
The Parliament of the Commonwealth of Australia

Case Studies on Biodiversity Conservation: Volume 2

**Second interim report of the inquiry into Australia's biodiversity
in a changing climate**

House of Representatives
Standing Committee on Climate Change, Environment and the Arts

November 2012
Canberra

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Cover images courtesy of committee secretariat

Front cover (L-R): Committee members in the Lower Lakes region; Committee members being briefed on Reef HQ Aquarium's coral propagation program; lotus flower in Kakadu's Yellow Water Wetlands.

Back cover (L-R): Reef HQ Aquarium's coral reef exhibit; Committee members at Melbourne Museum's *Wild* exhibition; bird amongst salvinia in Kakadu's Yellow Water Wetlands.

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Foreword

Since the June 2011 referral of this inquiry into Australia's biodiversity in a changing climate, the Committee has engaged in an extensive evidence-gathering process to adequately address the broad terms of reference. The Committee has travelled around the country to ensure a broad representation of issues relevant across Australia, inspecting many ecosystems of national importance and visiting research and other facilities relevant to the inquiry's terms of reference. I am pleased to note that the Committee has conducted inquiry activities, including site inspections, briefings and public hearings, in each of Australia's states and territories.

Although the Committee has completed its formal program of interstate site inspections, it continues to gather evidence to the inquiry through briefings and hearings. This second interim report is therefore intended to provide an update on the progress of inquiry and the important themes canvassed during site inspections since the Committee's last report to the Parliament in May 2012.

Following on from the first interim report, which covered the first half of the Committee's site inspections, this second interim report discusses the issues explored by the Committee during its inspections in Victoria, South Australia, the Northern Territory and Queensland.

Throughout the site inspection program, the Committee has been struck by the vast range of ecosystem types that exist in Australia, including those in terrestrial, marine and freshwater environments. The diversity of ecosystems has highlighted the different challenges facing natural resource managers across the country.

At the same time, however, the site inspections have also reinforced the fact that there are many challenges common to biodiversity conservation across the country. The threats that climate change poses – including changes in temperature, rainfall patterns, and sea levels – are likely to have implications for the way biodiversity is managed in all ecosystem types, albeit to varying extents and with different results. The uncertainty associated with the impacts of climate changes is also a common challenge for natural resource managers and policy

makers across the country, perhaps signalling the need for a new approach to natural resource management in an unpredictable climate.

Finally, I would like to take this opportunity to place on record my thanks to all of the local experts who met with and briefed the Committee during the site inspection program, and to all those who facilitated the Committee's visits. I also appreciate the cooperation of my fellow Committee members and acknowledge the significant commitments they and the committee secretariat have made in engaging in this important site inspection program.

Tony Zappia MP
Chair

Membership of the Committee

Chair Mr Tony Zappia MP

Deputy Chair Dr Mal Washer MP

Members Ms Jill Hall MP Mr Wyatt Roy MP

Ms Nola Marino MP

Committee Secretariat

Secretary Ms Julia Morris

Inquiry Secretary Ms Peggy Danaee

Senior Research Officers Ms Susan Dinon (from 28/5/12)
Mr James Nelson (to 25/5/12)

Administrative Officers Mr Peter Pullen
Ms Jessica Hargreaves (from 9/8/12)

Terms of reference

The Committee will inquire into and report on biodiversity in a changing climate, in relation to nationally important ecosystems. The inquiry will have particular regard to:

- terrestrial, marine and freshwater biodiversity in Australia and its territories
- connectivity between ecosystems and across landscapes that may contribute to biodiversity conservation
- how climate change impacts on biodiversity may flow on to affect human communities and the economy
- strategies to enhance climate change adaptation, including promoting resilience in ecosystems and human communities
- mechanisms to promote the sustainable use of natural resources and ecosystem services in a changing climate
- an assessment of whether current governance arrangements are well placed to deal with the challenges of conserving biodiversity in a changing climate
- mechanisms to enhance community engagement.

The scope of the committee's inquiry shall include some case studies of 'nationally important ecosystems', as defined by submissions to the inquiry.

List of abbreviations

AIMS	Australian Institute of Marine Science
CAP	Community Advisory Panel
CCEA	Climate Change, Environment and the Arts
CLLMM	Coorong, Lower Lakes and Murray Mouth
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEH	Department for Environment and Heritage (SA)
DEWNR	Department of Environment, Water and Natural Resources (SA)
DNA	Deoxyribonucleic acid
DRO	Daintree Rainforest Observatory
DSEWPAC	Department of Sustainability, Environment, Water, Population and Communities
ENSO	El Niño-Southern Oscillation
GBRMPA	Great Barrier Reef Marine Park Authority
IEP	Indigenous Employment Program
JCU	James Cook University
KNP	Kakadu National Park

KNYA	Kungun Ngarrindjeri Yunnan Agreement (Agreement between the Ngarrindjeri people and the Government of South Australia)
KRAC	Kakadu Research Advisory Committee
LED	Light-emitting diode
Lower Lakes	Lakes Alexandrina and Albert
NERP	National Environmental Research Program
NRA	Ngarrindjeri Regional Authority
OZCAM	Online Zoological Collections of Australian Museums
Ramsar	The Convention on Wetlands (Ramsar, Iran, 1971)
REDMAP	Range Extension Database and Mapping Project
Reef HQ	Reef HQ Great Barrier Reef Aquarium
UNESCO	United Nations Educational, Scientific and Cultural Organization
WTMA	Wet Tropics Management Authority

Introduction

- 1.1 On 2 June 2011, the Committee commenced an inquiry into biodiversity in a changing climate, in relation to nationally important ecosystems, with particular regard to:
- terrestrial, marine and freshwater biodiversity;
 - connectivity between ecosystems;
 - how biodiversity loss might affect human communities;
 - enhancing climate change adaptation;
 - sustainable use of natural resources and ecosystem services;
 - adequacy of current governance arrangements; and
 - enhancing community engagement.¹
- 1.2 As noted in the first interim report,² the Committee considered that such broad terms of reference necessitated an extensive inquiry process. In order to effectively inquire into such a comprehensive topic, the Committee undertook a nationwide site inspection and public hearing program, and to present two interim reports prior to the production of its final report. The first interim report was presented in May 2012, and covered site inspections in Western Australia, Tasmania and New South Wales. This second interim report has been prepared in order to update the House, inquiry participants and the Australian public on the progress of the inquiry, and covers inspections at the following sites:

1 The inquiry was referred to the Committee jointly by the Minister for Sustainability, Environment, Water, Population and Communities, and the Minister for Climate Change and Energy Efficiency.

