55 graduates from the *Wet Tropics Tour Guide Accreditation Training* on-line course.

The Authority received a grant from the Queensland Tourism Industry Council (QTIC) to develop Wet Tropics curriculum and fund places for the first cohort of guides. The inaugural Wet Tropics field school was held on the 7-8 December 2012. The second school was held in the Atherton Tablelands on the 15-16 March 2013. The training was developed in partnership with Savannah Guides Limited as well as JCU, Tablelands Regional Council, Tropical Tablelands Tourism and relevant Traditional Owner Groups.

The project will deliver an integrated professional development program for Indigenous and non-Indigenous tour guides. The resulting quality of guide knowledge and presentation skills will provide a competitive edge and sustain growth in the region.

The course helps raise the bar of professional standards in guiding in the Wet Tropics region. The Authority is continuing to support guides by offering professional guide schools to strengthen guide standards and networking.

National Ecotourism Conference

The National Ecotourism Conference was held in Cairns on 15-17 October 2012. The Wet Tropics Management Authority was one of the major partners and sponsors. The executive director convened one of the concurrent sessions on *Communities benefitting from Strategic Partnerships in Tourism*.

The Authority presented a paper to the National Ecotourism conference on 16 October 2012 which describes and promotes the Wet Tropics approach and model to guide training and professional development.

Wet Tropics magazine

The Authority developed an innovative partnership with Tropical Coast Tourism that resulted in the publication of the *Explore Magazine*. This visitor magazine tailored to the southern half of the Wet Tropics contains numerous references to the Wet Tropics World Heritage area and a range of visitor experiences. It contains a lift out detailed map of the World Heritage Area promoting access and visitation.

This was a cost effective way to distribute and communicate Wet Tropics World Heritage presentation material to visitors. The popularity of the magazine with 65,000 copies distributed, has ensured widespread availability of information about the Area at a relatively small cost to the Authority. An extra 36,000 copies of this map were produced to be distributed through all accredited visitor information centres in the region as well as key consumer shows in Melbourne, Sydney and Brisbane.

Bloomfield Track

The Authority has formed a *Bloomfield Track Presentation/Visitor Experience Working Group* comprising local business, councils and tourism marketing agencies to explore options and opportunities for improving the visitor experience along the Bloomfield Track. An initial meeting was organised and chaired by Wet Tropics staff with officers from Cairns Regional Council, Cook Shire Council and Wujal Wujal Council and Cape York Tourism on 13 May 2013 to discuss the issues and opportunities for tourism presentation along the track.

There is commitment from all parties to work together to improve the tourism experience along the Bloomfield Track, including helping visitors to better appreciate the area by using signage and other forms of interpretation. This included presenting its natural and cultural values and providing opportunities to slow people down, take longer to complete the journey, see more along the way and connect opportunities in and around Wujal Wujal and onward toward Cooktown.

Wet Tropics Tourism Network and stakeholder liaison

The Authority continued to broaden its tourism network to include those from the industry the Authority can work in partnership with on a wider range of projects. The Wet Tropics Tourism Network membership provides the Authority with intelligence and insight into current issues around access to protected areas for tourism purposes and the need to strengthen the quality and range of tourism products in the region.

Strategic Goal 6

Enduring partnerships enhance the integrity of the Wet Tropics World Heritage Area, its presentation and its function in the life of the community.

The Wet Tropics Management Authority is a small organisation with limited operational roles. It relies on the commitment and cooperation of its partners in government, the community and in industry to ensure that the goals of the World Heritage Convention are achieved in the Wet Tropics.

Some of the most important partners for the Authority in its work are:

- *Land owners and managers within the Wet Tropics World Heritage Area*. Most prominent among these are the Queensland Department of National Parks, Recreation Sport and Racing (NPRSR), which is responsible for the national parks, conservation reserves and other lands that comprise the bulk of the Area. Private land comprises a relatively small proportion of the Area, but the Authority is particularly conscious of the commitment of these owners whose land management practices benefit the entire community.
- *Local government*. The Wet Tropics World Heritage Area intersects with nine local government areas. Through sensitive design and management of transport, water and other council and community services infrastructure, sympathetic planning and regulation of development and leadership in matters such as pest control and community engagement, councils make a vital contribution to the Area.
- *State and Commonwealth environmental agencies*. Numerous Commonwealth and State agencies contribute to the Wet Tropics World Heritage Area. Prominent among these in the Queensland Government are the Departments of Environment and Heritage Protection; Natural Resources and Mines; Agriculture, Fisheries and Forestry; and Tourism, Major Events, Small Business and the Commonwealth Games. In the Commonwealth, the Departments of Environment, Heritage and Water; Resources, Energy and Tourism; and Agriculture, Fisheries and Forestry play particularly important roles.
- *Universities, research institutions and schools*. Through research and teaching, universities and schools build and communicate knowledge about the Wet Tropics World Heritage Area. They play a central role in achieving the World Heritage Convention goal calling for the transmission of World Heritage properties to future generations. CSIRO, James Cook University and other universities have made a vital contribution through research over many years, ensuring that the Wet Tropics is strongly positioned as one of the World's premier learning landscapes for rainforest ecology and management.
- *Rainforest Aboriginal people*. The Rainforest Aboriginal tribes that recognise the Wet Tropics World Heritage Area as their traditional country continue to have a vital interest and role in the protection and management of the landscape which lies at the centre of Rainforest Aboriginal culture.
- *The tourism industry*. The far north Queensland tourism industry and through this, a large proportion of the regional economy relies heavily on the globally significant natural values of the Wet Tropics rainforests. In turn, the tourism industry is a vital partner in presenting the Wet Tropics World Heritage Area to millions of visitors and communicating its values.
- *Regional community organisations*. Many community organisations in the region play an important role in support of the

Wet Tropics World Heritage Area. These include Terrain NRM, the regional natural resources management body; numerous catchment coordination groups; regional and local scale catchment management and landcare groups; and community conservation organisations. Recreation, arts and cultural organisations also are important partners for the Wet Tropics World Heritage Area.

The Authority's partnerships are evident in almost all elements of its work so feature in other parts of this annual report. Partnership activities that are not otherwise reported are summarised below.

Regional Managers Coordination Network

The Authority is an active participant in the Far North Queensland Regional Managers Coordination Network. This network, comprising senior public sector leaders in State, Commonwealth and local government in the region plays an important role in supporting collaboration between government agencies by sharing information relevant to implementation of government programs. During 2012, the Authority's executive director ended a two year term as chair of the network.

Australian Committee for IUCN

The Authority is a government agency member of the International Union for the Conservation of Nature (IUCN). Along with other Australian IUCN members, the Authority participates in the Australian National Committee for IUCN (ACIUCN). ACIUCN plays a valuable networking and information sharing role between government and non-government members of IUCN in Australia. ACIUCN hosted two major symposia during the course of 2012, including a World Heritage themed symposium in Cairns, celebrating the 40th anniversary of the World Heritage Convention. The Authority's executive director served as chair of the ACIUCN during 2012-13.

Department of National Parks, Recreation, Sport and Racing

Through the Queensland Parks and Wildlife Service (QPWS) the Department of National Parks, Recreation, Sport and Racing (NPRSR) is responsible for the national parks, conservation reserve and others areas of public land that total around 80% of the Wet Tropics World Heritage Area making it a vitally important partner for the Authority.

In 2012-13, the Authority provided NPRSR with $1.8M of Queensland State Government funding that had been appropriated for World Heritage management purposes. This arrangement helps to ensure NPRSR is able to address any particular priorities of the Authority in relation to the World Heritage status of the Wet Tropics landscape. It is important to note that the bulk of the QPWS program in the Wet Tropics is generally consistent with the goals of the World Heritage Convention.

Machinery of Government changes implemented following the change of Queensland Government in 2012 required consideration of the nature of the partnership now that the Authority and QPWS are in different portfolios. Consistent with other inter-agency funding transfer arrangements, a Memorandum of Understanding (MoU) will be required to support the previously established partnership agreement. In April 2013, through an exchange of letters, NPRSR and the Authority agreed that:

1. The purpose of the MoU is to identify and fund protected area management services to be delivered by NPRSR in the Wet Tropics World Heritage Area that contribute to the implementation of the World Heritage Convention
2. NPRSR and the Authority will collaborate in the development of a MoU for 2013-14 that is consistent with the above purpose and conforms with the *Management Scheme Intergovernmental Agreement for the Wet Tropics of Queensland World Heritage Area* and the Wet Tropics World Heritage Protection and Management Act 1993.

Australian World Heritage Advisory Committee

Represented by Authority Board Director Dr Alastair Birtles, the Authority collaborated with other Australian World Heritage properties through the Australian World Heritage Advisory Committee (AWHAC). AWHAC advises the Council of Australian Governments (COAG) Standing Council on Environment and Water through the Senior Officials Committee, on policies, programs and appropriate cultural protocols which benefit World Heritage properties in areas of common interest and on national or crosscutting issues. In addition to the opportunity to contribute to national policy for World Heritage, the Authority's participation in AWHAC helps increase capacity in the Wet Tropics and elsewhere by information sharing.

Australian World Heritage Indigenous Network

Wet Tropics Traditional Owners participate in the Australian World Heritage Indigenous Network (AWHIN) that assists in ensuring Traditional Owners associated with World Heritage properties have a proper influence in national management and policy. The Authority assisted the secretariat of AWHIN within the Department of Sustainability, Environment, Water, Population and Communities; and Wet Tropics AWHIN representatives with advice and information in advance of a network meeting in Darwin from 26-31May 2013.

Strategic Goal 7

The Wet Tropics Management Authority is an accountable and capable organisation

The Wet Tropics Management Authority continued to pursue high standards of business planning to ensure resources are allocated to the strategic priorities established by the Wet Tropics Management Authority Board and that progress is regularly monitored. Through this approach, the Authority creates a link between the goals of the World Heritage Convention and the day to day activities of its staff.

World Heritage Reporting

The United Nations Educational Scientific and Cultural Organisation (UNESCO) requires the preparation of World Heritage Periodic Reports every six years. The Periodic Report is the primary reporting and evaluation mechanism for all World Heritage properties. The Authority submitted its Periodic Report on the Wet Tropics World Heritage Area (via the Commonwealth Department of Sustainability, Environment, Water, Population and Communities) to the World Heritage Centre. At its 36th session held in Saint Petersburg (24 June - 6 July 2012) the World Heritage Committee adopted the 2011 Periodic Reports for World Heritage properties of the Asia-Pacific region including the Wet Tropics.

World Heritage Retrospective Inventory

The nomination files of World Heritage properties within the Asian and Pacific region were reviewed by the World Heritage Centre. The review identified that prior to 1999 inventories and baseline data was not gathered in a systematic or consistent way. As a result of this review the Authority was requested to provide a retrospective 'Statement of Outstanding Universal Value' for the Wet Tropics World Heritage Area as well as an accurate map depicting the boundaries of the property. The Authority prepared these retrospective products using the information provided in the original nomination document and the original International Union for Conservation of Nature, (IUCN) assessment reports for the Wet Tropics. At its 36th session, the World Heritage Committee formally adopted the Wet Tropics of Queensland retrospective Statement of Outstanding Universal Value. The Committee also adopted the Wet Tropics of Queensland World Heritage Area boundary mapping that the Authority prepared.

International Visitors

As a World Heritage Area, the Wet Tropics has an international profile. The Authority was pleased to host a number of international visitors seeking to learn about the values of the World Heritage Area and its system of management. Through this, the Authority contributes to strengthening global capacity for World Heritage management and helps Australia's and Queensland's reputation in support of the World Heritage Convention. The Authority's contribution is often in support of the Department of Environment, Heritage and Water or the Department of Foreign Affairs and Trade. Creating linkages with other environment and heritage managers in Asia and the Pacific also represents a contribution the Authority can make to Queensland's objective of sharing tropical expertise.

Mr James Enage, Chief Executive Officer of the Kokoda Track Authority visited the Authority twice during the year to discuss the potential of a twinning arrangement between the two authorities.

A delegation of 15 officials from the Government officials from the Wulingyan Scenic World Heritage Area in the Hunan Province of China, visited the Wet Tropics Management Authority to discuss World

Heritage management issues in July 2012. Authority staff were pleased to share their experiences in relation to the Wet Tropics World Heritage Area and to learn of the approach China is taking to the Wulingyan Scenic World Heritage Area.

Mr Arham Syazaili, Director General of the Ecotourism Division of the Malaysian Department of Wildlife and National Parks led a delegation of Malaysian environment and tourism officials in a visit to the Authority in October 2012. Authority staff were pleased to share information about the Authority's work in ecotourism and were particularly interested to learn of the approach Malaysia is taking to training and accreditation of national park tour guides.

Mr Yasushi Kinjo, section chief of the Nature Conservation Division, Department of Environmental and Community Affairs, Okinawa Prefectural Government, Japan, visited the Authority in November 2012. The Authority briefed Mr Kinjo about the history and issues associated with World Heritage listing of the Wet Tropics in the context of his interest in preparing a World Heritage nomination for parts of Okinawa.

The Authority hosted the Papua New Guinea Minister for Environment, the Hon John Pundari MP and a delegation of senior officials when they visited Cairns in January 2013. Minister Pundari was interested in governance arrangements for the Wet Tropics, in ecotourism and in engagement of Traditional Owners in environmental management.

2013-2018 Strategic Plan

Recognising that 2012-13 marked the final year of a four year Australian Government funding round, the Authority reviewed and renewed its strategic plan for the 2013-2018 period. This plan plays an important role in communicating the Authority's goals and objectives and guides the development of the annual operating plan. It provided the basis for the Authority's submission to the Australian Government for continuing funding for the corresponding period. The goals of the strategic plan provide the reporting framework for this annual report.

New investments and funding proposals

The Authority continued to seek new funding into projects that contribute to its strategic goals. It was successful in securing $260,000 via the Commonwealth Caring for Our Country (CFOC) project for Conservation Volunteers (CVA) and Biosecurity Queensland to undertake surveillance for the existence of any infestations of yellow crazy ants or electric ants from Palm Cove to Edmonton and in the Bingil Bay area.

The Authority was invited to develop a proposal through the Biodiversity Fund 2013-2014 for wildlife corridors at Smiths Gap. A formal submission was made on 12 April 2013 asking for approximately $900,000 to complete 10ha of biodiverse plantings and 16ha of restoration. A similar funding application was made to the CFOC Targeted Area Grants (Cape York). The Authority also submitted a CFOC application for about $700,000 to continue its revegetation work on the Southern Atherton Tableland.

The Authority was invited to develop a proposal through an expression of interest under the Commonwealth's Biodiversity Fund 2013-2014 and an expression of interest under the 2013-2014 CFOC program for projects focussed on eradication of yellow crazy ant infestations in the Wet Tropics region. Full submissions were subsequently made seeking funding of $2.4M.

The Authority collaborated with the University of the Sunshine Coast in partnership with many other organisations on two myrtle rust expressions of interest

to the Biodiversity Fund 2013-2014 and one expression of interest to the CFOC. The first bid was to screen for myrtle rust resistance in revegetation nurseries across the Wet Tropics. The second proposal was to develop strategies to reduce the impact of myrtle rust on myrtaceous species and key ecosystems in northern Australia.

Submissions

Australia's Biodiversity in a Changing Climate

The Authority made a submission to the House of Representatives Inquiry into *Australia's Biodiversity in a Changing Climate*. The submission re-presented the *2007-2008 State of the Wet Tropics Report* on climate change and draws attention to the particular vulnerability of Wet Tropics biodiversity to climate change and, consistent with the Authority's earlier report, advocates four main areas for action. The submission also encouraged the Inquiry to capitalise on the foundations of research into climate change in the Wet Tropics.

On 5 July 2012, the Committee held a public hearing in Townsville at which the executive director participated. On 6 July 2012 the Committee visited several sites north of Cairns. The itinerary of the visit was arranged by the Authority and assisted by James Cook University. The focus of the visit was to consider the vulnerability of terrestrial wet tropical ecosystems to climate change, as highlighted in submissions presented to the inquiry. The two-day inspection and public hearing program provided the Committee with an overview of the major climate change issues potentially affecting the biodiversity of the Wet Tropics ecosystems.

Draft State Planning Policy

The Authority made a submission on Queensland's draft State Planning Policy in April 2013. The submission welcomed the recognition of 'matters of national environmental significance' (which includes World Heritage properties) and the associated State policy that such matters be 'appropriately safeguarded to support healthy and resilient ecosystems'. The Authority's submission however seeks to have the policy position expanded to capture all natural and cultural heritage values associated with World Heritage properties, not just those related to biodiversity.

Ecotourism Facilities in national parks

The Authority made a submission on the consultation document '*Ecotourism Facilities on National Parks- Implementation Framework*'. The Authority supported the six overarching principles for guiding the consideration of ecotourism facilities in national parks. The Authority seeks early collaboration with the QPWS prior to undertaking site assessments and inviting expressions of interest regarding potential ecotourism facilities within the Wet Tropics World Heritage Area.

Queensland Ecotourism Plan 2013-2020

The Authority made a submission on the draft *Queensland Ecotourism Plan 2013-2020*. The Plan seeks to provide tourism operators, government and other stakeholders with clear direction on how Queensland will leverage its competitive advantage to become a bold, innovative, world leader in ecotourism. The Authority's submission highlighted its activities in relation to eco-tourism in the Wet Tropics and identified opportunities for further development of the industry.

Business Administration

Business planning systems

The Authority gives a high priority to developing a business plan that creates the highest possible value for the Wet Tropics community and stakeholders. The Authority is committed to developing and adapting its own capabilities to ensure it maintains capacity to meet the needs of the Australian and Queensland Governments and the Wet

Tropics community. The Authority's project management approach encourages clear identification of outcomes, objectives and milestones. It requires purposeful allocation of staff and other resources to organisational priorities and establishes a clear basis for organisational performance management.

Financial management

As the Authority is a Statutory Authority, its general-purpose financial statements details for 2012-2013 are incorporated in the overall Department of Environment and Heritage Protection financial statements. Total funding of $4.9M for 2012-2013 was provided to the Authority, principally by the Australian and Queensland Governments, and supplemented by other forms of income. The Authority realised an operating deficit of $328,000. A summary of the Authority's operating statement for 2012-2013 is provided in **Table 1**.

Table 1: Wet Tropics Management Authority Operating Statement

Controlled Revenue and Expenses	**Notes**	**2012-13**	**2011-12**
REVENUE		$'000	$'000
Revenue from Government			
Payments for Outputs		1,796	1,946
Asset Assumed/Liabilities transferred		0	0
Sub-total Government Revenue		**1,796**	**1,946**
Own Source Revenue			
User Charges		6	2
Grants and Other Contributions		3,173	3,001
Taxes fees and fines			
Gain on disposal of fixed assets			
Other Revenue			5
Interest			
Sub-total Own Source Revenue		**3,179**	**3,008**
TOTAL REVENUE		**4,975**	**4,954**
EXPENSES		$'000	$'000
Operating Expenses			
Program			
BBA Business Management		2,517	831
BBB Communities & Partnerships		267	960
BBC Planning & Conservation		723	1,162
BBD QPWS - WTMA Partnership Agreement		1,792	1,774
Sub-total Operating Expenses		**5,299**	**4,727**
Non-Operating Expenses			
Depreciation		4	6
Asset Writedowns/Loss on disposal			
Sub-total Non-Operating Expenses		**4**	**6**
TOTAL EXPENSES		**5,303**	**4,733**
OPERATING RESULT		-328	221

The Australian Government's allocation to the Authority for 2012 -12 was $3.2M. These funds were allocated to the Authority's programs. The Queensland Government through the Department of Environment and Heritage contributed $1.8M to the Authority to support management of the Wet Tropics World Heritage Area. These funds were then allocated to Queensland Parks and Wildlife Service for on-ground World Heritage management services.