2 House of Representatives Standing Committee on Climate Change, Environment and the Arts, *Case studies on biodiversity conservation: volume 1*, May 2012, p. 1; House of Representatives, *Debates*, no. 8, 28 May 2012, pp. 5631-34.

- Western Port and the Melbourne Museum, in Victoria;
 - the Coorong, Lower Lakes and Murray Mouth region, and Greenfields Wetlands, in South Australia;
 - Kakadu National Park in the Northern Territory; and
 - the Wet Tropics of Queensland World Heritage Area and Reef HQ Aquarium, in Queensland.
- 1.3 Throughout its site inspection program, the Committee had the opportunity to consider examples of community engagement, innovative ways of sustainably using natural resources, and complex governance arrangements, in the context of some of Australia's nationally significant ecosystems. The Committee has drawn these case studies from submissions and evidence received throughout the inquiry.
- 1.4 Since the inquiry was advertised on 2 June 2011, 87 submissions, 13 supplementary submissions and 60 exhibits have been received. To date, the Committee has carried out inquiry activities in each Australian state and territory, including 13 public hearings and eight site inspections.

Scope of this report

- 1.5 As noted earlier, this report provides an update on the progress of the inquiry since the presentation of the first interim report in May 2012, by reviewing site inspections undertaken by the Committee since then.
- 1.6 As with the first interim report, the Committee has declined to make specific recommendations at this stage. Conclusions presented are preliminary and may only refer to specific sites visited. It is anticipated in its final report that the Committee will deliberate on how these preliminary conclusions, together with evidence gathered during the inquiry, may form more comprehensive recommendations.
- 1.7 The remainder of the report is divided into four chapters, with each focusing on a region or site inspection program. The report describes the sites inspected, the ecosystem types, and issues that arose upon inspection and in briefings with local experts. A glossary including some of the pertinent, and perhaps more scientific, terms that have arisen during the site inspections, is included at the back of the report.

Museums and bird habitats in Victoria

- 2.1 The Committee visited various sites in and around Melbourne on 3 May 2012. The Committee inspected Melbourne Museum's natural history collections, research facilities, and exhibition spaces. The Committee also received briefings from BirdLife Australia and inspected shorebird habitats around Western Port.
- 2.2 The site inspections in Victoria provided the Committee with an opportunity to consider the significance of migratory bird populations, the threats to shorebird habitats, and the possible effects of climate change. The Committee also gathered evidence on the role of natural history museums in collecting, storing and communicating information on biodiversity, and heard about innovations in technology that will make it easier to engage the community in issues of biodiversity.

Committee activities

Melbourne Museum

- 2.3 The Melbourne Museum is home to Australia's second largest museum collection, with over 15 million objects dating back to 1857. It has more visitors and research staff than any other Australian museum.¹
- 2.4 The Committee inspected Melbourne Museum's extensive natural history collection and research facilities, and received briefings from senior staff. The visit gave the Committee the opportunity to inspect the Museum's private collections of marine and terrestrial invertebrates, mammals, birds,

1 Museums Board of Victoria, *Annual report 2010–11*, Museum Victoria, 2011, p. 2; Discussions with museum staff during site inspections, 3 May 2012.

and bird eggs (oology), as well as the Museum's tissue bank. In the public area, the Committee was shown through the Science and Life Gallery, which highlighted the key role of both static and interactive exhibits in educating the community about Australia's unique biodiversity.

- 2.5 Throughout its visit, the Committee met with and received briefings from the following representatives from Melbourne Museum:
- Dr Robin Hirst, Director, Collections, Research and Exhibitions; and
 - Dr Mark Norman, Head of Sciences.
- 2.6 The Committee also met with other Museum staff during the visit, including:
- Dr Jane Melville, Senior Curator, Terrestrial Vertebrates;
 - Dr Timothy O'Hara, Deputy Head of Sciences – Marine;
 - Ms Wendy Roberts, Reef Watch Co-ordinator; and
 - Dr Joanna Sumner, Manager, Genetic Resources.
- 2.7 Issues of particular interest to the inquiry which were examined during the visit included the role of museums in providing essential research and monitoring services for biodiversity conservation, and the capacity of museums to engage with the public through citizen science programs, new technologies, and public exhibits.

Figure 2.1 Members inspecting a marine specimen collection at Melbourne Museum



Photograph courtesy of committee secretariat

BirdLife Australia

- 2.8 BirdLife Australia is a not-for-profit, non-government organisation dedicated to the conservation of native birds. It seeks to do this through the study and management of birds and their habitats, and through the education and engagement of members of the public.² BirdLife Australia was formed in 2012 through the merger of Birds Australia and Bird Observation and Conservation Australia, established in 1901 and 1905 respectively.
- 2.9 During its visit to Victoria, the Committee visited the offices of BirdLife Australia and received briefings on the existing threats to bird species and how these were likely to be affected by climate changes. Accompanied by representatives of BirdLife Australia, the Committee travelled to Hastings, on Western Port, where it inspected salt marsh communities affected by development pressures around Warrine Park. The Committee also visited Koo Wee Rup lookout, which provided an appropriate backdrop for further discussions on issues affecting the area's significant shorebird populations.
- 2.10 During its visit to BirdLife Australia offices and Western Port Bay, the Committee received briefings from:
- Dr Graeme Hamilton, Chief Executive Officer, BirdLife Australia;
 - Dr Jenny Lau, Head of Conservation, BirdLife Australia;
 - Dr Birgita Hansen, Research Fellow, University of Ballarat; and
 - Mr Ken Gosbell, Member, Australasian Wader Studies Group.
- 2.11 During the briefings, the Committee received the following documents from BirdLife Australia representatives:
- *The State of Australia's Birds 2007: Birds in a Changing Climate*, Birds Australia, December 2007.
 - *Australia's Important Bird Areas: Key Sites for Bird Conservation*, Birds Australia, October 2009.
 - *Improving Our Understanding of Waterbirds in Western Port*, Central Coastal Board, Melbourne, August 2011.
 - *Dramatic Declines of Australia's Migratory Shorebirds – Indicative Data*, BirdLife Australia, 2012.