Audits

One operational audit was conducted by PGL Financial Services Pty Ltd in 2012-2013 for Commonwealth funds received.

Staffing and Contractors

At 30 June 2013 the approved staff establishment of the Authority totalled 23 permanent positions, none of which were vacant.

Contract staff supplemented staff resources during the year to provide a range of services. These services included marketing and communications, graphic designers, financial and workforce management; conservation and tourism activities and administrative support. **Table 2** shows expenditure on consultancies and contracts for 2012-2013 compared to the previous financial year.

Table 2: Expenditure on Contracts

	2012-2013	2011-2012
EXPENDITURE	**$**	**$**
Consultancies by Category *		
Management	0	0
TOTAL	**0**	**0**
Contract Staff by Program*		
Business Management	10,095	12,608
Communities & Partnerships	61,117	33,528
Planning & Conservation	5,942	62,968
Landscape Connectivity	96,227	0
Tramp Ants Wet Tropics	233,000	0
TOTAL	**406,381**	**109,104**

* Excludes the QPWS Service Agreement.

Workplace health and safety

The Authority adheres to the Queensland Government's health and safety management systems and procedures. The Authority recorded no accidents for 2012-13. Regular workplace health and safety inspections are conducted with no significant issues arising. Authority staff attended regular education, awareness and training sessions to ensure current accreditations are maintained.

Equal Employment Opportunity

All recruitment and selection recommendations are monitored and reviewed to ensure compliance with Queensland Government policies and procedures including current human resources directives. All appointments during 2012-2013 complied with directives and no equal employment opportunity complaints were received. At 30 June 2013 the Authority had 12 females and 11 males on staff and nil positions vacant. **Table 3** gives a profile of the Authority's staff.

Table 3: Employment by gender, occupational stream and salary

Employment by gender and occupational stream as at 30 June 2013 (based on actual occupants)

STREAM	Female (%)	Male (%)
Administration and Senior Executive Service	10 (50)	7 (35)
Professional	2 (10)	3 (15)
Technical	0	1 (5)
Operational	0	0
TOTAL	**12 (53)**	**11 (47)**

Employment by gender and salary level as at 30 June 2013 (based on substantive positions)

SALARY RANGE	Female (%)	Male (%)
$107,869 +		1 (5)
$101,610 - $107467		2 (10)
$91,712 - $98,341		2 (10)
$81,962 - $87,691	2 (10)	3 (15)
$71,435 - $77,644	4 (20)	1 (5)
$61,641 - $68,991	3 (15)	2 (10)
$52,132 - $59,293	3 (15)	
TOTAL	**12 (53)**	**11 (47)**

Terms and Abbreviations

Cr	Councillor
CVA	Conservation Volunteers Australia
CMA	Cooperative Management Agreement
Commonwealth Act	Wet Tropics of Queensland World Heritage Area Conservation Act 1994
CSIRO	Commonwealth Scientific, Industry and Research Organisation
CSLG	Conservation Sector Liaison Group
DEHP	Queensland Department of Environment and Heritage Protection
DNA	Deoxyribonucleic acid
NPRSR	Department of National Parks, Recreation, Sport and Racing
DTMR	Queensland Department of Transport and Main Roads (DTMR)
EKY	Eastern Kuku Yalanji
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
GIS	Geographic Information System
ha	Hectare
ILUA	Indigenous Land Use Agreement
IPA	Indigenous Protected Area
IUCN	International Union for Conservation of Nature
Jabalbina	Jabalbina Yalanji Aboriginal Corporation
JCU	James Cook University
MoU	Memorandum of Understanding
NERP	National Environment Research Program
NERP TE Hub	National Environment Research Program Terrestrial Ecosystem Hub
NiE	News in Education
NRM	Natural Resource Management
QLD	Queensland
QPWS	Queensland Parks and Wildlife Service
Queensland Act	Wet Tropics World Heritage Protection and Management Act 1993
RAPA	Rainforest Aboriginal Peoples Alliance
RNTBC	Registered Native Title Bodies Corporate
SAC	Scientific Advisory Committee
SEWPAC	Department of Sustainability, Environment, Water, Population and Communities
Terrain NRM	Terrain Natural Resource Management
The Area	Wet Tropics of Queensland World Heritage Area
The Authority	Wet Tropics Management Authority
The Plan	Wet Tropics Management Plan 1998
TERN	Terrestrial Ecosystem Research Network
UNESCO	United Nations Educational Scientific and Cultural Organisation
WHA	World Heritage Area
WTMA	Wet Tropics Management Authority
WTWHA	Wet Tropics World Heritage Area

STATE OF THE WET TROPICS 2012-2013

State of aquatic habitats, biodiversity and water resources in the Wet Tropics of Queensland

Barron Falls © Wet Tropics Images

Children exploring their local creek © Queensland Government

Executive Summary

This report provides a brief summary of the current state of knowledge of aquatic habitats, biota and ecological processes within the Wet Tropics region of north Queensland.

Freshwater ecosystems of the Wet Tropics contribute significantly to the World Heritage values of the region. They are ancient, with many aquatic species having Gondwanan origin. They support unique aquatic biota and assemblages including a high diversity of fish and invertebrates, including many species of conservation significance and endemic species that evolved *in situ* in the region.

Many aquatic habitats, such as the crater lakes and numerous waterfalls of the region are of exceptional natural beauty, attracting a large number of domestic and international visitors. Indigenous people have a long history of utilising the aquatic habitats of the region and are asserting their rights and increasing their capacity to play a greater role in co-managing the aquatic estate of the region, both within and outside of the World Heritage Area.

Just under half of the region is protected within the Wet Tropics World Heritage Area where habitat integrity is high. The other half of the region however, has been largely cleared and developed for urban and agricultural purposes. Streams are highly connected systems and their passage through the landscape marks an abrupt and dramatic change at the boundary of the World Heritage Area, from intact to modified ecosystems. Impacts to aquatic systems are therefore readily transferred into and out of the Wet Tropics World Heritage Area. Many of the larger aquatic species, especially fish that migrate between freshwaters and estuarine/marine habitats as part of their life-cycle, have to contend with such habitat quality variations.

The Wet Tropics World Heritage Area, and protected areas in general, have historically been designed for the protection of terrestrial rather than freshwater habitats, and despite nearly half the region being within the protected area estate, most is escarpment and upland areas. Unfortunately, most freshwater fish species

have most of their distribution outside of the protected area estate, in more heavily modified lowland stream reaches.

Six key messages that emerge from this report that can be summarised as:

1. **Our knowledge of the aquatic fauna of the region is relatively recent, having largely developed only in the last 25 years. Even today, new species of fish, turtles and crustaceans are still being discovered**. These discoveries are so profound, that some, such as the many new species of fish recently discovered in short, steep, coastal streams, are causing a re-examination of the way biodiversity patterns developed and are structured in the region.

   Whilst we are discovering many new species, some are disappearing. Four stream-dwelling frog species have declined to extinction or near extinction, and three others have suffered massive declines in distribution and abundance. All seven species are endemic to the Wet Tropics and an introduced disease appears to be the main cause of, or contributor to, their decline.

2. **Nine exotic fish species have been introduced and became naturalised in the Wet Tropics. The region also has the highest number of translocated native fish species (n=36) of any region in Australia. The Barron River has probably the most modified fish fauna of any river in Australia**. Despite having the highest overall fish diversity of any region in Australia, this is mostly concentrated in the lowlands as most upland Wet Tropics streams are naturally fish depauperate.

   This has prompted people to introduce numerous native and exotic fish, and even in some cases crustaceans, turtles and freshwater crocodiles, to upland streams such as the Barron River, radically altering their natural biotic communities. The introduction of native and exotic fish species is one of the few processes impinging upon the integrity of otherwise natural good condition streams, including some within the protected area estate.

   There are few options available for removal of unwanted fish once they have established a population, so early detection and preventing further introductions is the priority. As it is people who spread pest fish, public education is the key preventative measure.

3. **In the Wet Tropics lowlands, up to 80% of wetlands have been lost to development and the remainder are in a perilous state and are in urgent need of rehabilitation**. In stark contrast to the lowlands, most upland streams, and those draining the escarpment, are in very good condition. In the developed lowlands and tablelands, the greatest freshwater management issues include the loss of riparian vegetation and its replacement by aquatic and riparian weeds (mostly grasses and creeping plants), fish passage barriers and poor water quality runoff. Most floodplain lagoons and wetlands support only half the fish species they would have under pre-development conditions. Fortunately, many of these habitats offer to be resilient and some restoration activities are showing excellent and rapid results.

   Most fish passage management issues relate to the retrofitting and better design of road crossings. Several weed control and riparian restoration schemes are in operation throughout the region and these offer technically simple solutions that have numerous benefits for both terrestrial and freshwater habitat values. Despite the decline of much of the aquatic estate, with concerted effort, we can not only halt this decline but actually restore some of the diminished values.

However, greater resources are required to deal with the sheer scale of currently degraded aquatic ecosystems.

4. **Freshwater habitats link the Wet Tropics World Heritage Area to the Great Barrier Reef World Heritage Area.** Connectivity between these two World Heritage areas, is high through for example, the movement of mobile animals such as fish, and via water mass, especially during flood events. Unfortunately, the quality of water moving from the Wet Tropics to the reef is negatively impacting its health. Public awareness, and to a large extent scientific effort, have been focused on the impact of water quality on the Great Barrier Reef with much less research investment being directed at inventorying, monitoring and understanding the streams themselves.

   Whilst the investment in reducing urban and farm runoff and associated initiatives has considerable benefits to freshwater systems, many aquatic habitats, including floodplain lagoons and wetlands, are more affected by localised runoff, loss of riparian shading and aquatic weed invasion. These issues require *in situ* management of their own, and will receive only moderate benefits from reef-related initiatives.

5. **The potential effects of climate change have been studied for terrestrial, but not for freshwater ecosystems**. Whilst air temperature is widely predicted to increase, how this will translate into stream temperatures, is unclear as the effect is non-linear. The effects of climate change upon rainfall and streamflow are even less clear, but canopy cloud interception, which is a major supplier of moisture and streamflow in the dry season, is predicted to decline as clouds become less abundant at lower elevations.

   Key adaptation options are to identify refugia less likely to be affected by climate change, study the tolerance to increased water temperature of key faunal species, and to replant and restore streamside riparian vegetation whose shading effect can buffer small streams against temperature increases.

   Upland streams also house a greater proportion of species that are adapted to cooler, perennially-flowing waters and the threat of climate change presents a new challenge for which we lack sufficient data to make robust predictions. Unlike for terrestrial vertebrates, for which climate prediction modelling is well-advanced, the first models for freshwater fauna are only now being developed. Some aquatic species, such as the four species of *Euastacus* crayfish found only on small areas of mountain top streams, are highly vulnerable to any increases in temperature and are probably the most vulnerable aquatic species in the region. Despite this, and no doubt because they occupy hard to access habitats, we know virtually nothing about these species.

6. **Despite the abundant rainfall, water resources are not readily available for consumptive use, potentially leading to resource use conflicts**. Consumer demand for water is high and increasing rapidly, yet because of the high conservation values of the region, options for locating water storages are limited. Perennial streamflow is also a key driver of Wet Tropics diversity, tourism, recreational amenity and ecological services, thus constraining allowable extraction of surface and groundwater. Despite being the 'Wet' Tropics, demand management remains a high priority for water resource management, especially in the Cairns and Port Douglas areas, which already have relatively stringent water use restrictions.

Introduction

The Wet Tropics of Queensland World Heritage Area has outstanding natural values, meeting all four natural criteria for World Heritage listing. The Wet Tropics of Queensland is considered to:

- contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance - *Criterion (vii)*
- be an outstanding example representing the major stages of Earth's history, including the record of life, and significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features - *Criterion (viii)*
- be an outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals - *Criterion (ix)*
- contain the most important significant natural habitats for *in situ* conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation - *Criterion (x)*.

Freshwater ecosystems of the Wet Tropics contribute significantly to these criteria. They are ancient, with most aquatic species reflecting a Gondwanan origin. They support unique aquatic biota and a high diversity of fish and invertebrates, including many species of conservation significance and endemic species that evolved *in situ* in the region. Many aquatic habitats, such as the crater lakes and numerous waterfalls of the region are of exceptional natural beauty and aesthetic value, attracting recreational visitors and domestic and international tourists alike.

Waterfalls also provide unique stream habitat and are important in structuring the freshwater faunal communities of the region. Wet Tropics streams provide a range of ecosystem services, including good quality drinking water and water for irrigation and other economic developments.

Rainforest Aboriginal people have a close relationship with the Wet Tropics land and sea country which is embedded in customary law. For Rainforest Aboriginal people natural and cultural heritage is inextricably interconnected. Their values and assets in the Wet Tropics region include cultural and spiritual landscapes, places and materials, especially the waters (which includes waterways, springs, wetlands and marine waters). Many waterways provide healing places and story places as well as proving important food sources.

Although occupying just 0.2% of Australia's land area, the Wet Tropics contributes 6.6% of national annual runoff. By conveying this runoff between the Great Barrier Reef lagoon and its catchments, freshwater streams provide a significant link between two internationally-renowned World Heritage Areas. However, our knowledge of catchment effects upon the water quality of offshore and coastal waters greatly exceeds that of our knowledge of catchment effects upon streams and wetlands within those catchments. This is not unexpected, given the significant differential in research funding available to these topics.

The Wet Tropics is a unique region in Australia, being characterised by high rainfall and high relief terrain. Most headwater streams begin at altitude, tumbling over waterfalls and long reaches of rapids before entering the coastal floodplains with their abundant wetlands and productive estuaries. Streams within

the region are generally short, but of high gradient and with short floodplains and even shorter estuaries.

Australian rivers are among the most variable of any in the world. The rivers of the Wet Tropics, though still characterised as seasonal, provide a contrast to this pattern and display a relatively more consistent flow and discharge within and between years, compared to most Australian rivers, especially those of the adjoining dry tropical regions. The persistence of freshwater over millions of years, and the rugged terrain, are among the key factors leading to a high diversity of aquatic fauna and flora in the region.

The Wet Tropics World Heritage Area is drained by 13 major river systems and contains 30 wetlands of national significance. Of the just under 1.9 million ha within the Wet Tropics bioregion, just under 900,000ha are protected within the World Heritage Area and 77% of the region maintains intact vegetation communities. Aquatic habitats of the region harbour the greatest diversity of aquatic invertebrates in Australia. They are the preferred habitat for 30 frog species (many of high conservation value), 16 reptile and 73 bird species, whilst 40% of Australia's freshwater fish fauna are also found here.

Watercourses have riparian communities that are contiguous with the adjoining terrestrial forests and where they pass through open or cleared landscapes, provide corridors for the movement of terrestrial animals. Most aquatic habitats are freshwater but the World Heritage Area also includes small areas of estuarine and mangrove habitat.

Our knowledge of the biota and ecosystem functioning of aquatic systems in the Wet Tropics lags well behind that of terrestrial systems. The diversity and distribution of the terrestrial fauna and flora is well known, and is being comprehensively modelled. The first systematic surveys for fish in the region only occurred in the early 1990s. Turtles have still not been systematically surveyed and new species from both freshwater groups are still being found today.

This report includes consideration of all aquatic habitats within both the Wet Tropics World Heritage Area and Wet Tropics bioregion. This is because the linear connectivity of streams requires that they be considered in their entirety. They cannot be managed as segments. Streams that arise on upland tablelands may be subject to surrounding, and often intensive development, then flow through relatively undisturbed rainforest within the protected area estate, before entering highly modified lowland systems.

When referring to the Wet Tropics World Heritage Area in this report the words 'World Heritage Area' or 'the Area' is used. Reference to the 'Wet Tropics' or the 'region' refers to the bioregion or the high rainfall parts of the north Queensland coast in general.

Josephine Falls © C Clark

Freshwater fish

Summary

- 131 native fish species have been recorded from freshwater habitats in the Wet Tropics, 86 of which rely on those habitats (the remainder are more usually associated with estuaries)
- This is the highest freshwater fish diversity of any region in Australia and many species are endemic to the region (i.e. found nowhere else)
- Mountainous terrain and persistence of streamflow over millennia are key contributors to this high diversity
- Fish species richness is greatest in streams with the highest and most reliable flow, and many species endemic to the region are riffle specialists. Changes to flow regimes (e.g. from climate change or water extraction) may seriously affect fish communities
- Scientific knowledge of the fish fauna is relatively recent and many new species are still being discovered
- Within the Wet Tropics, 36 native fish species have been translocated to streams where they do not naturally occur. This represents the greatest number of such translocations for any region in Australia
- Nine exotic fish species have established populations in the Wet Tropics, and more occur in nearby rivers. The aquarium fishes - guppies and platys - are most widespread, but two tilapia species are considered the most problematic
- With exotic fish being common and many translocated native species present, the Barron River has probably the most modified fish fauna of any river in Australia.

Significance of the native fauna

Of the 131 fishes recorded from freshwater habitats within the Wet Tropics region, 86 are reliant upon freshwater habitats, the greatest diversity for any region in Australia. The most diverse families in the region are the gobies and gudgeons, followed by the glassfishes, rainbowfishes, eel-tailed catfishes and grunters. Endemic fish found nowhere else in the world include small-bodied species in the form of the Mulgrave River goby and rainbowfishes (Cairns rainbowfish, Lake Eacham rainbowfish, Uthcee Creek rainbowfish), and larger-bodied species, the Khaki grunter, Bloomfield River cod, Hogan's sole and a soon-to-be described eel-tailed catfish. This is a substantial number of endemic fish in terms of the biogeography of north-eastern Australian freshwater fishes.[1]

The freshwater fish fauna of the region has evolved under conditions of reliable, high-rainfall, sustaining fast flowing streams and more permanent year round discharge than is found elsewhere in Australia.[2] Consequently, a number of endemic fish species are riffle specialists.[3] Within some of the more diverse fish groups, species select for, and have adapted to, particular flow habitats within streams.[4] The reliability of flow over long timescales, including during the drier climates of the Pleistocene period, is suggested as the primary cause of high fish diversity. Even within Wet Tropics rivers, fish diversity is highest in those rivers with the most reliable flow regimes (Johnstone and Russell-Mulgrave catchments), even though they are not the largest catchments in the region.

Many of the fish species occupying lowland freshwater habitats in the Wet Tropics move to the estuary or sea for part of their life cycle, usually the larval/juvenile phase. This means that migration pathways are important, although, for many species their entire life cycle remains very poorly understood. Importantly, there are a number of recreational and commercial food species including marine migrants that make use of freshwater habitat and occur significant distances upstream (e.g. mangrove jack and barramundi).