2 Birds Australia, *Submission 40*, p. 1.

- ‘Birds in the Red’, *Decision Point*, 59, May 2012, pp. 8–9.
 - *Stilt: The Journal for the East Asian–Australasian Flyway*, 60, October 2011.
 - *Birds and Climate Change*, briefing notes, BirdLife Australia.
 - Central Coast Board brochure titled: *Shorebirds in Western Port*.
 - BirdLife Australia brochures titled: *Discover Birdlife; Your Support Makes a Huge Difference; Your Time Matters to Us; and Protecting Our Beach-nesting Birds*.
- 2.12 BirdLife Australia provided the Committee with an overview of the threats facing Australia’s bird populations, in addition to observed and anticipated effects of the changing climate. The Committee was specifically informed about the threats facing shorebirds in the Western Port area, where sea level rises threatened to swamp much of the existing habitat used for feeding and roosting. The Committee also heard about the impact on migratory shorebirds of industrial developments taking place in feeding grounds overseas.

Issues explored in Victoria

- 2.13 The Committee’s site inspection activities focused on the role of natural history museums in collecting and disseminating information on Australia’s biodiversity, and the impacts of climate change on shorebirds and their habitats. Briefings with representatives of Melbourne Museum and BirdLife Australia highlighted the evolving role for new technologies in effectively engaging the public on issues relating to biodiversity and climate change. The role of collaboration and cooperation – both within Australia and internationally – was also raised during the course of the Committee’s site inspections. These are discussed in further detail below.

Biodiversity research and monitoring: a role for museums

- 2.14 Natural history museums have an important role to play in biodiversity research and monitoring. During its inspection of the Melbourne Museum, the Committee heard about the invaluable resources that museum collections provide for important biological research. Museums also have an important role in species identification and distribution monitoring.
- 2.15 As noted earlier, the Melbourne Museum collection of over 15 million items includes examples of rare and extinct species, and specimens collected from populations that are now locally extinct. The Committee

heard that gene technology has enabled new types of research to be carried out on collection specimens. DNA technology, for example, has enabled comparisons between the genetic composition of locally extinct species with current populations, and has made it possible for the Museum to identify the source of previously unknown specimens. The Museum's tissue bank, in which animal tissues such as hearts, livers and feathers are frozen for future research, is also contributing to the Museum's research capacity. Similarly, field notebooks in the Museum's collection can be used by scientists to replicate past experiments, thereby allowing an assessment of changes in biodiversity over time.

- 2.16 Like many other public museums, the Melbourne Museum's collections are available for use by researchers from all over the world. The Committee was informed that most research at the Museum is undertaken by visiting researchers from other institutions, supplementing research carried out by directly employed staff. Current areas of research include: taxonomy, systematics, community ecology, phylogeny, and biogeography, in both marine and terrestrial biosciences; and conservation and resource management.³ Members of the public are able to draw on the expertise of the researchers by sending in specimens or photographs to the Museum's Discovery Centre for identification.⁴
- 2.17 Melbourne Museum contributes to many collaborative research projects and programs.⁵ For example, the Museum is a partner in the National Environmental Research Program's Marine Biodiversity Hub, a Commonwealth Government initiative that provides 'scientific information and advice to support decision making in the marine environment'.⁶ The Museum's researchers also contributed to the global Census of Marine Life, a 10-year project completed in 2010 which involved 2700 scientists from more than 80 countries. The census aimed to assess the diversity, distribution and abundance of the world's marine species, and created a baseline against which to measure changes to marine
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3 See Museum Victoria, 'Terrestrial environments', <<http://museumvictoria.com.au/collections-research/our-research/sciences/terrestrial-environments/>> viewed 23 May 2012; Museum Victoria, 'Marine sciences', <<http://museumvictoria.com.au/collections-research/our-research/sciences/marine-biology/>> viewed 23 May 2012.

4 Museum Victoria, 'Identifications', <<http://museumvictoria.com.au/discoverycentre/ask-us-a-question/identifications/>> viewed 23 May 2012.

5 Collaboration is formally carried out under the banner of Museum Victoria, which is the organisation responsible for operating Melbourne Museum and two other museums.

6 National Environmental Research Program, 'NERP Marine Biodiversity Hub', <<http://www.nerpmarine.edu.au/>> viewed 23 May 2012.

environments. The census also led to the discovery and formal description of more than 1200 new species.⁷

- 2.18 The Committee also heard that Museum experts provide advice to the Australian Quarantine and Inspection Service, and contributed to the proposed development of a national system for dealing with marine pests.