Research history

The study of native freshwater fish assemblages in the Wet Tropics is developing, but essentially dates back only 25 years in contrast with the rich history of research into terrestrial vertebrate groups such as birds and mammals. An initial wave of fish surveys based primarily on boat and back-pack electro-fishing during the 1990s advanced knowledge of the composition of the fish fauna and unveiled a number of the endemic species mentioned earlier.[5, 6, 7, 8, 9, 10, 11, 12] Relationships between fish assemblage composition and stream hydrology have been a central focus of much of this research, which has incorporated interactions with food web processes and fish recruitment into conceptual and empirical models.[13]

In parallel, there has been attention given to riparian zone effects on fish assemblage structure and function and considerable focus on the ecology and invasions of exotic species.[14,15] New discoveries in the past five years have renewed interest in the composition of fish assemblages. These finds have arisen from the application of different field, and laboratory based techniques including snorkelling and underwater video as well as genetic analyses[16, 17,18] Consequently, there is currently an upsurge in the number of newly recognised fish species.

One of the more notable discoveries has been finding an assemblage of small, brightly coloured gobies in the short-steep stream catchments that occur as fragments along the Wet Tropics coastline.[19,20] This has included finding representatives of four different genera of goby positioned at particular habitats along the stream gradient including above waterfalls. At the same time genetic studies are uncovering cryptic species such as an eel-tailed catfish that is surprisingly widespread, and an undescribed species of purple-spotted gudgeon that inhabits the upper Tully River system.[21]

Recently there have been efforts to plan for protecting freshwater ecosystems and fishes in the Wet Tropics. This has included considering the capacity of the World Heritage Area to afford protection to freshwater fishes. A recent study[22] found that for 45 fish species in the Wet Tropics, 89% have less than 20% of their distribution within the protected area estate.

There is a need to progress conservation planning by incorporating information on rare species and species that have recently been discovered in the region. This is especially relevant to the newly discovered goby fauna in short-steep coastal streams and the finding of many cryptic species on the Atherton Tablelands.

Genetics of isolated populations

A series of genetics studies of freshwater fishes in the Wet Tropics has revealed the existence of cryptic species and sub-species, and some interesting spatial arrangements of genetic diversity. The Atherton Tablelands has emerged from these collective studies as an important area for evolution and speciation. Work has centred on the smaller-bodied species such as purple-spotted gudgeons, rainbowfishes, hardyheads and blue-eyes as well as crustaceans, turtles and larger fish species such as catfish. [23,24]

There is clearly a need for further field sampling and genetic investigations. Importantly, there is little traditional taxonomic descriptive work to support these genetic findings and this requires urgent redress if this work is to be more useful for ecological and societal planning purposes.

Genetic studies of the lowland inhabitant, the Cairns rainbowfish (*Cairnsichthys rhombosomoides*), have revealed some astounding results. This species appears to be highly distinct from all other living rainbowfish species that occur in Australia, Papua New Guinea, Indonesia and Madagascar and is more closely related to the Blue-eyes (Family Pseudomugilidae).[25]

An earlier genetic study of the Cairns rainbowfish revealed extreme isolation of small stream populations in evolutionary time within the Wet Tropics; despite the fact that these populations are sometimes only separated by short distances (e.g. hundreds of metres) within drainage basins.[26] This phenomenon is very unusual among lowland riverine fishes. In very recent developments, extremely isolated populations of the Cairns rainbowfish, which may even turn out to be separate species, have just been reported from streams immediately north of the Daintree River.[27]

A common theme emerging from this genetic research is that there is generally little variation in populations across the lowland streams but in the uplands, there is much greater variation and differentiation. Populations that are geographically close, may be millions of years apart in evolutionary terms. In several species studied so far, the lowland populations appear to be more recent colonisers, whereas the upland populations have had much longer residency in the region.

These patterns are readily explained by the ability of the lowland rivers to connect during floods and the ability of some species to disperse, especially during periods of lower sea-level when there was greater connection between lowland rivers across wider floodplains that existed 18,000-6,000 years ago.

Conversely, the upland streams have no physical connection, even during floods and even within the same catchment. The existence of numerous waterfalls creates populations that remain reproductively isolated for millennia. This isolation has allowed new species to evolve and has also created many new evolutionary significant populations. Such findings are being made rapidly with the development of powerful, yet cheap and rapid genetic techniques, and are greatly changing our views on colonisation and evolutionary processes in the Wet Tropics.

Coastal stream fish fauna

Researchers have recently discovered a spicialised fish fauna inhabiting a number of short coastal streams within the Wet Tropics World Heritage Area. These streams are iin high rainfall areas and are swiftly flowing and generally small in size and with a shorter absent estuarine zone.

The fish fauna of these streams are related to those found in neighbouring Pacific Islands. The dominant group are small-bodied gobies of the subfamily Sicydiinae. These fishes have paired pelvic fins on the underside of the body that forms a suction cap, and in certain species is used for holding position in constant, high flow habitat or for climbing waterfalls.

These gobies typically have brightly coloured adult male and less colourful females. They live in streams as juveniles and adults, but have marine larvae that can travel considerable distances by sea. Larval duration is in the order of weeks to months, hence their distribution in neighbouring Pacific Islands, where there has been some level of research undertaken.

The colourful nature of these fishes makes them both of interest to the public and vulnerable to collection by aquarists. These species usually occur in low numbers and are confined to very short reaches of only a few streams. The small size of these streams also leaves these habitats vulnerable to impacts normally associated with larger river systems and require the protection of riparian buffer zones and consideration of environmentally friendly bridges or water abstraction. These small fishes are found almost exclusively in small streams, which are often more neglected in relation to town planning, agricultural practice and beach use.

Eight species of cling gobies from four genera recently discovered in the Wet Tropics. All of these fish live in small coastal streams for much of their life but their larvae require access to the sea
© B Ebner

Exotic fishes

There are many exotic fish species in north east Queensland, including nine species known from the Wet Tropics World Heritage area. All the exotic fishes come from just two families - Cichlidae and Poeciliidae. The cichlids include two tilapia species, as well as popular aquarium fish such as oscars. The Poeciliidae are live-bearers (give birth to live young rather than lay eggs) and include many smaller species that have been introduced widely around the world. In the Wet Tropics, these include gambusia, guppies, platys and swordtails.

Exotic fish species pose a serious threat to the Outstanding Universal Value of the Wet Tropics World Heritage Area for three primary reasons. Firstly, the region contains numerous relatively undisturbed and unmodified aquatic ecosystems for which the introduction of exotic fish represent the greatest disturbance they have been subject to. Secondly, Wet Tropics streams have very high environmental values and many species of high conservation value that may be impacted by exotic species. Finally, the number of exotic species in nearby catchments is high.

The coastal catchments between Townsville and Cairns host 20 exotic fish species, more than any other region in Australia.[31] Most exotic fishes are tropical species and used in the aquarium trade, which explains why exotic species are more common in waterways associated with tropical cities such as Townsville and Cairns.

Recent years have seen significant, even exponential, range extensions for some of the exotic species of most concern. Most new records are the result of releases by the general public. Preventing the spread of exotic fish species therefore requires a well-informed public. Burrow[32] provides the most recent summary of exotic fish distribution in the Wet Tropics, finding exotic species at 158 of the 764 sites surveyed. The selection of survey sites was not random however, and was weighted toward sites where exotic species were more likely to be present (e.g. lowland sites and sites near urban areas and public access points).

The only major waterways that, as far as is evident from formally recorded data, are free of exotic species, are the Bloomfield River and Cape Tribulation streams, Saltwater Creek and Mowbray River (near Mossman), Moresby River, Liverpool Creek, Hinchinbrook Island and streams around Cardwell.

The most widespread species is the guppy, a popular aquarium fish, which was recorded at 131 sites, followed by the platy at 66 sites. The two tilapia species were recorded at 61 and 51 sites respectively. Gambusia were only recorded from 26 sites but many of these were new records suggesting this species is still extending its range significantly.

There are two tilapia species present in the Wet Tropics, the Mozambique tilapia - *Oreochromis mossambicus* and the spotted tilapia (or black mangrove cichlid) - *Tilapia mariae*. The former species is considered the most problematic exotic fish species in the region. It was first found in the wild in Australia in 1977 and in the Wet Tropics in Cairns in 1978. In north Queensland, it is also abundant in the Townsville area (present there since 1978) and has recently invaded the Burdekin catchment (2004), the Endeavour River catchment (first report 2004, confirmed as established 2007) and a single specimen was recently collected (2008) in Eureka Creek, a tributary of the Walsh River (Mitchell River catchment).

Within the Wet Tropics region, it is commonly reported from a variety of locations. Its known range is from coastal streams north of Cairns, the upper and lower Barron catchments, Trinity Inlet streams, Russell-Mulgrave catchment, the lower

North and South Johnstone catchments and the upper Wild River (Herbert catchment).

Spotted tilapia are generally considered to be of lesser concern than the Mozambique tilapia, though this may reflect their more restricted distribution. The spotted tilapia are only known from the upper and lower Barron catchment, the Russell-Mulgrave and the lower North and South Johnstone catchments. Recent catch data suggests that despite being more recently introduced, spotted tilapia may now be more abundant than the Mozambique tilapia in Tinaroo Dam.

Gambusia (also commonly known as mosquitofish or plague minnows) are native to the eastern and south-eastern USA but have been introduced to many countries, primarily for supposed control of mosquito populations. They were introduced to many waterways in Australia for that reason, especially around World War II, though their efficacy in that regard is overrated. Considering this history, it is perhaps surprising how few locations they have been recorded from in the Wet Tropics. In north Queensland, they are more common around the Townsville area than the Wet Tropics (where guppies are more prevalent). They were only recently (2006) recorded for the first time from the upper Herbert catchment and the lower Herbert catchment (2008)[33]

Popular aquarium fishes - the closely related platys and swordtails were recorded from 66 and seven sites respectively. Amongst the cichlids, the midas cichlid has been confirmed (2007) as present in the Alice River, a stream draining Eubenangee Swamp, north of Innisfail. Jewel cichlids have been found in ornamental ponds at Cairns Civic Theatre since at least 1985 and red devils were present in a resort pond at the Port Douglas in 2001, though their current status is unknown. Various trout and salmon species have also been introduced to upland streams in the region but have not established breeding populations.

Native fish translocation and stocking

The stocking of fish into natural and artificial waters (dams and weirs) is a widespread practice in Queensland and is predominantly conducted for the purposes of recreational fishing. Fish Stocking is regulated under the *Fisheries Act 1994* (QLD), *Fisheries Regulation 1995* (QLD) and the *Fisheries (Freshwater) Management Plan 1999* (QLD). The latter outlines the conditions under which stocking is allowed, or where a permit is required from Queensland Fisheries authorities.

Prior to 1999, there were no regulations covering fish stocking and even fisheries staff were known to spread fishes to new waters where they did not naturally occur. In 2002, the Wet Tropics Management Authority (the Authority) commissioned a report on fish stocking in the Wet Tropics World Heritage Area. That report[34, 35] identified that a total of 36 native fish species have been translocated into waters of the Wet Tropics where they do not occur naturally. The Barron River is the most heavily affected by fish translocations with between 26-34 species having been translocated into and within various parts of the catchment, giving it the unenviable distinction of having the greatest number of native fish translocations of any catchment in Australia.

Most translocations have involved moving species from lowland river reaches to upland reaches above waterfalls, but some have involved moving fish species (e.g. yellowbelly, silver perch and catfish) from the Murray-Darling catchment. While these introductions are ecologically akin to introducing exotic species to the same waters, they do not elicit the same reactions from management agencies and the general public.

Currently the only active stocking programs occurring within the Wet Tropics region are into Tinaroo Dam, Koombooloomba Dam, and various estuaries with barramundi.

Koomooloomba Dam © Wet Tropics Images

Translocation of fish in the Wet Tropics World Heritage Area

Despite the extent of fish stockings that have occurred in the region, and the important faunal components of Wet Tropics streams that are considered to be vulnerable to predation by novel fish predators, no environmental evaluations of the impact of fish stocking have been undertaken in the Wet Tropics.

The distribution of translocated fishes in streams of the Wet Tropics World Heritage Area is not adequately known, nor is the extent of overlap between translocated fishes and potentially vulnerable species such as frogs and crustaceans.

The Wet Tropics Management Authority is working with Queensland Fisheries to develop a guideline for translocation of fish and crustaceans in the Wet Tropics World Heritage Area which will guide the Authority in its assessment for considering future fish translocations within the World Heritage Area.

Although the Wet Tropics harbours the most diverse fish fauna in Australia, these are mostly in coastal streams. In upland streams, waterfalls provide insurmountable barriers to fish movement and few fish species are naturally present. Many streams on the Atherton Tablelands for instance, including significant reaches of the Barron River itself, only have two to six fish species naturally present. Hence, the frequent translocation of fish into these fish-depauperate streams, that began early on in the European settlement of these upland areas.

Most of the early fish stockings involved manual carriage of small numbers of fish, and often these did not establish or persist. However, official government encouragement of stocking during the 1980s, and the advent of modern hatchery techniques, allowed large numbers of fish species to be introduced at low cost. It is estimated that approximately three million fish have been stocked into the Wet Tropics region under government-sanctioned stocking programs. In certain locations, most notably Tinaroo Dam, recreational fishing based on stocked fishes (mostly barramundi and red claw crayfish), has become a significant recreational, social and economic activity, attracting both locals and tourists.

The potential ecological impacts from introducing novel fishes are many and varied, but of particular relevance to the Wet Tropics World Heritage Area, is the extensive evidence from around the world of significant reductions, and in some cases extinction, of numerous amphibian species.

In the Wet Tropics several frog species only occur in streams with low or no fish predators and not unexpectedly, exhibit limited predator avoidance behaviour. Similarly, probably Australia's most well-known example of impact of translocated native fishes is the localised extinction of the Lake Eacham rainbowfish from Lake Eacham.[36] Barramundi stocked into Tinaroo and Koombooloomba dams are believed to stay mostly within the impoundments, with limited venturing into tributary creeks, thereby limiting their impacts to the impounded waters.

The Lake Eacham rainbowfish © TropWater

Lake Eacham rainbowfish

One of the most widely publicised examples of the impact of translocating native fishes is the total loss of the Lake Eacham rainbowfish (*Melanotaenia eachamensis*) from its type locality at Lake Eacham. This species was only formally recognised in 1982 and Lake Eacham was its only known habitat. By 1987, it was no longer present in Lake Eacham, with its elimination attributed to the translocation of native fish predators released into the lake. The Lake Eacham rainbowfish was regarded as the first freshwater fish in Australia to have become extinct in the wild since European occupation.

More recently, genetic analyses have shown that it is still present in a number of other localities such as Dirran Creek, Lake Euramoo and Bromfield Swamp. Attempts to reintroduce this species to Lake Eacham have failed. However, the introduction (translocation) of the common eastern rainbowfish to the lake has been successful.

Overall, eight native fish species, plus the red claw crayfish and the freshwater crocodile have been translocated to Lake Eacham. In addition to losing its namesake fish, gudgeons and the crayfish, *Cherax cairnsensis,* are now no longer found in the lake.

Several fish species, plus freshwater crocodiles, have also been introduced to the nearby Lake Barrine. The undetermined rainbowfish species recorded from Lake Barrine in the 1970s, has not been seen in recent years.

The localised extinction of the Lake Eacham rainbowfish stands as testament to the need to educate the community about inappropriate translocations and for environmental management agencies to place greater emphasis on aquatic management within protected areas.

Other freshwater vertebrates

Summary

- 29 frog species are restricted to the Wet Tropics rainforests, a level of endemism unmatched anywhere else in Australia
- Many frog species have highly restricted distributions, including single mountain tops, making them highly vulnerable
- Four endemic frog species have declined to extinction or near extinction and three others have suffered massive population and distribution decline
- Key threats to frogs are habitat clearing/degradation, disease and climate change
- There has been no turtle survey of the Wet Tropics and their distribution and ecology remain poorly known. A new species has recently been discovered and many unrecorded populations are likely to exist
- Freshwater crocodiles have been translocated to several new streams and waterbodies where they do not naturally occur, including the upper Barron River, Mena Creek and the high profile National Parks of Lake Eacham and Lake Barrine
- The distribution of platypus is poorly known and Wet Tropics populations appear to represent a genetically distinct population.

Frogs

Over 60 species of frog have been recorded in the Wet Tropics region, about half of which occur in rainforest habitats and half in drier habitats.[37] Of the 35 rainforest species, 29 (83%) are restricted to the Wet Tropics. This is an extremely high level of endemism, unmatched for frogs in any other region of Australia. Further, many of these species have very small distributions within the region, in some cases single mountaintops.

The Wet Tropics frogs show a mix of relationships, with surprisingly few related to New Guinea groups, while others show greater affinity with rainforest species to the south (e.g. Eungella and other rainforests of eastern Australia). Most endemic species are high altitude microhylid frogs, with a number of *Cophixalus* species being restricted to high elevation rainforests such as Thornton Peak, Carbine Tablelands, Mount Bellenden Ker, Mount Bartle Frere and Mount Elliot.[38] Other localised endemics occur in the Kuranda area (*Litoria myola)* and Black Mountain (*Cophixalus saxatilis)*. Many other species are endemic to the rainforests of the Wet Tropics as a whole, including most of the stream-breeding species.

There are three key threats to rainforest frogs of the Wet Tropics: habitat clearing and degradation; disease; and climate change.

Habitat clearing and degradation is not as much of an issue for frogs in the Wet Tropics as in other areas because a significant proportion of the rainforest and stream habitat falls within the World Heritage Area. However, it is still a threat in some parts of the region (e.g. lowlands, Atherton Tablelands) and for highly localised species. An example of the latter is the Kuranda tree frog (*Litoria myola*), which is restricted to a very small area in the vicinity of the townships of Kuranda, Myola,

Kowrowa and Mantaka.[39] The thirteen known breeding sites are not within the World Heritage Area or the protected area estate. Threats include the clearing or degradation of rainforest or stream habitat (in which they breed). The survival of this species is largely dependent on activities on private lands as even the single breeding site located within a protected area is impacted by activities that occur upstream in the catchment, outside the protected area. Wherever development occurs, streams are generally impacted and the effects of these impacts on stream-breeding frogs remain very poorly known.

The most serious impact on stream-breeding Wet Tropics frogs over the last few decades has been disease caused by 'chytrid' fungus (*Batrachochytrium dendrobatidis*). This water-borne fungus has led to dramatic declines in many frog species, especially stream-breeding rainforest species. Over the last 25 years, four species have declined to extinction or near-extinction and another three species have suffered massive population declines.

These latter three species have generally disappeared from the uplands but persist in the lowlands. Of the four species that declined to extinction or near-extinction, *Litoria nyakalensis* has not been seen since 1990; *Taudactylus acutirostris* not since the mid-1990s, *Taudactylus rheophilus* not since 2000, and *Litoria lorica* was feared extinct for 16 years until rediscovered at a single site on the Carbine Tableland in 2008.[40]

Extensive recent surveys have failed to find the three missing species (now feared extinct) and have not found other populations of *L. lorica*. *Litoria lorica* persists well at the single known site (approx. 4km of stream) despite high levels of chytrid infection, and this persistence is believed to be due to the hot temperatures at this open forest site being less suitable for chytrid.[41]

Similar declines in frog populations which has occurred in the Wet Tropics have also occurred elsewhere in eastern Australia and on other continents. In the last few decades, hundreds of frog species across the world have gone extinct and many more have declined to threatened status. The cause is generally accepted to be disease. Chytrid fungus, infects frog skin and tadpole mouthparts, often leading to death.