Committee comment

- 2.19 The Committee recognises and appreciates the important work that natural history museums do to provide governments, the scientific community, and the general public with a better understanding of biodiversity issues. The Melbourne Museum's collections and research facilities greatly exceed the relatively small amount that can be put on public display at any one time, a fact clearly demonstrated to the Committee throughout the site inspection.
- 2.20 During the course of the inquiry, participants have commented on the need for reliable baseline data to enable the effective monitoring of changes in biodiversity over time. Such data are necessary for an adaptive approach to be taken to biodiversity management. The Committee's visit to Melbourne Museum highlighted the important role of natural history museums in carrying out research to establish this baseline data and monitor changes over time.
- 2.21 Natural history museums need to be adequately funded in light of the important identification, research and monitoring work they carry out. The Committee heard about instances where funding for equipment had been secured, without funding for salaries to ensure the equipment could be operated. The Committee is also aware that museums may need to look increasingly to private and philanthropic sources of funding. A balance needs to be struck with respect to funding for natural history museums, taking into account competing demands on finite government resources, as well as acknowledging the public good delivered by such museums.
- 2.22 In the absence of a national natural history museum, state-based museums, including Melbourne Museum, have largely operated independently. The Committee acknowledges the role of the Council of Australasian Museum Directors, an association for leaders of national, state and regional museums in Australia and New Zealand, and Museums Australia, the national advocacy and professional body for the museum sector. The extent of cooperation and collaboration through these bodies
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⁷ Census of Marine Life, 'About the census: a decade of discovery', <<http://www.coml.org/about-census>> viewed 23 May 2012.

is, however, limited. The Committee believes there is an increasing need for greater coordination between Australia's state-based museums in research and information-sharing, particularly in light of the national scale of threats to Australia's biodiversity associated with climate change. The Online Zoological Collections of Australian Museums (OZCAM, discussed below) and the Atlas of Living Australia (a central online repository of data about Australia's species) are welcome initiatives towards this end, and the Committee supports the development of further collaborative projects in the future. Increased coordination could reduce unnecessary duplication in research and increase the efficiency and effectiveness of museums' efforts.

New technologies for community engagement

- 2.23 At the Melbourne Museum, the Committee was briefed on several electronic tools being used to better engage the community in biodiversity issues and the work of the museum. The Committee observed camera and computer equipment that is being used to convert collection specimens into digital format, making them accessible in more ways than was previously possible, such as through the Museum's website.
- 2.24 The Field Guide to Victorian Fauna is an example of a smart phone and tablet application that has been developed by the Museum. It contains detailed descriptions and high quality images of over 700 animal species found in Victoria.⁸ The Museum plans to add more species and update descriptions on an ongoing basis, and the Committee heard that there are also plans to expand the application to cover fauna from all across Australia.
- 2.25 The OZCAM is a collaborative project in which the digital records of nine Australian natural history museums are being made available online. This aggregation of museum records means that data is available to researchers and members of the public Australia-wide, beyond the geographic regions covered by individual museums. The OZCAM has also contributed data to the Atlas of Living Australia, and to significant international initiatives such as the Global Biodiversity Information Facility and the Ocean Biogeographic Information System.⁹

8 See Museum Victoria, 'Museum Victoria's field guide to Victorian fauna: now available on the app store', <<http://museumvictoria.com.au/discoverycentre/mv-field-guide-app/>> viewed 23 May 2012.

9 OZCAM, 'About OZCAM', <<http://www.ozcam.org.au/ozcam-data/>> viewed 23 May 2012.

2.26 The Committee was impressed by the range and quality of interactive exhibits at 'Wild', a current exhibition in the Science and Life Gallery of the Melbourne Museum's public area. The exhibition features more than 750 preserved animals from around the world,¹⁰ a sample of the Museum's vast zoological collection. The Committee inspected moveable touch screen devices that present images and video of each species, supplemented by information on conservation and the impacts of climate change and human activity. The Committee also inspected an interactive 'touch table' display that illustrates the migration of red-necked stints from Victoria to their breeding grounds in Siberia, highlighting the importance of adequate food supplies and habitat along the migration path to ensure the birds successfully make the journey. The Committee heard that the Museum aims to get the general public, particularly young people, interested in and excited about species, and therefore to improve their appreciation and understanding of the importance of biodiversity.

Figure 2.2 Members inspecting interactive devices in Melbourne Museum's *Wild* exhibition



Photograph courtesy of committee secretariat

10 Museum Victoria, 'Wild: amazing animals in a changing world', <<http://museumvictoria.com.au/melbournemuseum/discoverycentre/wild/>> viewed 24 May 2012.

Committee comment

- 2.27 The Committee observed visiting school children and families actively engaging with Melbourne Museum's biodiversity-related exhibitions. The interactive nature of the exhibitions provided visitors with an immersive experience and the Committee was pleased to see the level of visitor engagement with various exhibits.
- 2.28 The Committee notes the exciting opportunities offered by information technologies to enhance connections to young people in particular, to stimulate their interest in biodiversity, to encourage an appreciation of the value of biodiversity, and to perhaps inspire careers in the natural sciences. New information technologies also have the potential to improve collaboration in the science community, both nationally and internationally, and open up the information held by museums to a whole new audience, including citizen scientists.

Citizen science

- 2.29 The Committee's meetings with representatives from both Melbourne Museum and BirdLife Australia highlighted the contributions of community volunteers in gathering data on biodiversity. Furthermore, the Committee was advised that the involvement of these 'citizen scientists' helps research and conservation organisations engage sections of the community in issues relating to biodiversity and climate change.
- 2.30 Under the Museum Victoria banner, Melbourne Museum coordinates and participates in several programs that draw on input from citizen scientists. For example, Reef Watch Victoria is a not-for-profit project run in partnership with the Museum that 'encourages divers and snorkelers to monitor marine life at their favourite dive sites'.¹¹ Volunteer divers are provided with reef monitoring kits to help monitor and report on seasonal changes in species, special natural events, pest species, and illegal activities. The project aims to develop local knowledge about marine habitats and species, enhance the extent to which the community values the marine environment, and contribute to better management and conservation policies. Survey data, once validated, are made available to others through the project's website.¹²