It is generally believed that chytrid spread internationally by some means, and continues to do so in some parts of the world. Chytrid is generally considered to be introduced to Australia, but this remains unresolved. Because frog populations declined in otherwise undisturbed rainforests, this rules out habitat disturbance as the primary causal factor for the Wet Tropics frog declines. Why chytrid only causes declines in certain species and in some areas and not others also remains uncertain.

The third threat is climate change. Given the number of endemic rainforest frogs in the Wet Tropics that are restricted to mountain-tops (particularly *Cophixalus* species), climate change is a potentially serious threat. The exact nature of likely impacts on Wet Tropics frogs remains uncertain. *Cophixalus* are a diverse group of microhylid frogs, with 13 species occurring in this region (all are endemic). All are terrestrial breeders, layiing their eggs in moist places, such as leaf-litter, under rocks and logs, from which fully formed froglets hatch out.[42] Most *Cophixalus* have highly localised distributions, with over half being restricted to a single mountain range.

The following species being of particular note: *Cophixalus coninnus* (>1100m on Thornton Peak), *C. monticola* (>1100m in a localised area of the Carbine Tableland) and *C. neglectus* (generally >1200m on the Bellenden Ker Range).[43,44] The highest points in the upland areas inhabited by

these three species are 1374m, 1317m and 1622m, respectively, giving these species altitudinal ranges of just 200-400m.

Several other species are found above approximately 700m. The mountaintop *Cophixalus* are generally listed as threatened species due to small distributions and projected declines in habitat area and quality due to climate change. While in general declines have not been demonstrated in most of Australia's mountaintop species, climate change predictions are severe. Williams[45] modelled climate change impacts in the Wet Tropics region and highlighted *Cophixalus* as a group particularly threatened. In particular, the modelling suggested loss of core environment and potential extinction of *C. concinnus* in a matter of decades. The exact nature of climate change impacts on Wet Tropics frogs remains to be seen but it is clearly a potentially significant threat.

Cane toads are widespread throughout the Wet Tropics. Although they are generally rare within rainforest, they are often abundant on the edges and along roads and trails in the forest. Females are often found significant distances into the rainforest, usually along streams but even up to 1100m in remote mountain rainforest. Cane toads are generally rare in the rainforest because they prefer to forage in more open habitats and breed in standing water (e.g. ponds) rather than flowing streams. Breeding does occur on occasion along remote rainforest streams in the Wet Tropics.[46] Toads are a well-recognised threat to Australian ecosystems but are not considered a significant threat to Wet Tropics rainforest frogs.

Freshwater turtles

Turtles are a widely recognised component of the freshwater fauna, yet surprisingly, there has been no systematic survey of turtles in the Wet Tropics region. Some species are highly visible, being found near the water surface or sunning on exposed surfaces, however several species are cryptic and less well known than fishes, and new species and range extensions are still being recorded.

There are six known turtle species in the Wet Tropics region. The sawshell turtle (*Wollumbina latisternum*) is the most common and widespread in the region, being present in most flowing waterways and upland streams. The species is found above waterfalls and can be found at high altitudes. Krefft's river turtle (*Emydura macquarii krefftii*) prefers wetlands and slower moving streams and occurs in coastal drainages. Its known distribution in the Wet Tropics is scattered and undoubtedly incomplete due to lack of survey effort. It is most likely present in most lowland streams of the Wet Tropics. Anecdotal evidence suggests they may have been translocation to westerly-flowing rivers.

The northern yellow-faced turtle (*Emydura tanybaraga*) was first described in 1997. They are ecologically similar to sawshell turtles and are found in lowland reaches of several rivers in the Northern Territory and on Cape York but there are major gaps in our knowledge of their distribution within that range. Their formally-recognised occurrence within the Wet Tropics is marginal and limited. Recent genetic research suggests *E. tanybaraga/E. krefftii* hybrids occur in the Mulgrave (and Normanby) River.[47]

The long-necked turtle *Chelodina canni*, was first described in 1992. It has a widespread distribution, occurring from the Roper River in the Northern Territory across the Gulf Carpentaria and down the east coast to central Queensland. This species prefers floodplain habitats and ephemeral wetlands. Its distribution within the Wet Tropics is poorly known but it may be present in a number of coastal swamp wetlands.

Recently two new species have been discovered. The Johnstone River snapping turtle, was described as *Elseya stirlingi* in 1985. It is only known from the Johnstone River, though it appears to be relatively abundant there in both lowland and upland reaches. More recent studies cast doubt on the specific status of this species, with some evidence that it may be synonymous with *Eleysa irwinii*, a turtle (named after Steve Irwin's father Bob Irwin who discovered it in 1990) that is only known from the Bowen and lower Burdekin River systems.

Recent genetic studies lend some support to this suggestion, despite the significant distance between the two populations. The specific status of this species remains to be resolved. Recently, another large turtle species was discovered in a major Wet Tropics river. Preliminary morphology and genetic studies suggest this is a new species and studies to describe it are currently underway.[48]

Turtles have been under-represented in freshwater studies in most regions, but have recently come to prominence in relation to water resource developments. Because of their ecology and life-history, turtles are especially vulnerable to changes in flow and water level, as well as riparian degradation and introduced predators (mainly predation of eggs laid in riverbanks). Several major catchments along the east coast including the Johnstone River contain endemic turtle species who, because of their limited range and vulnerability to the above threats, are of high conservation value.

Because of the lack of systematic surveys for turtles in the Wet Tropics, it is likely that additional species, or at least new populations of existing species, are yet to be discovered. Although these turtle species are new to western science, local Traditional Owners are well aware of their existence and have been utilising them as a food source.

Crocodiles

Both species of crocodile native to Australia occur within the Wet Tropics. The estuarine crocodile, *Crocodylus porosus*, occurs in most estuaries and lower freshwater river reaches of the region. Whilst the presence of estuarine crocodiles in lowland freshwater lagoons and swamps is expected, the distribution of estuarine crocodiles within freshwater streams would surprise most people. They occur up to the base of significant barriers, such as waterfalls, in most catchments including the Herbert River Gorge, Tully River and Johnstone River and in the Daintree River. They are also known from above waterfalls on Adeline Creek at around 400m altitude. The expanding distribution of estuarine crocodiles poses an increasing management issue as the risk of conflict increases, especially in urban areas and around popular lowland swimming holes.

The freshwater crocodile, *Crocodylus johnstoni*, is not considered a threat to human safety, being smaller and much less aggressive than its relative. Their range within the Wet Tropics is limited, with the upper Herbert catchment, being possibly the only Wet Tropics waterway where they naturally occur. Unfortunately, crocodiles have also been translocated to new locations where they do not naturally occur. The crocodile population of Lake Barrine, which features in boat tours there, is not natural.

Translocated freshwater crocodiles have also been reported from nearby Lake Eacham and the Barron River, where they appear to have established populations. Recent media reports also suggest freshwater crocodiles have been translocated to Mena Creek, near Paronella Park. The spread of translocated crocodiles is a significant yet largely unheralded change to the large animal fauna of Wet Tropics waterways. Whilst these new

populations may provide a tourist attraction, they may also adversely affect other aquatic recreational activities and the celebration of their unnatural occurrences provides a poor example of aquatic management.

Other aquatic vertebrates

A variety of other vertebrate species utilise aquatic habitats in the Wet Tropics. Waterbirds are frequent, especially on lowland swamps and floodplain wetlands. Most rivers and streams in the Wet Tropics have water dragons and most permanent streams have platypus and native water rats, both of which are especially common in mid-elevation streams, and reptiles such as water skinks and aquatic-adapted snakes. The frequency and distribution of this large animal fauna is not always well-known, though anecdotal records abound.

The platypus (*Ornithorynchus anatinus*) is present in the majority of Wet Tropics streams and rivers draining to the east coast as far north as the Annan River, south of Cooktown. Recent reports of platypus occurring in river systems draining west to the Mitchell River system (Rifle Creek, Macleod River and Platypus Creek on Mt. Windsor Tablelands) are exciting as they challenge the previously accepted understanding that there are no platypus in west flowing (gulf draining) rivers.[49,50]

The platypus in northern Queensland is the smallest found in Australia and represents a genetically distinct evolutionarily significant unit from that which is found in the rest of mainland Australia[51] and should receive special management consideration. Their dependency on freshwater ecosystems makes platypus highly vulnerable to the anthropogenic modification and degradation of those systems. The sensitivity of these ecosystems also places the platypus at potential risk from the effects of climate change.

A sawshell turtle in Emmagen Creek © B Ebner

Freshwater invertebrates

Summary

- Thousands of freshwater invertebrate species await discovery in the Wet Tropics and their keystone role in the ecology of these streams has barely been examined
- The freshwater invertebrate fauna of the Wet Tropics are largely Gondwanan in origin. The cool, shaded waters of the region has allowed these Gondwanan species to persist
- Loss of riparian canopy cover and invasion by riparian weeds significantly impacts upon these communities
- Most invertebrates are small but spiny crayfish of the genus *Euastacus*, are large, visually striking iconic species, that are only found in coldwater streams
- Four spiny crayfish species are restricted to small distributions on high elevation mountain tops in the region. They are highly vulnerable to climate change and any increase in temperature.

Freshwater crustacea

Numerous crustacean species inhabit the Wet Tropics, but most are small widespread species. The most commonly fished-for species, which is also widely used in aquaculture, is the red claw crayfish, *Cherax quadricarinatus*. This species is actually native to waterways of Cape York Peninsula, the Gulf of Carpentaria and the Northern Territory. It has been widely translocated throughout Australia and internationally, including into many streams in the Wet Tropics and is popularly fished for in Tinaroo Dam.

The largest and most vulnerable crustaceans in the Wet Tropics are the spiny crayfish of the genus *Euastacus*. These belong to an ancient group of large crayfishes that are endemic to the eastern states of Australia, from Cooktown to Victoria. Fifty species are known in the genus and they are distinguished by spines along the base of their claws. With their large size and sometimes striking colours, they are iconic aquatic species. Most species prefer cool mountain streams, occupying progressively higher elevations with decreasing latitude.[52]

Four species are found in the Wet Tropics, all of which, because of their need for cool water, are restricted to habitats above 700m elevation within the World Heritage Area. The species are Roberts crayfish, *Euastacus robertsi*, the red and blue spiny crayfish, *Euastacus fleckeri*, the Balan spiny crayfish, *Euastacus balanensis*, and the Cardwell hairy crayfish, *Euastacus yigara*.

Roberts crayfish are known only from Thornton Peak and Mount Finnigan in headwaters streams of the Annan and Daintree rivers. They have a highly restricted distribution and appear to have a small population, possibly numbering only in the hundreds.

The red and blue spiny crayfish reaches 10-15cm in length and inhabits streams in the Mount Lewis and Mount Spurgeon areas, west of Mossman, building burrows up to 1.2m deep. The Balan spiny crayfish is a small-bodied species attaining less than 10cm in length, and inhabits small streams of the Lamb Range behind Cairns and headwaters of the Mulgrave and Russell rivers.

The Cardwell hairy crayfish is a burrowing species that reaches 10–15 cm in length and is distributed in headwaters streams of the Herbert and Tully rivers above 700m elevation. Juveniles reside in the riparian zone along creeks and adults live in complex burrow systems that reach into the water table rather than being connected directly to the stream.

The two most northerly distributed *Euastacus* species, the Roberts spiny crayfish and the red and blue spiny crayfish are an ancient sub-group that have evolved separately from all other spiny crayfish.[53]

Endemic crayfish on mountain tops

Spiny crayfish of the genus *Euastacus* are an ancient Gondwanan group, having evolved during previous cooler climates. Most species are now restricted to cool, high elevation streams and consist of isolated populations.

This thermal intolerance has led to their speciation and restricted, isolated distributions on 'mountain top islands in a sea of lowlands'.

Whilst their high elevation habitats keep them away from most other threats, with their highly restricted mountain top distribution, and dependence upon cool water temperature, they appear to be significantly threatened by climate change or increases in stream temperature.

Despite this threat, nothing is known of their basic ecology, thermal tolerances and preferences, and the possible effects of climate change. Three of the four species are already listed as *endangered* on the IUCN red list. All *Euastacus* species are protected in Queensland with no take allowed. However, illegal fishing remains a problem and many fishers are probably unaware of the difference between *Euastacus* and other crayfishes.

Mount Lewis spiny crayfish © J Furse and S Appleton

Other freshwater invertebrates

Aquatic invertebrates are a significant and important component of all freshwater ecosystems, making up a substantial part of the biodiversity and performing many ecosystem functions including leaf litter processing, nutrient cycling and energy transfer. Many species are aquatic larval stages of insects, but the biota also contains representatives from many other invertebrate phyla, including worms, molluscs, crustaceans, spiders and mites.

Information on the aquatic invertebrate fauna in the Wet Tropics is extensive compared with other bioregions in Queensland.[54,55,56]

The freshwater invertebrate fauna of the Wet Tropics is largely Gondwanan, rather than tropical, in origin, with the altitude and high degree of stream shading in the Wet Tropics allowing many species adapted to cool waters, to persist in the tropics. Significant diversification has occurred within the Wet Tropics, allowing a high degree of endemism to develop as well. Direct comparisons of Wet Tropics regional diversity with other regions is complicated by taxonomic knowledge, variation in sampling effort, differing patterns of diversity in different taxa and the scale at which diversity is being compared (e.g. within-stream diversity vs. regional diversity). However, there is no doubt that the Wet Tropics hosts a diverse fauna.

Several studies have shown that freshwater invertebrates of the Wet Tropics are generally more tolerant than expected, to the kinds of water quality perturbations normally seen in the region. This includes elevated nutrients, temperatures and turbidity. Habitat conditions, especially loss or degradation of the riparian zone however, have a much larger impact upon the invertebrate community.

Altitude obviously has a strong effect on freshwater invertebrates, especially due to the effect of stream temperature. Upland streams also tend to offer coarser, more cobble-like, substrate habitats and more frequent riffles and waterfalls. Invertebrate communities are also greatly affected by substrate type, sediment size and instream and riparian plant communities. Thus, significant changes in community composition can occur over very small spatial scales, even in lowland streams.

Two locations stand out as significant sites of scientific research in the Wet Tropics - Yuccabine Creek in the upper Herbert River catchment and Birthday and Camp Creeks in the, Paluma Range. Much of this research has been focused on the ecological role stream invertebrates play, especially in relation to the processing of detrital litter in streams, and the food chains dependent on this process. Taxonomic description of the Wet Tropics invertebrate fauna is limited, and patterns of diversification and distribution within the region have only been studied for a few select groups (e.g. chironomid midges and leptophlebiid mayflies). Thousands of aquatic invertebrates from the region remain undescribed.

Waterfalls are habitats of limited spatial extent with wide separation between them. Clayton[57] studied the waterfalls of the Wet Tropics and found them to harbour specialised invertebrates adapted to life in (on) such habitats. Filter-feeders are common in the current as are species grazing algae on rocks and they spatially separate strongly on the basis of current velocity and splash zones. Perennial waterfalls are present in most Wet Tropics catchments but are especially prevalent in the Johnstone River catchment.

Freshwater habitats and their management

Summary

- Within the Wet Tropics, most mountain streams are essentially intact but most lowland streams are highly disturbed
- Up to 80% of coastal wetlands have been drained and cleared and most of the remainder are in very poor condition. Despite this, values are high and 30 wetlands are listed in the national Directory of Important Wetlands and there are ten declared Fish Habitat Areas
- Many wetland condition assessments have been undertaken but using a variety of methods and in a variety of geographic locations, providing limited comparability to develop a region-wide census of habitat condition and status
- Riparian vegetation loss is significant but its restoration provides tangible benefits and is one activity where the environmental benefit is matched to the ability of community groups to undertake the works, making it a priority management activity
- A total of 5,536 potential fish passage barriers have been identified within the region, 83% of which are road or rail crossings of streams and water courses
- The abundance of good quality water provides a range of ecosystem services, especially for drinking, swimming, fishing and recreation
- The scenic and aesthetic values of aquatic habitats such as lakes, gorges and waterfalls are a major part of the region's attraction to tourists
- Rainforest Aboriginal people aspire for their rights, knowledge, culture and management practices to be incorporated into the management of water resources.

Wetland and waterway condition

The status of freshwater habitats across the Wet Tropics region is a tale of two contrasting situations. Most of the mountain streams, inside the World Heritage Area, remain essentially intact and relatively undisturbed. In contrast the streams of the lowlands, and those on the developed tablelands, are highly disturbed. On the coastal floodplains in particular, wetlands have been cleared and drained, largely for agricultural development. Streamside riparian vegetation has been extensively cleared and many smaller streams have been filled in.

In a series of reports from 1993-2000, the condition of stream and wetland habitats were assessed for various Wet Tropics catchments, using a consistent methodology, by staff from the then Department of Primary Industries [58,59,60]. These studies covered the Johnstone, Moresby, Russell-Mulgrave, Liverpool, Maria and Hull, Daintree, Saltwater and Mossman the Barron River catchments. For three of these catchments, the loss of wetlands was assessed by comparing wetland extent from 1952 and 1992 aerial photography. The results are summarised in **Table 1** by net change (areas of hectares gained against areas of loss).

Table 1: Changes in Areal Extent of Floodplain Wetlands 1952-1992.

	Johnstone Catchment		Russell-Mulgrave Catchment		Moresby Catchment		Overall	
	net change (ha)	% change	net change (ha)	% change	net change (ha)	% change	net change (ha)	% change
Mangroves/saltpans	+26	+15	+12	+1	+640	+29	+678	+21
***Melaleuca* forests**	-995	-78	-2,052	-53			-3,047	-59
Mixed *Melaleuca* forests	-204	-44	-347	-52			-551	-49
Palm forests	-279	-64	-1,028	-58			-1,307	-59
Freshwater/sedge Swamps	-274	-55	-515	-48			- 789	-50
Lowland rainforest			-1,451	-82			-1,451	-82
Freshwater wetlands					-2,188	-65	-2,188	-65
Total freshwater wetlands	-1778	-65	-5,381	-54	-1,548	-27	-9,385	-62

Mangrove extent was essentially unchanged, except in the Moresby catchment where it increased greatly. No net loss of mangroves is not surprising, given these habitats are not converted into agriculturally productive land and have not been extensively cleared or drained. The gain in mangroves in the Moresby catchment is at the expense of significant dieback of freshwater Melaleuca paperbark swamps which are being colonised by mangroves. The salinisation of the paperbark swamp has been examined but no obvious cause determined.[61] Across the three catchments, total net loss of freshwater wetlands averaged 62%. As this summary only applies to the period 1952-1992, actual net loss would probably be more in the order of 80%. This is consistent with estimates of wetland loss for the Tully-Murray catchment, where, based on extensive catchment-wide mapping, it was estimated that *Melaleuca* swamps and palm swamp forests, which together comprised 16% of the land area prior to settlement, have been reduced by 71%.[62]

Of the 50 floodplain lagoons in the Tully-Murray catchment, 40-45 have been destroyed.[63] Across the developed Wet Tropics floodplains, many of the wetlands that have not been cleared and drained, are in poor condition, being greatly affected by clearance of surrounding land, altered hydrology and significant weed invasions. Water quality is generally poor and fish diversity in most remaining floodplain lagoons is lower than historically known.

Some restoration activities have shown remarkable improvements in water quality and fish diversity when the dominance of aquatic weeds has been reduced,[64] and some artificially-constructed wetlands in intensive agricultural environments, have provided valuable aquatic habitat for fish, birds and crocodiles.[65]

Burrows[66] compiled an assessment of the condition of wetlands and waterways across the whole of the Wet Tropics for the FNQ 2010 Regional Planning Strategy. That study included aquatic systems outside of

Josephine Falls © C Clarke

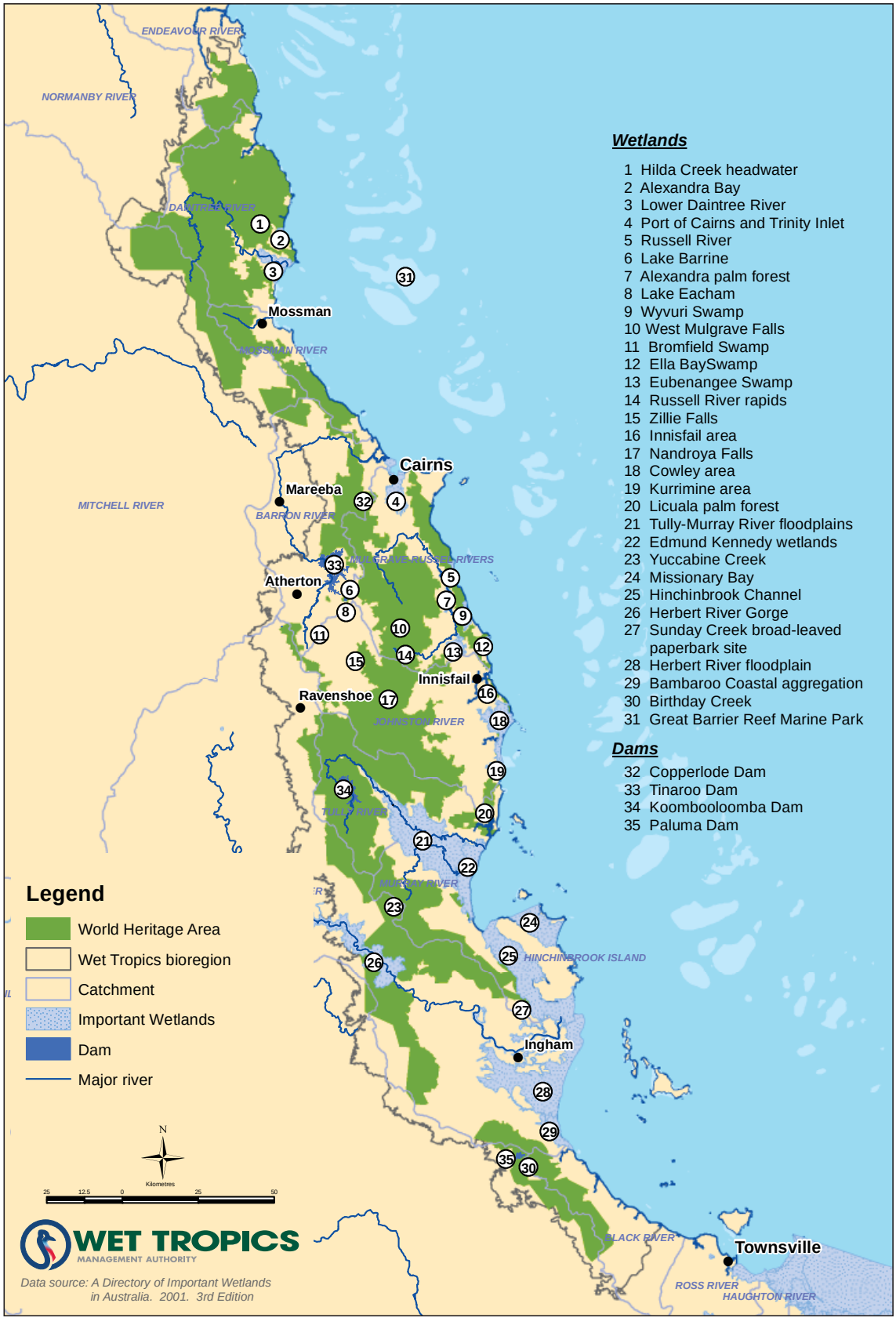
the World Heritage Area, with those inside deemed to already be adequately managed and protected. That report identified 233 key waterways and 78 key wetlands across the study area.

Not long after, the Wet Tropics Management Authority commissioned a report on water infrastructure development that included an assessment of conservation and ecological values of streams within the World Heritage Area. The purpose of the study[67,68] was to determine the suitability of streams as sources of domestic and rural water supply without detriment to World Heritage values.

Water Quality Improvement Plans have been completed for three major catchments including the Daintree-Mossman, Barron River/Trinity Inlet and the Tully–Murray catchments. These summarise the state of knowledge of water quality in those catchments and identify priority actions to improve the situation. In 2010, a Healthy Waterways Planning Management process commenced as an adjunct to the Wet Tropics Water Resource Planning process to develop Healthy Waters Management Plans for the remaining major catchments of the Wet Tropics that did not have Water Quality Improvement Plans. The water quality and condition of aquatic ecosystems across 542 river reaches in those catchments were assessed by a desktop data review and expert opinion approach and reported.[69] Most waterways, apart from those in the developed floodplains, were assessed as having good water quality and healthy riparian vegetation.

Within the Wet Tropics there are 30 wetlands or wetland complexes that are listed on the national Directory of Important Wetlands and 10 estuarine areas declared as Fish Habitat Areas (see **Figure 1**). Despite these listings and the fact that nearly half of the Wet Tropics region is within the Wet Tropics World Heritage Area, the majority of stream and wetland types are outside of the World Heritage Area which is dominated by low order upland streams.[70]

Figure 1. Wetlands of national importance, catchment areas, dams and major rivers within and adjacent to the Wet Tropics World Heritage Area



Infrastructure and barriers to movement between habitats

Figure 2 shows the habitat migration strategies of fishes recorded from freshwaters in the Wet Tropics.[71] Many species that normally live in estuarine or nearshore marine waters have, at various times, been found in freshwater reaches. These estuarine vagrants make a significant contribution to the ecology of lowland waterways.

Approximately one-third of the fish that occur in freshwaters of the Wet Tropics migrate between freshwaters and estuarine/marine waters as part of their life-cycle. Any barriers to their return movement into freshwaters can result in their extirpation from those reaches upstream of the barrier. Thus, even where fish habitat may be in good condition, some species may not be able to access it. Given the lowland reaches of many Wet Tropics waterways run through modified floodplains, rivers and creeks, physical barriers to fish movement, either complete or partial, are common.

A 2010 audit of potential fish passage barriers in the region[72] identified 5,536 artificial physical barriers that may be impacting upon fish passage to some degree, in just under 20,000km of stream length assessed. With 1,087 and 1,069 potential barriers, the Russell-Mulgrave and Johnstone catchments respectively, had both the greatest absolute number of potential barriers but also the most number of potential barriers per kilometre of stream. Road and cane rail crossings comprised 65% and 18% of potential barriers respectively.

Many of these structures may, upon further inspection not turn out to act as passage barriers. Conversely, many other structures too small to be identified at the scale (1:100,000) at which the mapping was conducted, may act as barriers.

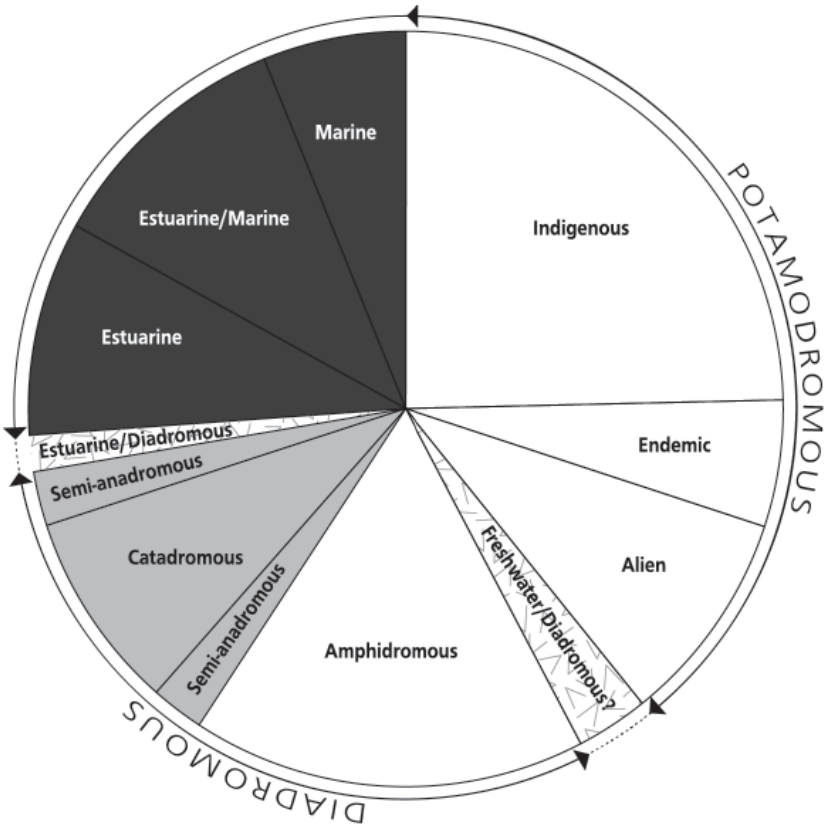
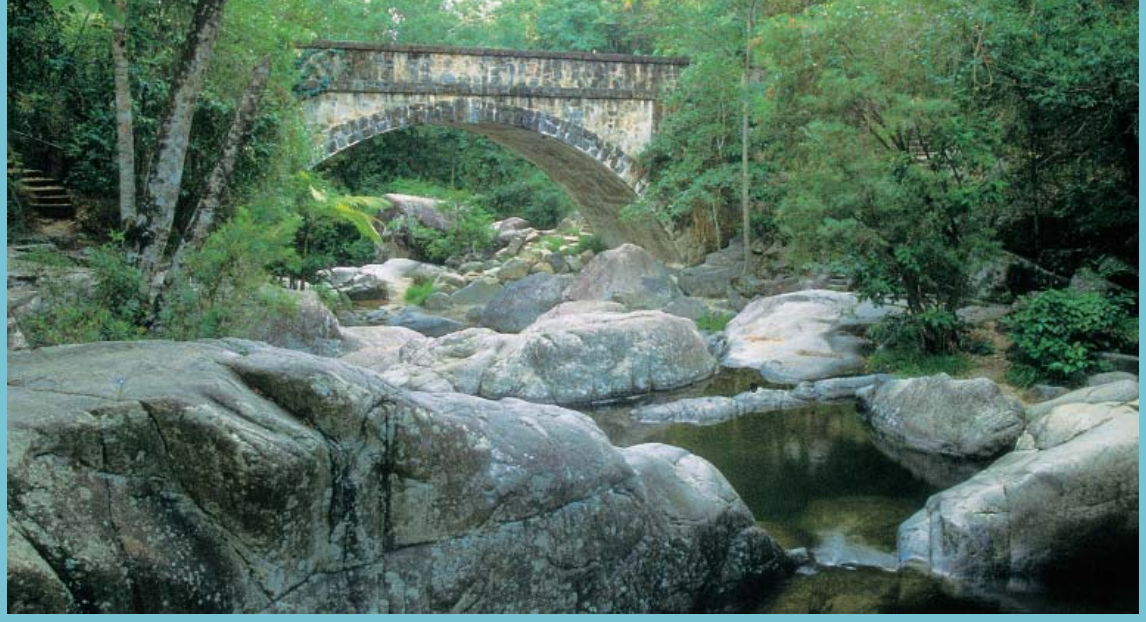


Figure 2. Habitat migration strategies of fishes recorded from freshwaters in the Wet Tropics

The segments shaded in white reflect entirely freshwater species broken down into indigenous species, those that are endemic and only found in the Wet Tropics, and alien species. Diadromous species are migratory between freshwater and sea and are shown in pale grey. Dark grey indicates marine and estuary species that are sometimes encountered in freshwater. There are some species for which their life cycle still remains unclear (grey stippled segments).



Bridge over Crystal Creek © Wet Tropics Images

Fish friendly practice infrastructure and culverts

Nearly every coastal stream and river in the region is affected by in-stream barriers of some sort. Barriers to native fish movement by weirs, dams, culverts and bridges result in reduced reproductive success and access to suitable habitat by aquatic organisms.

The Wet Tropics Management Authority is working with researchers from James Cook University and the Department of Transport and Main Roads to produce effective and cost efficient fish-friendly designs for culverts and in-stream creek fish ways which will overcome in-stream barriers. Several of these initiatives, such as the *Wet Tropics Road Maintenance Codes of Practice* are now being adopted in other parts of Queensland.

Streamside vegetation

Healthy streamside (riparian) vegetation is one of the most important positive drivers of stream health, providing a wide range of benefits to the ecology and functioning of aquatic ecosystems.

Unfortunately, in the Wet Tropics, loss of such vegetation is a common form of stream degradation, especially in agricultural settings. This loss, and subsequent replacement by exotic weeds such as para grass (*Urochloa mutica*) and hymenachne (*Hmenachne amplexicaulis*), and to a lesser extent Singapore daisy (*Sphagneticola trilobata*) and glush weed (*Hydrophila costata*) is well documented. These weeds are also known to completely infill smaller tributary streams.

Fortunately, riparian restoration through tree planting is one of the more achievable environmental management activities and is widely practiced across the region by a number of (usually community-based) organisations. The advantages of such an approach are the technical simplicity and community involvement of such activities and the benefits that intact riparian systems also have for terrestrial fauna.

One of the many important roles played by riparian vegetation is to limit the transfer of solar radiation. This manifests itself in several ways, with effects on instream water temperature and on the growth of aquatic and semi-aquatic plants, being of particular relevance to the Wet Tropics. High water temperatures are directly lethal where they exceed tolerance thresholds of sensitive biota.

This is important as many rainforest stream taxa, especially invertebrates, despite living in the tropics, evolved in higher latitudes and are adapted to colder waters. Temperature greatly influences water quality by mediating the rate of chemical reactions and the rate of metabolism of individuals and the ecosystem itself. Warming water results in reduced dissolved oxygen concentrations (warmer water holds less oxygen than colder water), yet oxygen demand and consumption (respiration) is much greater when water is warmer - therefore oxygen requirements are greatest when availability is least.

In addition, increased water temperature due to reduced shading caused by the removal of riparian vegetation, may favour species such as the exotic fish tilapia that breed whenever the water is warm enough. Stream temperatures can rise or fall quite rapidly along relatively short stream lengths (several degrees over a few hundred metres), depending on factors such as the water volume, flow rate and air temperature.

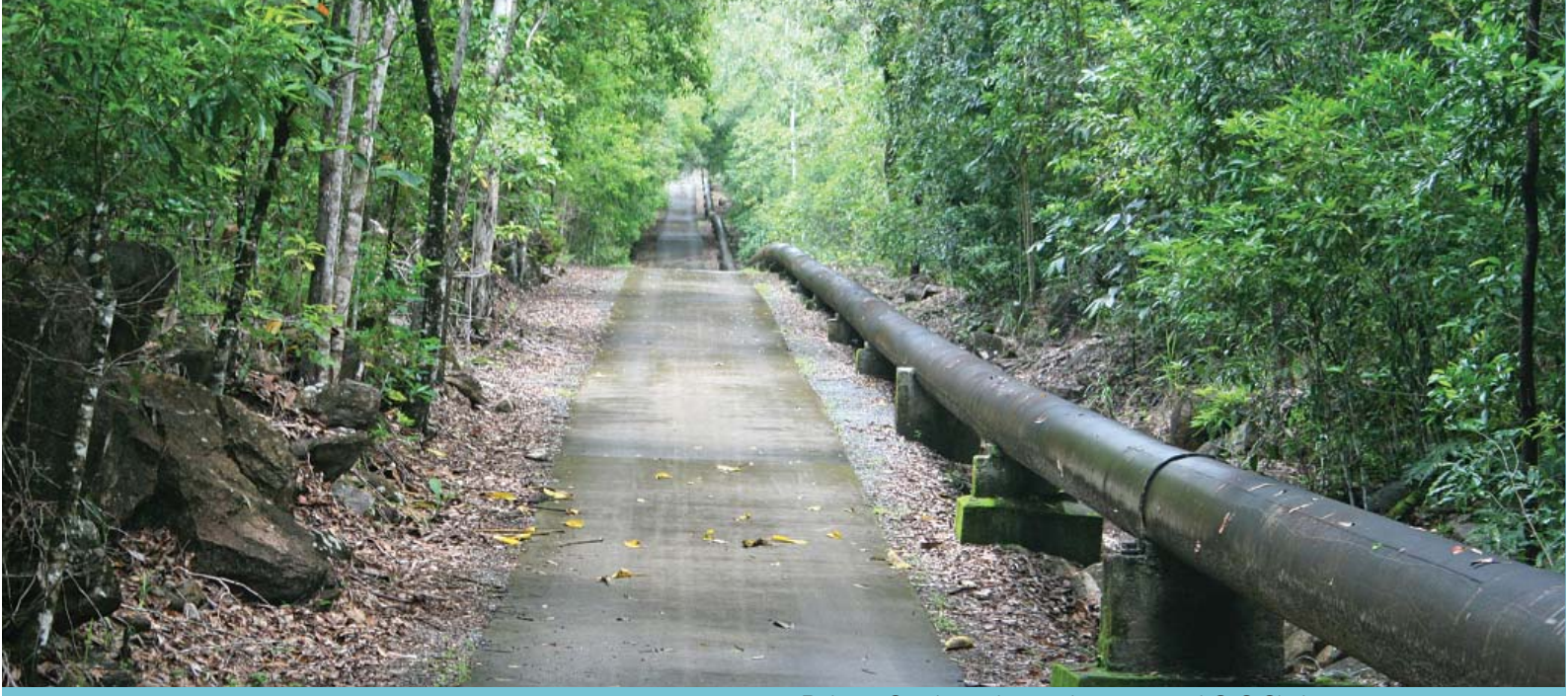
Light availability limits the growth of instream aquatic plants. Where light availability increases due to loss of riparian canopy cover, introduced exotic aquatic and riparian weeds become dominant. Para grass, an African species introduced for ponded pasture and stream bank stabilisation, is the most abundant weed taking advantage of riparian disturbance. Para grass greatly alters instream habitat by trapping sediment and infilling channels, at least until the next flood events washes the accumulated sediment away.

Exotic fishes, which are more tolerant of poor water quality and more better at occupying disturbed habitats, take advantage of this situation to increase their abundance. Para grass contributes little to food webs because native consumers cannot process the type of carbon produced by para grass and this reduces the productivity of affected streams. Finally, para grass infestations are usually dense and limit the recruitment of native tree and shrub species, preventing natural regrowth of the riparian community. Fortunately, like for stream temperature and reconnection of stream corridors, the solution is to re-establish the integrity of the riparian community via tree planting, as para grass does not grow well under heavy shading.