11 Reef Watch Victoria, 'About Reef Watch', <<http://www.reefwatchvic.asn.au/AboutUs.htm>> viewed 24 May 2012.

12 Reef Watch Victoria, 'About Reef Watch', <<http://www.reefwatchvic.asn.au/AboutUs.htm>> viewed 24 May 2012.

- 2.31 The Committee was informed that Museum Victoria is also looking at establishing the Victorian node of the Range Extension Database and Mapping Project (REDMAP). The REDMAP, initiated in Tasmania, is a citizen science project in which members of the public, particularly fishermen, are invited to report observations of marine species that are found outside their known distribution area. Sightings are verified by experts, where possible, and the data enable observations about how biodiversity is changing over time, including the shifting of species' ranges. The information collected is mapped and displayed on the REDMAP website.¹³ At a public hearing in Hobart in January, the Committee was informed that REDMAP is in the process of being expanded nationally, with the national launch expected in late 2012.¹⁴
- 2.32 BirdLife Australia depends on its network of thousands of amateur birdwatchers to monitor the abundance and distribution of bird species around Australia. Volunteer birdwatchers take part in regular bird surveys and contribute their data to the Atlas of Australian Birds – one of the few long-term Australian programs for monitoring biodiversity and one of BirdLife Australia's most important projects. As at May 2012, there were 13 381 registered contributors, known as Atlassers, of whom 3872 were classified as 'active'.¹⁵
- 2.33 BirdLife Australia informed the Committee about the *Action Plan for Australian Birds 2010*, which follows earlier action plans in 1990 and 2000. The 2010 plan 'analyses the status of all the species and subspecies of Australia's birds to determine their risk of extinction' and identified 238 threatened or extinct bird taxa.¹⁶ The Committee heard that BirdLife Australia is using the data to identify the most vulnerable species and inform conservation programs, by monitoring current bird distributions, predicting vulnerabilities to climate change, and anticipating range changes.

13 REDMAP, 'What is Redmap?', <<http://www.redmap.org.au/about/What-is-redmap/>> viewed 24 May 2012.

14 Dr Gretta Pecl, Institute for Marine and Antarctic Studies, *Transcript of evidence*, 31 January 2012, pp. 18–19.

15 BirdLife Australia, 'Birddata – The Atlas of Australian Birds', <<http://www.birddata.com.au/atlasstats.do>> viewed 24 May 2012.

16 Birds Australia, 'New action plan for Australian birds', <<http://www.birdsaustralia.com.au/homepage-news/new-action-plan-for-australian-birds.html>> viewed 24 May 2012.

Committee comment

- 2.34 The Committee notes that citizen science is increasingly being recognised as a way of tapping into the local expertise of amateur scientists and the broader community. The Committee is pleased that citizen science initiatives are being embraced by some of the key organisations involved in biodiversity conservation. With appropriate quality controls in place, citizen science can contribute to a more detailed understanding of Australia's biological diversity, and related changes over time.
- 2.35 In addition to generating valuable data, citizen science delivers the benefit of increasing the community's awareness of biodiversity issues and engagement in conservation efforts. Citizen science initiatives have the capacity to form a vital link between the community, scientists, and decision-makers.

Climate change and other threats to Australian birds

- 2.36 BirdLife Australia advised the Committee that birds are good indicators of environmental health, due to their relative prominence in ecosystems. The Committee was provided with an overview of the major threats to Australian bird populations and their habitats, including: land clearing and habitat fragmentation; altered fire regimes; over-extraction of water from rivers; loss of wetlands; feral predation; grazing; and fishing practices. BirdLife Australia expects climate change to exacerbate these threats, as well as introduce new threats.¹⁷
- 2.37 Aside from interactions with these existing threats, the Committee heard that climate change itself is expected to have, and is already having, direct impacts on many bird species. The most notable effects to date have been changes to the distribution of bird species, changes which have been observed in the absence of any other known threatening processes. In response to shifting food sources due to temperature increases, many birds appear to have extended their ranges further south in general, and upslope in alpine areas. The Committee was advised that the cumulative loss of bird habitat over many decades, particularly in southeastern and southwestern Australia, has impaired the ability of birds to adapt to the direct effects of climate change.

17 BirdLife Australia, *Birds and climate change*, briefing notes.

- 2.38 At a public hearing in Melbourne on 4 May 2012, BirdLife Australia told the Committee that birds are particularly vulnerable to extreme heatwaves, which are predicted to increase in frequency and severity due to climate change.¹⁸ The Committee was also informed that birds are particularly sensitive to changes in habitat and food availability resulting from climate change.¹⁹
- 2.39 The Committee was informed about the significance of migratory shorebirds, bird species that make annual round trip migrations between breeding grounds in the northern hemisphere and non-breeding areas in the south. Under various international agreements, Australia has an obligation to protect migratory birds and their habitats.²⁰ Western Port, southeast of Melbourne, is one of Victoria's most important sites for migratory shorebirds. It is recognised as a wetland of international significance under the Ramsar Convention,²¹ and is regularly used by around 20 000 birds, including around 10 000 shorebirds and 10 000 waterfowl.²²
- 2.40 During its visit, the Committee learned there are four major threats to the birds of Western Port:
- Disturbance, particularly to roosting sites, by humans, pets, and watercraft;
 - habitat loss, particularly due to development and erosion;
 - predation by feral animals, including cats, foxes, and black rats; and
 - climate change.
- 2.41 With respect to climate change, sea level rises are expected to have a significant impact on intertidal foraging sites and high tide roosting sites in Western Port. Under a sea level rise of 0.8 metres, as projected for 2100 under some climate change scenarios, the Committee heard that more than 90 per cent of existing high tide roosting sites would be
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18 Mr Charlie Sherwin, BirdLife Australia, *Transcript of evidence*, 4 May 2012, p. 14.

19 Mr Sherwin, BirdLife Australia, *Transcript of evidence*, 4 May 2012, p. 14.

20 Department of Sustainability, Environment, Water, Population and Communities, 'Migratory waterbirds', <<http://www.environment.gov.au/biodiversity/migratory/waterbirds/index.html>> viewed 19 October 2012.

21 Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987.

22 Central Coastal Board, *Improving our understanding of waterbirds in Western Port*, CCB, Melbourne, August 2011, p. 2.

inundated. While some adaptation may be possible under natural conditions, in many sites coastal development and artificial levee banks will prevent opportunities for the shoreline to shift in response to sea level rises. At Hastings, the Committee examined the succession of different vegetation types in the intertidal zone, from mangroves through to narrow strips of saltmarsh, grasslands, and tea trees, all set immediately against a road and housing development. It was apparent that with even a relatively modest sea level rise, shorebird foraging in the area would be severely restricted.

Figure 2.3 Photograph of remnant coastal wetland in Western Port illustrating the potential pressures on habitat from nearby development



Photograph courtesy of committee secretariat

2.42 BirdLife Australia has initiated several projects to help improve the resilience of bird populations to climate change. These include:

- *Shorebirds 2020*, which aims to raise community awareness of the importance of tidal ecosystems, improve information gathering and seek protection for critical shorebird areas threatened by human development;
- *Woodland Birds for Biodiversity*, which aims to ‘improve on-ground management and protection of woodland habitat’; revegetate and restore habitat to improve its connectivity and magnitude; and monitor the impacts of climate change on woodland birds; and

- *Beach-nesting Birds*, which focuses on improving the management of nesting sites, encouraging change in the behaviour of beach users, and modelling the impacts of sea level rises on relevant habitats.²³

Committee comment

- 2.43 The Committee notes the vulnerability of bird species in particular to the effects of climate change – both in isolation and when combined with the range of existing stressors on birds and their habitats.
- 2.44 The Committee recognises the complexities associated with efforts to conserve bird habitats, particularly where shorebird habitats face additional pressures due to coastal developments. Nevertheless, the Committee welcomes efforts to protect key bird habitats and to build the resilience of birds to climate change impacts. Indeed, the Committee is aware of recent research suggesting that revegetation efforts can improve bird-related biodiversity in woodland ecosystems.²⁴

International cooperation on migratory birds

- 2.45 As noted above, Western Port is home to many migratory shorebirds, including the red-necked stint, the eastern curlew, the curlew sandpiper, the great knot, and the red knot. Many of these bird species breed in the Arctic during the northern summer then migrate up to 12 000 kilometres to spend the annual non-breeding season in southern Australia's intertidal wetlands. The Committee was informed that over 30 years' worth of data collected regularly by volunteers at sites around Western Port suggest a concerning trend, with nearly all migratory shorebird species declining in numbers. Species that have seen particularly dramatic declines include the eastern curlew, the curlew sandpiper and the red knot.
- 2.46 The major route taken by these birds during their migration from the Arctic to southern Australia is known as the East Asian–Australasian Flyway.²⁵ The Committee was advised that the absence of changes to

23 BirdLife Australia, *Birds and climate change*, briefing notes.

24 DB Lindenmayer, AR Northrop-Mackie, R Montague-Drake, M Crane, D Michael, S Okada and P Gibbons, 'Not all kinds of revegetation are created equal: revegetation type influences bird assemblages in threatened Australian woodland ecosystems', *PLoS ONE*, 7(4): e34527. doi:10.1371/journal.pone.0034527, 2012, <<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0034527>> viewed 8 September 2012.

25 Central Coastal Board, *Improving our understanding of waterbirds in Western Port*, CCB, Melbourne, August 2011.

Australian shorebird sites in recent years suggested that the species declines were attributable to changes outside Australia.²⁶

- 2.47 The Committee was informed that the loss of habitat in East and South East Asia is suspected to be the primary cause of the declines in Australia's migratory shorebird numbers. Tidal mudflats around the Yellow Sea are key stop-over sites for many birds on the East Asian-Australasian Flyway, and access to adequate food sources in these areas is essential for birds to continue travelling the long distance to their Arctic breeding grounds. The Committee heard that between 50 and 60 per cent of the tidal zone around the Yellow Sea has been reclaimed, and BirdLife Australia provided several examples of recent large scale industrial developments on sites which were once important feeding grounds.
- 2.48 It was suggested that, although Australia has bilateral agreements in place with the governments of Japan, China and the Republic of Korea for the protection of migratory birds,²⁷ the agreements have not been entirely effective in preventing the destruction of key stop-over habitats.

Committee comment

- 2.49 Given that climate change is expected to provide an even more challenging set of circumstances for bird species, the Committee considers there would be benefits in mitigating other pressures on migratory birds wherever possible. The Committee therefore notes concerns about the adequacy of international agreements for the protection of migratory bird habitats and will consider this matter carefully in the context of its inquiry.

Concluding remarks

- 2.50 Having received evidence from other museums at public hearings held earlier in the inquiry process, the Committee was pleased to have the opportunity to visit a natural history museum in Melbourne. Highlights of the visit included seeing firsthand the scope of the Melbourne Museum's collections and research facilities, and hearing about how technological

26 Australasian Wader Studies Group, *Dramatic declines of Australia's migratory shorebirds – indicative data*, BirdLife Australia, 2012.

27 The agreements are respectively known as the Japan–Australia Migratory Bird Agreement (JAMBA), the China–Australia Migratory Bird Agreement (CAMBA) and the Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA).

advances are changing the way in which the museum conducts its research and engages with visitors and the general public.

- 2.51 Noting the importance of birds as key indicators of environmental health, the Committee appreciated the opportunity to inspect key shorebird habitat in Western Port. The site inspection highlighted the vulnerability of birds to existing threats and the anticipated effects of climate change.
- 2.52 The Committee wishes to record its thanks to Melbourne Museum and BirdLife Australia, whose representatives provided invaluable assistance and information throughout the Committee's site inspections in Victoria.

3

Water and biodiversity in South Australia

- 3.1 As the driest state in the driest inhabited continent in the world,¹ South Australia received considerable attention at the height of the drought experienced by southeastern Australia from 1997 to 2009, the worst drought in the 110-year instrumental record.² The impact on the Coorong, Lower Lakes and Murray Mouth (CLLMM) region, in particular, was a major focal point. Located at the downstream end of the Murray–Darling River system, there was concern that the drought, combined with the over-allocation of water resources upstream, had severely compromised the region’s internationally significant biodiversity.
- 3.2 Some of the environmental impacts of the drought have abated since 2009. However, many of the challenges for the region remain, and these were part of the focus of the Committee’s site inspections in the CLLMM region on 16 May 2012.
- 3.3 Apart from this focus, the Committee was interested to see the development of innovative practices for the sustainable use of water resources and the protection of biodiversity assets. On 17 May 2012, the Committee inspected the constructed Greenfields Wetlands, which contribute to addressing concerns about the availability of water from the River Murray and the potential ecological impacts of stormwater run-off on marine ecosystems.