The role that riparian vegetation plays in stripping nitrogen from farm runoff is less clear, though likely beneficial, and is the subject of a current investigation. A significant scientific study of the ecology of Behana Creek[73] found the creek, with its intact riparian zone, to be healthy despite being surrounded by intensive agriculture.

The width and density of the riparian zone that should remain intact in order to provide many of the ecological services listed above is not clear and is likely to be variable. In the agricultural situations where riparian revegetation is required, only narrow corridors for reinstatement are feasible in most cases. Fortunately, research indicates that the width required to improve aquatic habitat is not large, and may even be as narrow as a band of trees sufficient to provide some key functions such as bank stability, habitat, stream shading and a supply of detrital material.

Surprisingly, despite the significant and visually obvious loss of riparian vegetation across the region, the extent of the issue has not been quantified. However, a number of reports have been produced identifying priorities for riparian restoration.[74,45]



Behana Creek pipeline and access road © C Clarke

Environmental values of water

The Department of Environment and Heritage Protection is working with stakeholders to identify environmental values of fresh water, estuarine and coastal water resources of the Wet Tropics. Environmental values identified by the community reflect the use and high regard that local communities have for these resources for drinking water, stock watering, irrigation, industry, and cultural/ spiritual values.

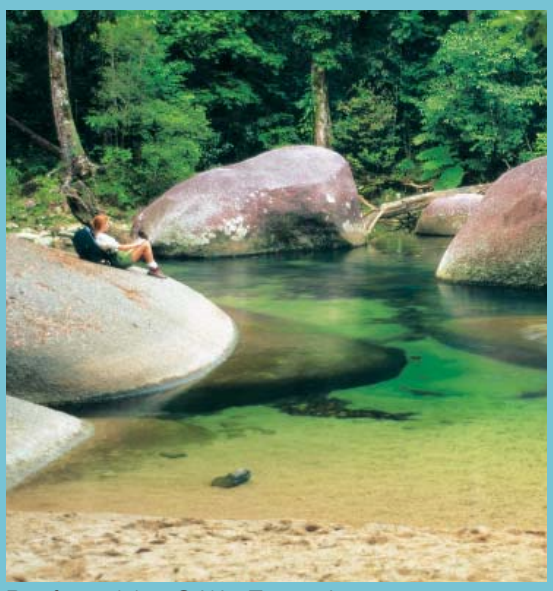
This work is being undertaken as part of the broader *Environmental Protection (Water) Policy 2009* which is the framework for identifying the management goals for Queensland waters; stating water quality objectives to protect environmental values; and to monitor and report on the condition of Queensland waters

http://www.ehp.qld.gov.au/water/policy/wet-tropics-evs.html

Human and societal values

The aquatic assets of the Wet Tropics region provide a wide range of social, cultural and economic values for residents and visitors and intrinsic values for the general community across Australia and internationally. It is estimated that 4.4 million tourists visit the Wet Tropics World Heritage Area each year and the scenic and aesthetic values of aquatic habitats and the recreational opportunities they provide, are a major part of the attraction to tourists. Swimming and fishing are two of the most common recreational uses of the region's waterways.

Urban centres and major industrial and agricultural enterprises depend upon the region's rainfall and water resources. The relatively good quality of the fresh water resource provides a range of ecosystem services, especially for drinking, swimming, fishing and recreation. Water resources are often valued for their traditional consumptive or production values (e.g. the cost of supplying drinking water or water for agriculture) but the non-market values which are more difficult to quantify, are becoming increasingly important considerations in management and are particularly prominent in the Wet Tropics with its abundance of natural aquatic values. Studies have shown



Rainforest hiker © Wet Tropics Images

Water and recreation

There is strong recognition of the quality of life benefits derived by the community from the freshwater ecosystems of the World Heritage Area.

Swimming, fishing, bird watching, bush walking and sight-seeing are dependent on the quality of our waterways and their associated riparian vegetation. Opportunities for water based recreational activities also provide an important connection between the World Heritage Area and the community.

that the spiritual and aesthetic qualities of the Wet Tropics World Heritage Area are more important than its economic uses – the importance of 'just knowing it is there and protected'.[72]

Across Australia, and internationally, indigenous people are playing increasingly stronger roles in the management of land and sea resources. Many indigenous customs include very strong attachments to water resources and indigenous people possess a wealth of traditional ecological knowledge of great use to contemporary management. In northern Australia, indigenous people manage and/or have rights to a significant portion of the land estate, so such initiatives integrate indigenous rights and interests with resource management needs.

Historically, indigenous environmental management has mostly been around terrestrial resources, but more recently, the focus on aquatic ecosystems and values has increased. Part of this has been driven by the increasing societal demand for limited water resources and the need to ensure that indigenous values, rights and perspectives are adequately represented in contemporary water resource management. Indigenous people assert their rights to water resources and are fundamental to water reform and decisions on water planning, use and ecosystem management.

In the Wet Tropics, where water resources are abundant and central to traditional customs, Rainforest Aboriginal people are expressing a desire for their traditional ecological knowledge to be recognised and utilised in the management of aquatic ecosystems, and aspire to have a greater role in land and water resource management working in partnership with government staff, scientists and other stakeholders.

This has fostered the development of indigenous land and sea management ranger programs across northern Australia, including the Wet Tropics, which show great promise for co-management and sharing of experiences across different knowledge systems. Such approaches will require greater engagement from management agencies and greater understanding of the differences between western science and ecosystem management paradigms compared to the more spiritual and holistic approaches of indigenous people.

Water resources

Summary

- The Wet Tropics region hosts six dams, numerous weirs and 21 major surface water intakes. Three of the dams (Copperlode, Koombooloomba and Paluma) are within the World Heritage Area
- Despite having the greatest rainfall of any region in Australia, additional water storage options are limited but demand is high, such that shortfalls in the Cairns and Port Douglas urban areas are predicted in the near future
- This scarcity when surrounded by an abundance of water, creates special challenges in managing water resources
- Many key aquatic assets (e.g. fish, scenic waterfalls) depend upon groundwater to maintain flow, and options to extract groundwater as an alternative to building surface water storages, are also proving controversial
- Water quality monitoring is common in the region but is focused on agricultural runoff to the Great Barrier Reef lagoon
- Our understanding of water quality in freshwater habitats trails that of agricultural runoff to the reef, and pesticides have recently emerged as a significant, understudied, management issue.

Water resource planning

With some of the most consistent and highest rainfall in Australia, the Wet Tropics has an abundance of fresh water. However, water planning and conservation is just as critical as in other, drier regions. Water demand is increasing due to increasing agricultural, urban and industrial development. The high conservation values of Wet Tropics waterways limits options for water storage infrastructure, and many key environmental values (e.g. waterfalls) are dependent upon maintaining intact flow regimes, conflicting with the water demand. This scarcity when surrounded by abundance, creates special challenges in conserving and managing water resources.

The Far North Queensland Regional Water Supply Strategy[76] outlines options for managing the regional water supplies for the next 50 years. It identifies a looming shortfall of urban water supply, particularly in Cairns and Port Douglas, and recommends demand management and water conservation strategies to reduce the shortfall. Among other options, Cairns City Council is investigating sourcing additional water from Behana Creek and the Mulgrave aquifer, a move which has generated some community resistance.

Given the lack of large surface storage options and the risk of relying upon sometimes variable surface flows for secure water supplies, the use of underground water supplies is being investigated. However, the degree of dependence of streamflow upon aquifer supplies is generally poorly known, creating uncertainty about the environmental impacts of such extractions.

Groundwater extraction from the Tablelands' basalt aquifer is also of concern as it is thought to be vital for recharging many higher order stream tributaries which originate in the World Heritage Area and supply water for many scenic waterfalls popular with locals and tourists.

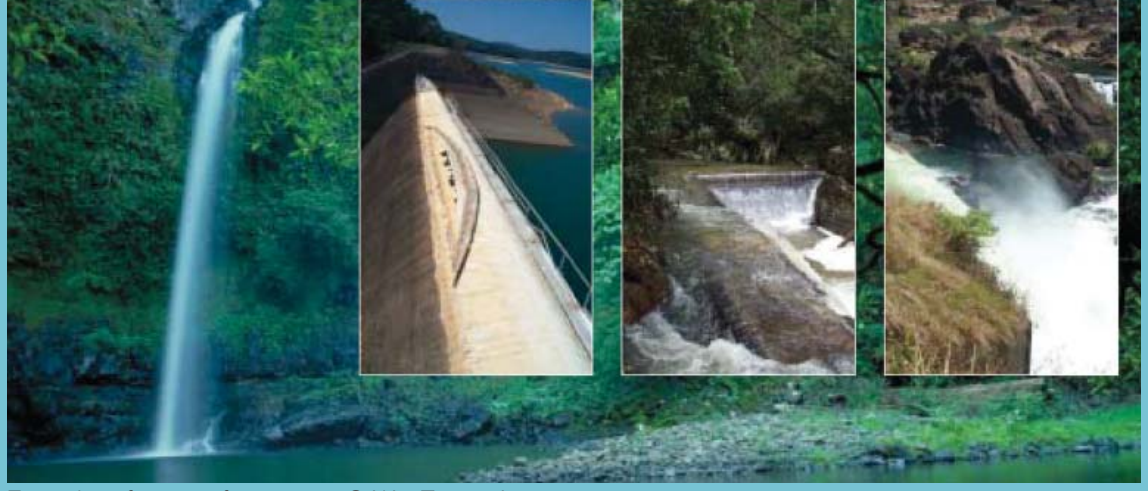
The Wet Tropics Management Authority is a key agency in these contentious but critical resource decisions, even where the actual water extraction is outside the boundaries of the World Heritage Area itself. Increased future demands and resource constraints will also place more pressure to allow greater extraction of water from within the World Heritage Area.

Existing large water infrastructure within the region includes the Tinaroo Dam, Barron and Kuranda weirs on the Barron River, Copperlode Dam on Freshwater Creek, Koombooloomba Dam on the upper Tully River, Herberton town dams on the upper Wild River (Herbert catchment) and Paluma Dam, which drains into the upper Burdekin catchment. Three of these dams occur within the World Heritage Area. In addition, there are many small weirs and at least 21 major water intakes from various streams across the region. There are 38 operating gauging stations in the region and 49 closed gauging stations, providing a rich dataset on stream flow in major streams.

In 1999, Wet Tropics Management Authority commissioned a *Code of Practice for Maintenance and Operation of Water Extraction Infrastructure in the Wet Tropics World Heritage Area*, which acts as a guide for the Authority to mitigate impacts on the World Heritage Area. This code of practice included identifying via an assessment of Conservation Value of Waterways in the World Heritage Area sub-catchments where water extraction was or was not feasible on environmental grounds. [77]

In Queensland, Water Resource Plans are used to provide a statutory basis for the allocation of water between the environment and various human uses. After several years of development, a Water Resource Plan for the Barron catchment was first prepared in 2002. A draft Water Resource Plan for the remaining Wet Tropics catchments was released for public comment in March 2013. The draft plan identifies 913,750ML of reserves of unallocated water to provide for human uses throughout the catchments covered by the plan. The plan claims to maintain flows at the downstream end of all catchments, at >90% of their flows prior to any water resource development.

Daintree River and Thorton Peak © K Trapnell



Examples of water infrastructure © Wet Tropics Images

Water Infrastructure Codes of Practice

In the Wet Tropics World Heritage Area, dams, weirs and culverts result in pressures on aquatic ecosystems by causing:

- changes in natural flow regimes as a result of water extraction and supply
- direct modification or destruction of important habitats
- barriers to the movement of plants and animals, for example within rivers and between rivers and their floodplain
- decreased water quality and quantity
- increased colonisation by introduced and exotic animal and plant species.

Under the *Wet Tropics Management Plan 1998* infrastructure agencies require a permit to undertake maintenance activities. One tool employed by the Wet Tropics Management Authority and infrastructure agencies to mitigate impacts is the use of environmental Codes of Practice which are also stipulated as a condition of Wet Tropics permits.

As well as these general Code of Practice provisions, the Authority also requires that Environmental Management Plans be developed as an additional condition of some permits to allow more explicit compliance monitoring. The intention of these Environmental Management Plans is:

- to provide detailed prevention, minimisation and mitigation strategies by identifying and mapping both environmental values and potential maintenance activity impacts to those values
- to specify mitigation strategies together with appropriate monitoring
- if an undesirable or unforeseen level of impact occurs, to specify the appropriate corrective action.

Water quality

Much of the investment in water quality research and extension activity is motivated by improving the quality of runoff to the Great Barrier Reef lagoon, rather than concern for the Wet Tropics waterways themselves.

Water quality monitoring of Wet Tropics streams has occurred sporadically over the past two to three decades. These monitoring programs have had many different objectives, some of which have included the examination of water resources and water quality issues for the development of water resource management plans;[78] investigations on the presence, fate and potential impact of contaminants in groundwater;[79] assessment of in-stream catchment health;[80] effects of agricultural runoff;[81] and the determination of water quality runoff to the Great Barrier Reef.[82]

Many of these studies have been synthesised in Water Quality Improvement Plans that have been developed for the

various catchments of the Wet Tropics.[83,84,85,86,87,88] These studies highlight that the key in-stream water quality issues in Wet Tropics streams are elevated levels of dissolved inorganic nitrogen (nitrate) and photosystem-II inhibiting herbicides both of which are largely sourced to agricultural practices in the region (sugarcane, bananas, dairy), as well as widespread hypoxia in lowland streams and wetlands in agricultural districts.

Several studies in the Wet Tropics region have highlighted that many streams are contaminated with pesticide residues, (both water and bottom sediments). Of these pesticides, the photosystem-II inhibiting herbicides such as diuron, atrazine and hexazinone (sourced to the sugarcane industry) are the most commonly detected and are likely to pose the highest pesticide risk to streams.[89]

However, a broader suite of pesticides sourced to the sugarcane and banana industry are also emerging as possible issues.[90] Further monitoring is required to decipher which organic constituent is implicated. While the direct impacts of pesticide residues to the freshwater streams are largely unknown and unquantified, some residues exceed water quality guidelines for ecosystem protection and hence are of concern in the region.

Remnants of the long-banned organo-chlorine insecticides (e.g. DDT, dieldrin, heptachlor) can still be detected in the biota (oysters, mussels, mudcrabs, bony bream and catfish) and benthic sediments of the streams and estuaries of the Wet Tropics.[91,92] However, the concentrations are unlikely to pose any risk to the ecosystem. Some of the currently used herbicides (atrazine, 2,4-D) have also been detected in certain biota;[93] the risk of this bioaccumulation is unknown.

Previous studies have shown that increased sediment erosion occurred particularly after the 1970s (up to 3 fold increase in suspended sediment export), coinciding with the expansion of the sugarcane industry,[94] although improved practices in the industry have considerably reduced sediment runoff from canelands.[95] Much of this extra sediment was exported out of the catchment into the adjacent World Heritage listed Great Barrier Reef lagoon.

Water quality datasets from several estuarine sites in the Wet Tropics [96] found many contained elevated levels of nutrients including oxidised nitrogen, ammonia and filterable reactive phosphorus. Several of the sites were ranked poor for chlorophyll *a* concentrations and some sites were also poor for dissolved oxygen levels, suggesting they are experiencing some form of eutrophication in certain seasons.

Whilst increased nutrient, sediment and pesticide loads result from land clearance, and runoff from urban and agricultural areas, within streams and wetlands, hypoxia is common. This may result from elevated nutrient loading via eutrophication, but is also a natural process inherent in tropical waterbodies, especially those deep enough to stratify.

This natural tendency is exaggerated by agricultural runoff, loss of riparian shading and dominance of water-choking weeds. Complete surface coverage of wetlands by floating weeds such as water hyacinth and by emergent weeds, block sunlight-driven photosynthesis resulting in respiration levels high enough to consume all the available oxygen in the water. Removal of aquatic weeds and restoration of riparian cover, even in the absence of any reductions in farm runoff, have shown remarkable improvements in stream water quality and return of pollution sensitive fish species.

Climate change in the Wet Tropics

Summary

- The Wet Tropics rainforests have expanded and contracted many times in response to past climate changes
- These contractions and expansions are reflected in the diversity and distribution patterns of biota, especially terrestrial vertebrates
- However, the patterns and distribution of most freshwater fish and invertebrates appear little affected. Notable exceptions include spiny crayfish and various invertebrates that are restricted to high elevation mountain tops
- Whilst air temperature is reliably predicted to increase under climate change, projections for future rainfall and streamflow change are uncertain although stronger seasonality of rainfall and streamflow may be expected
- Increases in water temperature do not automatically match changes in air temperature due to thermal buffering by factors, such as streamflow and shading by streamside vegetation and/or adjacent mountains
- Up to half the water inputs in some rainforests may come from interception of clouds blowing through the trees, a process that is affected by air temperature
- Key adaptation actions include understanding the thermal regimes of streams and the tolerance limits of their faunas; identifying and protecting refugial habitats; and maintaining and restoring riparian vegetation along narrower waterways.

Past climate change

During the late Pleistocene, 13,000-8,000 years ago, the Wet Tropics rainforests covered a much smaller area than they do today, being largely restricted to higher elevation locations and deep protected gorges, having been displaced by sclerophyll forests at many areas of lower elevations during this drier period. A return to higher rainfall has allowed the rainforest to expand to its current distribution. Such patterns have repeated several times during the Quaternary period.

The diversity and distribution patterns of certain biotic groups reflect these past rainforest contractions, with this effect being best displayed by terrestrial vertebrates and the existence of high diversity climatic refuges in upland areas.[98] In contrast, for the most part, the patterns and distribution of freshwater fish and most invertebrates appear little affected by these rainforest contractions and expansions. Exceptions include some insects and certain crayfishes in the genus *Euastacus*, which are restricted to high mountain tops.

It has been suggested that the taller mountain ranges received enough rainfall to maintain sufficient streamflow in lower reaches, and that combined with the continued presence of significant shading from streamside riparian vegetation (whether rainforest remnants or from sclerophyll species) maintained cooler water in mid and lowland streams, enabling freshwater fauna to maintain a greater distribution than their terrestrial counterparts during such periods of rainforest contraction.

The vagility of freshwater invertebrates with aerial adult life stages may also have obscured such patterns, recolonising streams after the rainforest expanded again. Alternatively, aquatic species may be less affected by changes in temperature. There is little empirical evidence to test this hypothesis, but most of the widespread fish and invertebrates have relatively broad habitat and environmental tolerances (within limits). However, many of the more restricted and higher conservation value species in the region are far more specialised and/or sensitive.

Some effects of historical rainforest contractions may become more evident in the genetic profiles of various groups as the number of genetic studies increases. Despite broad latitudinal and altitudinal distributions of most species, recent genetic studies across a range of groups has shown substantial genetic variation over small spatial scales, indicating that distribution patterns past and present are more complex than can be explained by the current distributions. The effect of past rainforest contractions should be an active area of research in freshwater ecology, not only to explain the current patterns of diversity and distribution but to help predict responses to future climatic changes.

Future climate change

Whilst climate change is not a new phenomenon and major environmental changes have occurred historically, climate projections predict unprecedented rates and magnitudes of temperature change. Globally, freshwater ecosystems are considered more vulnerable to climate change than terrestrial or marine habitats.[99]

Climate projections for the Wet Tropics under a high emission scenario suggest a rise in mean air temperature of 3.3˚C by 2085. Exactly how rises in air temperatures will translate into water temperatures is uncertain. Water temperature rises may be mitigated (at least in the short term) by factors such as cold groundwater seepage, and shading from topographic relief and riparian vegetation.