1 Government of South Australia, ‘Importance of water’, <<http://www.sa.gov.au/subject/Water,+energy+and+environment/Water/Water+resources+in+SA/Importance+of+water>> viewed 9 October 2012.

2 B Timbal, ‘The continuing decline in South-East Australian rainfall: update to May 2009’ in PA Sandery, T Leeuwenburg, G Wang and AJ Hollis (eds), *CAWCR Research Letters*, issue 2, July 2009, Centre for Australian Weather and Climate Research, Melbourne, 2009, pp. 4–11, <http://www.cawcr.gov.au/publications/researchletters/CAWCR_Research_Letters_2.pdf> viewed 16 October 2012.

- 3.4 Over these two days, the Committee's site inspection program in South Australia addressed matters relating to freshwater, marine and terrestrial biodiversity; impacts of biodiversity loss on human populations; the sustainable use of natural resources; and community engagement.

Committee activities

The Coorong, Lower Lakes and Murray Mouth region

- 3.5 The CLLMM region is approximately 142 500 hectares in size and contains a diverse range of freshwater, estuarine and marine habitats.³ The region is a Ramsar site, known as the Coorong and Lakes Alexandrina and Albert (Lower Lakes) Wetland of International Importance. It is an area of high biodiversity value, and home to many endemic plant and animal species. The Coorong and Lower Lakes have been recognised by BirdLife International as Important Bird Areas, given their significance for resident waterbird, migratory shorebird, and orange-bellied parrot populations.⁴ The Coorong also acts as an important refuge for animals during times of drought.
- 3.6 The Ramsar site covering the region is currently used for several purposes, including conservation, recreation, water storage and extraction, grazing and cropping, and urban and residential development. Local employment is mainly in the agriculture, viticulture, fishing, manufacturing, and tourism industries.⁵
- 3.7 Years of drought and over-use of water had left these 'internationally significant wetlands dry, the lakes disconnected, communities and industries under significant stress,' and native species threatened.⁶

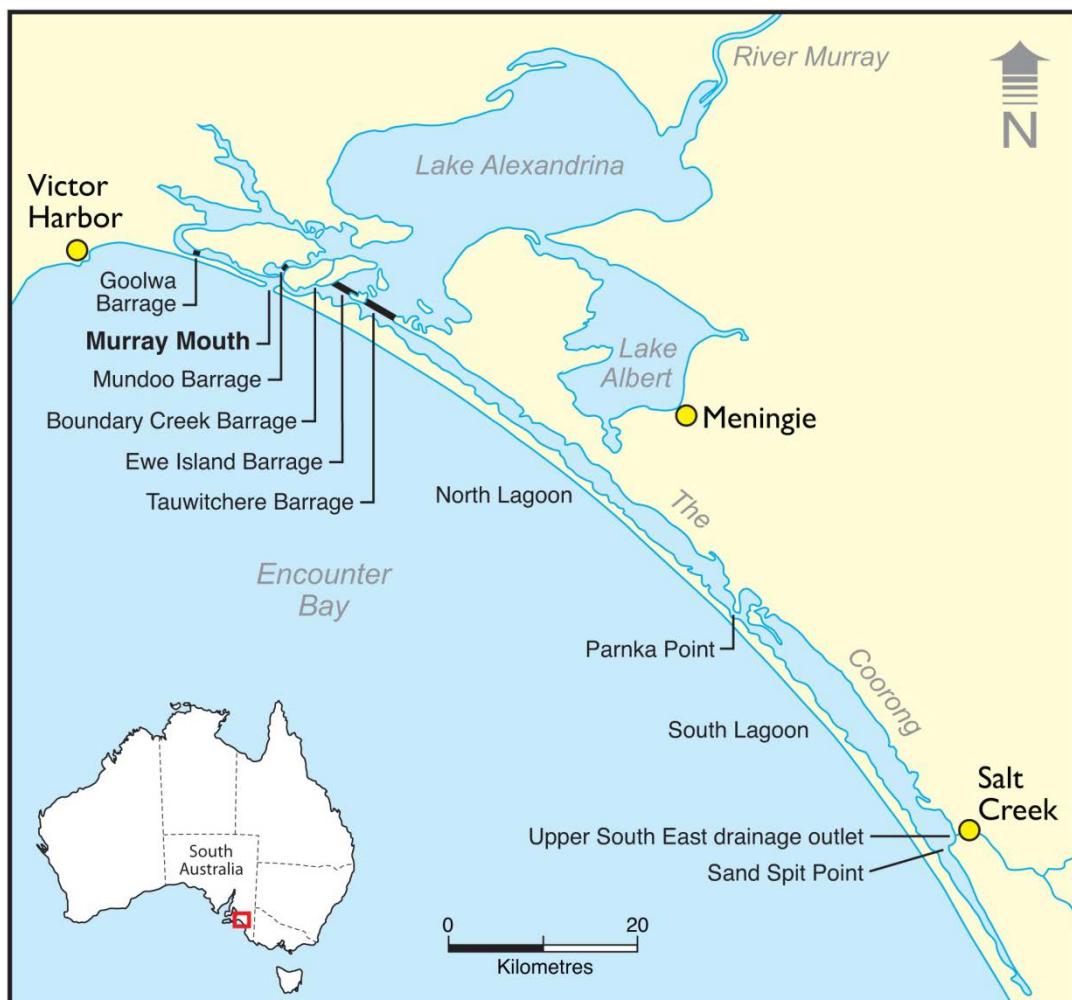
3 South Australian Department of Environment, Water and Natural Resources (DEWNR), 'Coorong, Lower Lakes and Murray Mouth region', <http://www.environment.sa.gov.au/conservation/rivers_wetlands/coorong_lower_lakes_murray_mouth> viewed 16 October 2012.