Projections for future rainfall are much more variable and uncertain than temperature projections. Whilst most models for the Wet Tropics suggest an increase in rainfall, some models predict decreases by as much as 400mm.[100] Rainfall patterns are likely to become more seasonal, with longer dry seasons and shorter wet seasons. Overall rainfall changes are projected to remain within the variability of the current climate. This is indicative of the high natural variation in annual rainfall experienced by the region.

Given the current uncertainty in rainfall, runoff and river flow projections for the future are also understandably, variable and uncertain. Most models predict an increase in mean annual river flows for the Wet Tropics region although some models predict decreases. Given the likely shifts towards more seasonal rainfall patterns, runoff is also expected to follow suit with alterations to flow regimes towards more seasonal flows.

Climate induced alterations to river flow and temperature regimes pose a high risk to freshwater biodiversity. Likely consequences are shifts in freshwater species ranges and possibly extinctions where species are unable to migrate to more suitable habitats. Work to predict Wet Tropics terrestrial species range shifts and future biodiversity hotspots using bioclimatic modeling, needs to be reciprocated for freshwater species which have, to date, been neglected by modelers.

Freshwater biota life histories are inextricably linked to stream flow regimes and their characteristics (magnitude, duration, timing, rate of change, frequency and

predictability). Alterations to flow regimes will have serious conservation implications. River water temperature regimes have an analogous suite of characteristics (magnitude, duration, timing, rate of change, frequency and predictability) that control the distribution of freshwater species.

However, water temperature data for streams and rivers are lacking for most of the region. Furthermore, knowledge of water temperature preferences and physiological temperature tolerances are virtually unknown for the vast majority of freshwater species in the Wet Tropics bioregion. Opportunities exist to mitigate the impacts of future water temperature rises, and even improve stream water temperature regimes through riparian planting to shade streams. In essence, even under conditions of increased air temperature, extensive riparian planting could still see water temperatures decrease, rather than increase, in streams that currently have little riparian shading.

Protecting endangered frogs into the future

The armoured mistfrog (*Litoria lorica*) was historically known from several sites on Thornton Peak and the Carbine Tableland in the northern Wet Tropics World Heritage Area. However, like many other stream-breeding rainforest frogs, the species declined suddenly in the late 1980s and early 1990s and disappeared from all known sites in 1991 and was not seen for 17 years. Most biologists feared *Litoria lorica* was extinct.

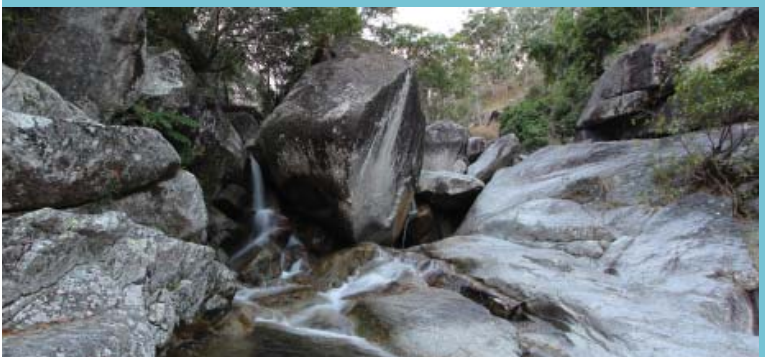
The armoured mistfrog was rediscovered in 2008 on the Carbine Tableland at a site it was not formerly known from. At this site *Litoria lorica* is common and persists well despite chytrid fungus infection, the disease-causing agent implicated in the original declines. This persistence is attributed to the warmer environmental temperatures at this open forest site compared to the nearby rainforest sites it disappeared from.

Continued monitoring reveals that this single population continues to persist at high abundance. However, targeted surveys over recent years have failed to find the species at any other site. This has led to the conclusion that *Litoria lorica* persists at only this single site.

To improve the chances of survival of this species the decision was made to translocate 40 adults (< 10% of the population) to a new site. In September 2013 approximately 20 males and 20 females were moved to a new site approximately 4km away from the current site. This new site has similar environmental characteristics as the current site and falls within the likely historic range of *Litoria lorica*. This management action was conducted as a collaboration between James Cook University, National Environment Research Program (NERP), Department of Environment and Heritage Protection and the Western Yalanji Aboriginal Corporation.

It is hoped that the translocated individuals will establish and form a second wild population over the coming years. Continued monitoring will measure the success of this translocation.

Litoria lorica habitat © C Hoskin



Litoria lorica © C Hoskin

Climate refuges are considered essential for the conservation of freshwater biodiversity in the face of climate change. Although there are other mechanisms for building resilience (such as reducing other pressures or threats) and assisting biodiversity through the worst of the climate extremes, identifying and protecting refuges is a key component of most climate change adaptation plans. Existing studies identifying freshwater refuges have to date only been conducted at a continental scale and should be down-scaled to inform local adaptation actions within the Wet Tropics.

Freshwater ecosystems have very high biodiversity relative to their areal extent. Maintaining contiguous habitat, with little or no loss or fragmentation is another key element in climate-adaptation planning. How climate change will interact with the existing threats to freshwater habitat is unknown.

Forest and stream hydrology; climate impacts and ecological implications

The Wet Tropics rainforests are highly dependent on rainfall, however, the interception of water droplets from clouds and fog blown through the forest by wind also provides a very important source of water, especially during the dry season when, at some sites, over half of the water input is from direct cloud interception rather than rain.[101,102]

The rainforest ecosystems of the Wet Tropics are highly dependent on climate but if climate was to change, what would be the potential impacts on these forests and the ecosystems that they support? Much of the *in situ* and off-site ecological impacts of any climate change will be propagated via rainfall and cloud interception which affects the water balance of the forest canopy, rather than temperature. *In situ* effects on rainforest fauna and flora will depend on changes in the amount of water held on the canopy and the length of time the canopy is wet.

Off-site impacts will be propagated via changes in the canopy water balance that affect downstream runoff. Recent research in the Wet Tropics rainforests has provided accurate models of the rainforest water balance that are driven by climatic inputs[103]

In most Wet Tropics rainforests around half of the water input (provided by rainfall and cloud interception) is lost as evaporation and the remainder largely drains from the site (in the dry season relatively small amounts replenish soil moisture). This runoff or locally 'excess water' therefore forms a major part of the flow of water in downstream rivers.

The process is significant to the overall water budget of the region, especially in terms of water recharge during the dry season. For the upland rainforests, cloud-stripping contributes up to 70% of the total water input into the forest system during the drier months. During the wet season, high rainfall masks the importance of cloud stripping which nonetheless still contributes 10-20% of the total water input into the region's upper catchments.

Under current climate conditions, cloud stripping occurs in rainforests higher than 600m asl (above sea level). With every degree of warming the base of the cloud condensation layer is predicted to rise by an average of 100m. By 2050 we may expect temperatures to be between 1.0^{0}C to 3.0^{0}C warmer than at present which equates to a rise in the effective cloud stripping condensation layer from 600m asl to 900m asl. With 3.0^{0}C of warming, the effective cloud stripping area in the Wet Tropics will decrease by as much as 40%. What this will mean for absolute water yields remains unknown, except to conclude that water yields will be significantly lower, especially in the dry season.

Recommendations

Emerging management issues

In being listed as a World Heritage Area, the World Heritage Committee of UNESCO confirmed the Wet Tropics as has outstanding universal value and integrity. Freshwater ecosystems of the Wet Tropics contribute significantly to the World Heritage values of the region. They are ancient, with many aquatic species reflecting a Gondwanan origin. The World Heritage Area supports unique aquatic biota and assemblages including a high diversity of fish and invertebrates. The area is habitat for many species of conservation significance and endemic species that evolved *in situ* in the region.

The freshwater ecosystems of the Wet Tropics World Heritage Area do not exist in isolation and whilst the habitats within the World Heritage are well managed and in general, in good condition, several emerging challenges exist:

- Freshwater ecosystems provide major biotic and energy conduits between the Wet Tropics World Heritage Area and lands outside the World Heritage, including the Great Barrier Reef World Heritage Area. Recent research has increased our recognition of the strength and co-dependency of these cross-boundary relationships, especially in relation to fish stocking and passage, water quality and ecosystem health. This has required greater cross-agency cooperation and community participation to ensure these issues are appropriately managed.
- Increasing coastal development and urbanisation along Australia's east coast is also placing further pressure on coastal resources, increasing the importance of management across boundaries and collaborating with other resource management agencies
- Water demand is soon likely to exceed water availability for some key rapidly growing urban areas. Water demand management is a particularly contentious issue especially in a region where water is publicly perceived as being in abundance. This will be an area requiring greater planning attention; fostering of innovation and best practice; community education; cross-agency/jurisdiction cooperation; and potential conflict management in future years.

Future priorities

There are still a number of priority research, planning and policy attention areas that require addressing in relation to understanding, managing and maintaining freshwater ecosystem function and biodiversity in the Wet Tropics World Heritage Area:

Gaps in knowledge of biota. Many new species are still being discovered, particularly in hard to access streams within the World Heritage Area. Key gaps are our limited knowledge of fauna in small, steep, streams of the coastal mountain ranges, and our knowledge of invertebrates, turtles and surprisingly – platypus. Thousands of aquatic invertebrate species await discovery and documentation. Turtles are the last remaining vertebrate group for which there has been no systematic survey in the Wet Tropics.

Impacts of introduced species. Numerous species, including fish, crustaceans and crocodiles, have been introduced to the region's waterways but there is little understanding of their impact, even where the introductions have occurred within the World Heritage Area itself. We need to better understand the distribution of introduced species and their habitat usage and behavioural interactions with native fauna.

Vulnerable key species. There are many species of high conservation value with limited distributions. Key among these though are the four species of spiny crayfish that are restricted to high elevation mountain tops. Their requirement for cold water restricts their range and makes them highly vulnerable to potential climate change and warming, yet we know nothing of their ecology and habitat and physiological tolerances. Fish species with limited ranges such as the Bloomfield cod, which only occurs in one stream reach in the Bloomfield River, are also under threat from introduced fish species, as exemplified by the loss of Lake Eacham rainbowfish from its type locality due to introduced fishes.

Researcher sampling Emmagen Creek, Daintree lowland © TropWater

Decline of frog species. Four stream-dwelling frog species have declined to extinction or near extinction, and three others have suffered massive declines in distribution and abundance. All seven species are endemic to the Wet Tropics. Urgent attention is required to understand the management needs, including potentially translocating some of the remaining individuals, of these species.

Rehabilitating wetlands and maintaining fish passage. Up to 80% of lowland wetlands have been lost and the most of the remainder are in poor condition. Thousands of potential fish passage barriers exist, mostly in the form of road crossings and culverts. The technical knowledge for this action is largely known, but rehabilitation/ retrofitting is a costly exercise that also requires significant planning and cooperative efforts from many stakeholders. Long-term maintenance (e.g. for weed control) may be required in many situations.

Retention and replanting of streamside vegetation. Streamside (riparian) vegetation has been cleared along many streams, creating numerous environmental problems. The techniques for replanting are largely known and relatively low-tech, although planning and stakeholder cooperation is required. Planning at local and regional scales is required to select priority streams for riparian restoration activities.

Decline in water quality. Hypoxia (low dissolved oxygen) is the most widespread water quality issue, especially in relation to weed dominance of waterways and agricultural runoff. Catchment-scale agricultural runoff is being improved via the Reef Rescue program whilst localized weed control and riparian restoration is the main requirement for other instream water quality issues. Pesticides are a new threat, following the recent recognition of their common occurrence in coastal waterways. Nothing is known of their impact in freshwater systems.

Impact of climate change. Very little is known about the tolerances of key aquatic biota to increased water temperature. Relatively little is known about what are the temperatures of streams in the Wet Tropics and how they might respond to increased air temperature and potentially reduced streamflow. Not all potential effects are strictly temperature-related. The impact of reduced cloud capture on canopy wetness and dry season flow in upland streams looms as a significant unheralded threat.

Supporting indigenous aspirations. Increased involvement of indigenous people in aquatic resource management requires further expansion and long-term commitment, as does exploration of incorporating traditional ecological knowledge into contemporary management practices.

Managing water resources. Demand management and greater water-use efficiency is required to fend-off looming water resource conflict and avoid construction of significant new water infrastructure or increased water extraction in high conservation value waterways. Appropriate planning is a key part of achieving that outcome.

Building capability and community understanding. The community are the environments greatest assets. Promoting a deeper understanding of the links between environmental services provided by water and community well-being will provide benefits across all other water management issues.

References

1 Unmack, P.J. 2013. Biogeography. In: Humphries P. and Walker K. (eds) *Ecology of Australian Freshwater Fishes.* CSIRO, Australia.

2 Kennard M.J., Pusey B.J., Olden J.D., Mackay S.J., Stein J.L. and Marsh N. 2010. Classification of natural flow regimes in Australia to support environmental flow management. *Freshwater Biology*, **55**: 171–193.

3 Pusey B.J., Kennard M.J. and Arthington A.H. 2008. Origins and maintenance of freshwater biodiversity in the Wet Tropics region. In: *Living in a Dynamic Tropical Forest Landscape* (Eds N.E. Stork & S.M. Turton), pp. 150–160. Blackwell Publishing, Carlton, Victoria.

4 Donaldson, J. A., Ebner, B.C. and Fulton, C.J. 2013. Flow velocity underpins microhabitat selectivity in amphidromous gobies of the Australian Wet Tropics.

5 Russell, D.J. and Hales, P.W. 1993. *Stream Habitat and Fisheries Resources of the Johnstone River Catchment*. Department of Primary Industries, Northern Fisheries Research Centre, Cairns. QDPI Information Series QI93056. 59pp.

6 Russell, D.J., Hales, P.W. and Helmke, S.A. 1996a. *Stream Habitat and Fish Resources in the Russell and Mulgrave Rivers Catchment*. Department of Primary Industries, Northern Fisheries Research Centre, Cairns. QDPI Information Series QI96008. 58pp.

7 Russell, D.J. and Hales, P.W. 1997. *Fish Resources and Stream Habitat of the Liverpool, Maria and Hull Catchments*. QDPI Information Series QI97039. Queensland Dept. of Primary Industries, Brisbane. 68pp.

8 Russell, D.J., McDougall, A.J. and Kistle, S.E. 1998. *Fish Resources and Stream Habitat of the Daintree, Saltwater, Mossman and Mowbray Catchments*. QDPI Information Series QI98062. Queensland Department of Primary Industries, Brisbane. 72pp.

9 Russell, D.J., McDougall, A.J., Ryan, T.J., Kistle, S.E., Aland, G., Cogle, A.L. and Langford, P.A. 2000. *Natural Resources of the Barron River Catchment 1: Stream Habitat, Fisheries Resources and Biological Indicators*. QDPI Information Series QI00032. Queensland Dept. of Primary Industries, Brisbane. 108pp.

10 Russell, D. J., Ryan, T. J., McDougal, A. J., Kistle, S. E. and Aland, G. 2003. Spatial diversity and spatial variation in fish assemblage structure of streams in connected tropical catchments in northern Australia with reference to the occurrence of translocated and exotic species. *Marine and Freshwater Research* **54**: 813–824.

11 Pusey, B.J. and Kennard, M.J. 1994. *The Freshwater Fish Fauna of the Wet Tropics Region of Northern Queensland*. Report to the Wet Tropics Management Authority.

12 Pusey B.J., Kennard M.J. and Arthington A.H. 2004. *Freshwater Fishes of North-Eastern Australia*, pp. 702. CSIRO Publishing, Melbourne, Vic.

13 Rayner, T.S., Pusey, B.J. and Pearson, R.G. 2008. Seasonal flooding, instream habitat structure and fish assemblages in the Mulgrave River, north-east Queensland: towards a new conceptual framework for understanding fish-habitat dynamics in small tropical rivers. *Marine and Freshwater Research* **59**: 97–116.

14 Russell, D. J., Thomson, F. E. and Thuesen, P. A. 2013. Age and growth of two newly established invasive populations of *Tilapia mariae* in northern Australia. *Journal of Fish Biology* **82***:* 1211-1225.

15 Also refer to other TropWater reports www.jcu.edu.au/Tropwater

16 Thuesen P.A., Ebner, B.C., Larson, H., Keith, P., Silcock, R.M., Prince, J. and Russell, D.J. 2011. Amphidromy links a newly documented fish community of continental Australian streams, to oceanic islands of the West-Pacific. *PLOS One* **6**: e26685.

17 Ebner, B.C. and Morgan D.L. 2013. Using remote underwater video to estimate freshwater fish species richness. *Journal of Fish Biology* **82**: 1592–1612.

18 Adams, M., Page, T. J., Hurwood, D. A. and Hughes J. M. 2013. A molecular assessment of species boundaries and phylogenetic affinities in *Mogurnda* (Eleotridae): a case study of cryptic biodiversity in the Australian freshwater fishes. *Marine and Freshwater Research* On-line first

19 Ebner, B.C., Thuesen, P.A., Larson, H. and Keith, P. 2011. A review of distribution, field observations and precautionary conservation requirements for sicydiine gobies in Australia. *Cybium* **35**: 397–414.

20 Thuesen P.A., Ebner, B.C., Larson, H., Keith, P., Silcock, R.M., Prince, J. and Russell, D.J. 2011. Amphidromy links a newly documented fish community of continental Australian streams, to oceanic islands of the West-Pacific. *PLOS One* **6**: e26685.

21 Adams, M., Page, T. J., Hurwood, D. A. and Hughes J. M. 2013. A molecular assessment of species boundaries and phylogenetic affinities in *Mogurnda* (Eleotridae): a case study of cryptic biodiversity in the Australian freshwater fishes. *Marine and Freshwater Research* On-line first

22 Januchowski-Hartley S.R., Pearson R.G., Puschendorf, R. and Rayner T. 2011. Fresh waters and fish diversity: distribution, protection and disturbance in tropical Australia. *PLoS ONE,* **6**: e25846.

23 Unmack P.J. and Dowling T.E. 2010. Biogeography of the genus *Craterocephalus* (Teleostei: Atherinidae) in Australia. *Molecular Phylogenetics and Evolution* **55**: 968–984.

24 Adams, M., Page, T. J., Hurwood, D. A. and Hughes J. M. 2013. A molecular assessment of species boundaries and phylogenetic affinities in *Mogurnda* (Eleotridae): a case study of cryptic biodiversity in the Australian freshwater fishes. *Marine and Freshwater Research* On-line first

25 Unmack, P.J., Allen, G.R., and Johnson, J.B. 2013. Phylogeny and biogeography of rainbowfishes (Melanotaeniidae) from Australia and New Guinea. *Molecular Phylogenetics and Evolution* **67**: 15–27.

26 Thuesen P.A., Ebner, B.C., Larson, H., Keith, P., Silcock, R.M., Prince, J. and Russell, D.J. 2011. Amphidromy links a newly documented fish community of continental Australian streams, to oceanic islands of the West-Pacific. *PLOS One* **6**: e26685.

27 Martin, K. C. and Barclay, S. 2013. New distribution records for the Cairns Rainbowfish *Cairnsichthys rhombosomoides* (Melanotaeniidae): implications for conservation of a restricted northern population. *Aqua, International Journal of Ichthyology* **19**: 155-164.

28 Ebner,B.C. and Thuesen, P.A. 2010. Discovery of stream-cling-goby assemblages (*Stiphodon* species) in the Australian Wet Tropics. *Australian Journal of Zoology* **58**: 331–340.

29 Ebner, B.C., Kroll, R., Godfrey, P., Thuesen, P.A., Vallance, T., Pusey, B., Allen, G., Rayner, T.S. and Perna, C.N. 2011. Is the elusive *Gymnothorax polyuranodon* really a freshwater moray? *Journal of Fish Biology* **79**: 70–79.

30 Thuesen P.A., Ebner, B.C., Larson, H., Keith, P., Silcock, R.M., Prince, J. and Russell, D.J. 2011. Amphidromy links a newly documented fish community of continental Australian streams, to oceanic islands of the West-Pacific. *PLOS One* **6**: e26685.

31 Webb, A. 2007. Status of non-native freshwater fishes in tropical northern Queensland, including establishment success, rates of spread, range and introduction pathways. *Journal and Proceedings of the Royal Society of New South Wales* **140**: 63-78

32 Burrows, D.W. 2009. *Distribution of Exotic Freshwater Fishes in the Wet Tropics Region, Northern Queensland, Australia* Report No. 09/19 Australian Centre for Tropical Freshwater Research, James Cook University, Townsville.

33 Burrows, D.W. *unpublished data.*

34 Burrows, D.W. 2002. *Fish Stocking and the Distribution and Potential Impacts of Translocated Fishes in Streams of the Wet Tropics Region, Northern Queensland.* Report No. 02/04 Australian Centre for Tropical Freshwater Research, James Cook University

35 Burrows, D.W. 2004. *Translocated Fishes in Streams of the Wet Tropics Region, North Queensland: Distribution and Potential Impact.* Cooperative Research Centre for Tropical Rainforest Ecology and Management. 77 pp.

36 Barlow, C.G., Hogan, A.E. and Rogers, L.G. 1987. Implication of translocated fishes in the apparent extinction in the wild of the Lake Eacham rainbowfish, *Melanotaenia eachamensis. Australian Journal of Marine and Freshwater Research* **38**: 897-902.

37 Hoskin, C.J. and Hero, J-M. 2008. *Rainforest Frogs of the Wet Tropics, north-east Australia*. Griffith University, Gold Coast, 96 pp.

38 Hoskin, C.J. 2004. Australian microhylid frogs (*Cophixalus and Austrochaperina*): phylogeny, taxonomy, calls, distributions and breeding biology. *Australian Journal of Zoology* **52**: 237–269.

39 Hoskin, C.J. 2007. Description, biology and conservation of a new species of Australian tree frog (Anura: Hylidae: *Litoria*) and an assessment of the remaining populations of *Litoria genimaculata* Horst, 1883: systematic and conservation implications of an unusual speciation event. *Biological Journal of the Linnean Society* **91**: 549-563.

40 Puschendorf, R., Hoskin, C.J, Cashins, S.D., McDonald, K., Skerratt, L.F., Vanderwal, J. and Alford, R.A. 2011. Environmental refuge from disease-driven amphibian extinction. *Conservation Biology* **25**: 956-964.

41 Hoskin, C.J., and Puschendorf, R. *In progress*.

42 Hoskin, C.J. 2004. Australian microhylid frogs (*Cophixalus and Austrochaperina*): phylogeny, taxonomy, calls, distributions and breeding biology. *Australian Journal of Zoology* **52**: 237–269.

43 Shoo, L.P. and Williams, Y. 2004. Altitudinal distribution and abundance of microhylid frogs (*Cophixalus and Austrochaperina*) of north-eastern Australia: baseline data for detecting biological responses to future climate change. *Australian Journal of Zoology* **52**: 667-676.

44 Hoskin, C.J. and Hero, J-M. 2008. *Rainforest Frogs of the Wet Tropics, north-east Australia*. Griffith University, Gold Coast, 96 pp.

45 Williams, S.E., Bolitho, E.E. and Fox, S. 2003. Climate change in Australian tropical rainforests: an impending environmental catastrophe. *Proceedings of the Royal Society of London Series B* **270**: 1887-1892.

46 Hoskin, C.J. *personal observations*.

47 Todd, E. 2013. *Evolutionary Biogeography of Australian Riverine Turtles*. Unpublished PhD thesis, School of Marine and Tropical Biology, James Cook University, Townsville.

48 Schaffer, J. TropWATER, *unpublished data*.

49 Grant, T.R. 1992. Historical and current distribution of the platypus, *Ornithorynchus anatinus*, in Australia. Pages 232-254 In: Augee, M.L. (ed.) *Platypus and Echidnas*. The Royal Zoological Society of NSW, Sydney.

50 Grant, T.R. 2007. *Platypus,* 4th ed. CSIRO Publishing, Colliingwood, Victoria.

51 Kolomyjec, S.H., Grant, T.R., Johnson, C.N. and Blair, D. (*in press*) Regional population structuring and conservation units in the platypus (*Ornithorhynchus anatinus*). *Australian Journal of Zoology.*

52 McCormack, R.B. 2012. *A Guide to Australia's Spiny Freshwater Crayfish*. CSIRO Publishing, Australia.

53 Shull, H.C., Pérez-Losada, M., Blair, D., Sewell, K., Sinclair, E.A., Lawler, S., Ponniah, M., Crandall, K.A. 2005. Phylogeny and biogeography of the freshwater crayfish *Euastacus* (Decapoda: Parastacidae) based on nuclear and mitochondrial DNA. *Molecular Phylogenetics and Evolution* **37**: 249–263.

54 Pearson, R.G., Benson, L.J. and Smith, R.E.W. 1986. Diversity and abundance of the fauna in Yuccabine Creek, a tropical rainforest stream. Pp. 329-342, In P. de Deckker and W.D. Williams (eds) Limnology in Australia. CSIRO, Melbourne.

55 Connolly, N.M., Christidis, F., McKie, B., Boyero, L. and Pearson, R. 2008. Diversity of Invertebrates in Wet Tropics Streams: Patterns and Processes. In: Living in a Dynamic Tropical Forest Landscape (Eds N.E. Stork and S.M. Turton), pp. 161–177. Blackwell Publishing, Carlton, Victoria.

56 Pearson, Richard G. 2005. Biodiversity of the freshwater invertebrates of the wet tropics region of northeastern Australia: patterns and possible determinants. In: Tropical Rainforests: past, present and future. University of Chicago Press, Chicago, USA, pp. 470-485.

57 Clayton, P.D. 1995 The Ecology of waterfalls in the Australian Wet Tropics. PhD thesis, James Cook University, Townsville.

58 Russell, D.J. and Hales, P.W. 1993. Stream Habitat and Fisheries Resources of the Johnstone River Catchment. Department of Primary Industries, Northern Fisheries Research Centre, Cairns. QDPI Information Series QI93056. 59pp.

59 Russell, D.J., Hales, P.W. and Helmke, S.A. 1996a. Stream Habitat and Fish Resources in the Russell and Mulgrave Rivers Catchment. Department of Primary Industries, Northern Fisheries Research Centre, Cairns. QDPI Information Series QI96008. 58pp.

60 Russell, D.J., Hales, P.W. and Helmke, S.A. 1996b. Stream Habitat and Fish Resources of the Moresby River Catchment. Department of Primary Industries, Northern Fisheries Research Centre, Cairns. QDPI Information Series QI96061. 45pp.

61 Whiting, J. 1998. Changes in Melaleuca communities in the Cowley Beach Training Area, north Queensland: 1943-1997. Honours Thesis, School of Tropical Environment Studies and geography, James Cook University, Townsville.

62 Tait, J.P. 1994. Lowland Habitat Mapping and Management Recommendations: Tully-Murray Catchments. Report to Cardwell Shire Catchment Coordinating Committee. Department of Primary Industries, North Region. 51pp+appendices.

63 Malcolm, H. Department of Primary Industries, unpublished data

64 Veitch, V., Burrows, D.W., Hudson, D. and Butler, B. 2007. Removal of Aquatic Weeds From Lagoon Creek, Herbert Catchment North Queensland: Trialling Novel Removal Methods and Demonstration of Environmental Benefits. Report No. 07/15 Australian Centre for Tropical Freshwater Research, James Cook University, Townsville.

65 Digman, R. 1994. Creation of Lagoons or Wetlands in a Tropical Agricultural Setting. Self Published.

66 Burrows, D.W. 1998. FNQ2010 Regional Environment Strategy Key Waterways Report. Report No. 98/02 Australian Centre for Tropical Freshwater Research, James Cook University. 81pp.

67 Pusey, B., Werren, G., Burrows, D.W. and Pearson, R.G. 1999. Value of Waterways in the Wet Tropics World Heritage Area. Report 99/10 (two volumes) Australian Centre for Tropical Freshwater Research, James Cook University.

68 Natural Resources Assessments Pty Ltd, River Research Pty Ltd and Australian Centre for Tropical Freshwater Research. 1999. *Conservation Values of Waterways in the Wet Tropics of Queensland World Heritage Area*, Report to the Wet Tropics Management Authority, September 2009. 30+pp.

69 Godfrey, P. and Pearson, R. 2012. Wet Tropics Waterways Condition Assessment: Mulgrave, Russell, Johnstone and Herbert Rivers. Report 12/03, Australian Centre for Tropical Freshwater Research/ TropWATER, James Cook University, Townsville.

70 Januchowski-Hartley S.R., Pearson R.G., Puschendorf, R. and Rayner T. 2011. Fresh waters and fish diversity: distribution, protection and disturbance in tropical Australia. *PLoS ONE*, **6**: e25846.

71 Ebner, B.C., and Donaldson, J.A. JCU and CSIRO, *unpublished data*.

72 Lawson, T., Kroon, F., Russell, J. and Thuesen, P. 2010. *Audit and Prioritisation of Physical Barriers to Fish Passage in the Wet Tropics Region*. Milestone report, MTSRF Project 2.6.2 CSIRO Sustainable Ecosystems.

73 Connolly, N.M., Pearson, B., Loong, D., Maughan, M. and Pearson, R.G. 2007. Hydrology, Geomorphology and Water Quality of Four Wet Tropics Streams with Contrasting Land-use Management. *In* Arthington, A.H. & Pearson, R.G. (eds.) *Biological Indicators of Ecosystem Health in Wet Tropics Streams*. Final Report Task 3 Catchment to Reef Research Program Cooperative Research Centre for Rainforest Ecology & Management and Cooperative Research Centre for the Great Barrier Reef World Heritage Area. Pages 15–78.

74 Wet Tropics Management Authority, 2004. *Wet Tropics Conservation Strategy: the Conservation, Rehabilitation and transmission to future generations of the Wet Tropics World Heritag Area*. 108pp.

75 Wet Tropics Management Authority, 2012. Annual Report and State of the Wet Tropics 2011-12. *The function of the Wet Tropics of Queensland World Heritage Area in the Life of the Community*, WTMA. 86pp.

76 Strategic Water Initiatives - Regional Water Supplies, 2010. *Far North Queensland Regional Water Supply Strategy*, Department of Environment and Resource Management, Brisbane. 176pp.

77 Pusey, B., Werren, G., Burrows, D.W. and Pearson, R.G. 1999. *Value of Waterways in the Wet Tropics World Heritage Area*. Report 99/10 (two volumes) Australian Centre for Tropical Freshwater Research, James Cook University.

78 Hunter, H.M., Sologinkin, S.J., Choy, S.C., Hooper, A.R., Allen, W.S., Raymond, M.A.A. and Peeters, J. 2001. *Water Management in the Johnstone Basin*. Department of Natural Resources and Mines, Brisbane.

79 Rasiah, V., Armour, J. D., and Cogle, A. L., 2005. Assessment of variables controlling nitrate dynamics in groundwater: Is it a threat to surface aquatic ecosystems. *Marine Pollution Bulletin* **51**: 60-69.

80 Arthington, A.H. and Pearson, R.G. (eds.) *Biological Indicators of Ecosystem Health in Wet Tropics Streams*. Final Report Task 3 Catchment to Reef Research Program Cooperative Research Centre for Rainforest Ecology & Management and Cooperative Research Centre for the Great Barrier Reef World Heritage Area.

81 Pearson R., Crossland, M., Butler, B. and Manwaring S., 2003. *Quantification of the Effects of Cane Field Drainage on Stream Ecology*. Report No. 03/02. Australian Centre for Tropical Freshwater Research, James Cook University.

82 Mitchell, A., Reghenzani, J., Faithful, J., Furnas, M. and Brodie, J. 2009. Relationships between land use and nutrient concentrations in streams draining a 'wet-tropics' catchment in northern Australia. *Marine and Freshwater Research* **60**: 1097-1108.

83 Davis, R. 2006. *Douglas Shire Water Quality Improvement Plan*. Douglas Shire Council.

84 Barron, F. and Haynes, D. 2009. *Water Quality Improvement Plan for the Catchments of the Barron River and Trinity Inlet*. Terrain NRM.

85 Lewis, S. and Brodie, J. 2011a. *A Water Quality Issues Analysis for the Russell River Catchment*. Report No. 11/07 Australian Centre for Tropical Freshwater Research, James Cook University.

86 Lewis, S. and Brodie, J. 2011b. *A Water Quality Issues Analysis for the Mulgrave River Catchment*. Report No. 11/06 Australian Centre for Tropical Freshwater Research, James Cook University.

87 Lewis, S. and Brodie, J. 2011c. *A Water Quality Issues Analysis for the Johnstone River Basin*. Report No. 11/05 Australian Centre for Tropical Freshwater Research, James Cook University.

88 Terrain NRM. 2008. *Summary of the Draft Tully Water Quality Improvement Plan for consultation*. July 2008.

89 Bainbridge, Z.T., Brodie, J.E., Faithful, J.W., Sydes, D.A. and Lewis, S.E. 2009. Identifying the land-based sources of suspended sediments, nutrients and pesticides discharged to the Great Barrier Reef from the Tully Basin, Queensland, Australia. *Marine and Freshwater Research* **60**: 1081-1090.

90 Shaw, M., Furnas, M.J., Fabricius, K., Haynes, D., Carter, S., Eaglesham, G., and Mueller, J.F 2010. Monitoring pesticides in the Great Barrier Reef. *Marine Pollution Bulletin* **60**:113-122.

91 Duke, N.C., Bell, A.M., Pedersen, D.K., Roelfsema, C.M., Godson, L.M., Zahmel, K.N., MacKenzie, J. and Bengston-Nash, S. 2003. *Mackay Mangrove Dieback. Investigations in 2002 with recommendations for further research, monitoring and management*. Final Report to Queensland Fisheries Service, Northern Region (DPI) and the Community of Mackay Region. Centre for Marine Studies, The University of Queensland: Brisbane, 157pp.

92 Negri, A.P., Mortimer, M., Carter, S. and Müller, J.F. 2009. Persistent organochlorines and metals in estuarine mud crabs of the Great Barrier Reef. *Marine Pollution Bulletin* **58**: 765-786.

93 Russell, D.J., Hales, P.W. and Moss, A. 1996. Pesticide residues in aquatic biota from north-east Queensland coastal streams. *Proceedings of the Royal Society of Queensland* **106**: 23–30.

94 Arakel, A.V., Hill, C.M., Prioewicz, J. and Connor, T.B. 1989. Hydro-sedimentology of the Johnstone River estuary. *Hydrobiologia*, **176/177**: 51-60.

95 Prove, B.G., Doogan, V.J. and Truong, P.N.V. 1995. Nature and magnitude of soil erosion in sugarcane land on the wet tropical coast of north-eastern Queensland. *Australian Journal of Experimental Agriculture* **35**: 641-649.

96 Cox, M.E., Moss, A. and Smyth, G.K. 2005. Water quality condition and trend in north Queensland waterways. *Marine Pollution Bulletin* **51**: 89-98.

97 Veitch, V., Burrows, D.W., Hudson, D. and Butler, B. 2007. *Removal of Aquatic Weeds From Lagoon Creek, Herbert Catchment North Queensland: Trialling Novel Removal Methods and Demonstration of Environmental Benefits*. Report No. 07/15 Australian Centre for Tropical Freshwater Research, James Cook University, Townsville.

98 Williams, S.E. and Pearson, R.G. 1997. Historical rainforest contractions, localized extinctions and patterns of vertebrate endemism in the rainforests of Australia's Wet Tropics. *Proceedings of the Royal Society of London Series B* **264**: 709-716.

99 Sala, O.E., Chapin, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oesterheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M. and Wall, D.H. 2000. Biodiversity - Global biodiversity scenarios for the year 2100. *Science* **287**: 1770-1774.

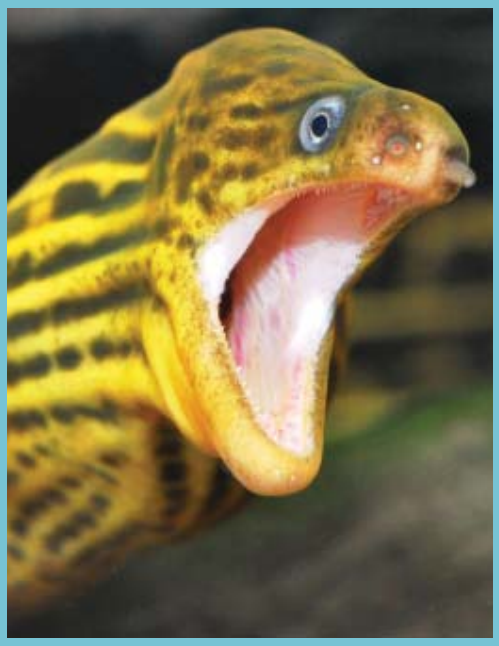
100 James, C.S., VanDerWal, J., Capon, S.J., Hodgson, L., Waltham, N., Ward, D.P., Anderson, B.J. and Pearson, R.G. 2013. *Identifying Climate Refuges for Freshwater Biodiversity Across Australia*, National Climate Change Adaptation Research Facility, Gold Coast, 150 pp.

101 Wallace, J.S. and McJannet, D. 2012. Climate change impacts on the water balance of coastal and montane rainforests in northern Queensland, Australia. *Journal of Hydrology* **475**: 84-96.

102 McJannet, D.L., Wallace, J.S. and Reddell, P. 2007. Precipitation interception in Australian tropical rainforests: I. Measurement of stemflow, throughfall and cloud interception. *Hydrological Processes* **21**: 1692-1702.

103 Wallace, J.S. and McJannet, D.L. 2008. Modelling interception in coastal and montane rainforests in northern Queensland, Australia. *Journal of Hydrology* **348**: 480-495.

104 Wallace, J.S. and McJannet, D. 2013. How might Australian rainforest cloud interception respond to climate change? *Journal of Hydrology* **481**: 85-95.



Moray eel © B Ebner

WET TROPICS
MANAGEMENT AUTHORITY

Level 1 15 Lake Street Cairns Corporate Tower Cairns 4870
PO Box 2050 Cairns 4870
Ph 07 4052 0555 | Fax 07 4031 1364
wettropics@wtma.qld.gov.au
www.wettropics.gov.au

Front cover: Josephine Falls © Wet Tropics Images