4 G Dutson, S Garnett and C Gole, *Australia's Important Bird Areas: Key Sites for Bird Conservation*, Birds Australia (RAOU) Conservation Statement No. 15, October 2009, pp. 32–3.

5 DEWNR, 'Coorong, Lower Lakes and Murray Mouth region', <http://www.environment.sa.gov.au/conservation/rivers_wetlands/coorong_lower_lakes_murray_mouth> viewed 16 October 2012.

6 Department for Environment and Heritage (DEH), *Securing the future: a long-term plan for the Coorong, Lower Lakes and Murray Mouth*, Government of South Australia, Adelaide, 2010.

Figure 3.1 Location of the Coorong, Lower Lakes, Murray Mouth, and Barrages



Source Modified from: S Lamontagne, K McEwan, I Webster, P Ford, F Leaney and G Walker, Coorong, Lower Lakes and Murray Mouth: knowledge gaps and knowledge needs for delivering better ecological outcomes, *Water for a Healthy Country National Research Flagship*, CSIRO, Canberra, 2004, fig. 1, p. 3

3.8 The Committee visited six distinct sites in the CLLMM region—which are briefly described below—and gained an insight into some of the complexities associated with natural resource management in the region. Throughout the site inspection program, the Committee was accompanied by Mr Russell Seaman, Environmental Advisor with the South Australian Department of Environment, Water and Natural Resources (DEWNR).⁷ At each site, Mr Seaman provided briefings which focused on: the region's biodiversity values; ongoing and climate change-related threats to biodiversity; DEWNR initiatives; and the importance of community engagement in natural resource management.

⁷ On 1 July 2012, the South Australian Department of Environment and Natural Resources became the Department of Environment, Water and Natural Resources (DEWNR). For consistency, the latter title is used throughout this report.

3.9 During the inspections, the Committee received the following documents from the DEWNR:

- *BushBids Murray Plains and Rangelands: Woodland*, South Australian Murray–Darling Basin Natural Resources Management Board.
- *Applying a climate change adaptation decision framework for the Adelaide–Mt Lofty Ranges Natural Resource Management Board*, South Australian Department of Water, Land and Biodiversity Conservation.

Lakes Alexandrina and Albert

3.10 The River Murray, Australia's longest river, terminates in South Australia at the Southern Ocean, having passed through Lake Alexandrina, the Murray estuary and, finally, the Murray Mouth. Lake Albert is a terminal lake connected to Lake Alexandrina by a narrow channel. Lakes Alexandrina and Albert, collectively referred to as the Lower Lakes, are comprised of fresh to brackish and saline waters, and support significant biodiversity, including threatened bird species such as the orange-bellied parrot, Australasian bittern, and fairy tern.⁸

3.11 During the site inspections of the Lower Lakes, the Committee was briefed on local biodiversity values, threats to biodiversity including land use and climate change, and some of the DEWNR's relevant climate adaptation measures.

Clayton Bay and Dunn's Lagoon

3.12 Clayton Bay is located on the Lower Murray River. Dunn's Lagoon (also known as Clayton Wetland) is a back basin of Lake Alexandrina and located on the east side of the township of Clayton. It is a large, open, permanent wetland, and is relatively shallow in most parts. The wetland has three main connections with Lake Alexandrina. These broad, shallow inlets incorporate three islands including Goose Island to the west and Goat Island to the east. Water levels in the wetland fluctuate in accordance with water levels in Lake Alexandrina.

3.13 Dunn's Lagoon spans several land tenures including private and council land. The wetland is managed by a stakeholder group and is a popular place for recreational pursuits such as boating. The private land surrounding the wetland is used primarily for grazing.

8 BirdLife Australia, 'Birddata – Important Bird Area: Lakes Alexandrina & Albert', <http://www.birddata.com.au/iba.vm> viewed 27 September 2012.

3.14 During the inspection of Dunn's Lagoon, the Committee heard that the area is one of the top five ecologically important sites in the CLLMM region. Indeed, areas such as Dunn's Lagoon are considered the drivers of the ecology of Lakes Alexandrina and Albert.

Milang Lakes Hub

3.15 The Lakes Hubs at Milang and Meningie were established in 2009 and 2010 respectively, to help disseminate information and provide collaborative links between government and local communities. The Hubs provide a conduit between government and community members to deliver environmental restoration projects in the region.

3.16 The Lakes Hub at Milang is an initiative of the Milang and District Community Association and is part of the South Australian Government's Murray Futures program, funded by the Australian Government's Water for the Future initiative. The Committee visited the Milang Lakes Hub and received briefings from:

- Ms Karyn Bradford, Lakes Hub Executive;
- Ms Carole Richardson, Local Action Planning Coordinator; and
- Ms Gemma Cunningham, Community Engagement Manager, DEWNR.

3.17 At the Milang Lakes Hub, the Committee received the following documents:

- *Seeds to reeds: Lower Lakes Community Nurseries Newsletter*, 10th edition, Lakes Hub, March 2012.
- *Weekly Bulletin*, No. 96, Lakes Hub, 7 May 2012.
- *Local people, local issues, local action*, Goolwa to Wellington Local Action Planning Board Inc.
- *Development and implementation of a community engagement strategy for the Lower Lakes bioremediation and revegetation project, 2009–2011: Final report*, Milang & District Community Association Inc.

Wyndgate, Hindmarsh Island

3.18 Hindmarsh Island is located on the Lower Murray River, near the town of Goolwa. It is a popular tourist destination, and much of the land on the island is used for agricultural purposes.

- 3.19 The Committee visited the DEWNR office at Wyndgate on Hindmarsh Island, which is one of the sites from which Coorong National Park is currently managed, and received briefings from:
- Mr Tim Hartman, Ngarrindjeri Regional Authority; and
 - Mr Lachlan Sutherland, Ngarrindjeri Partnerships Coordinator, DEWNR.
- 3.20 At Wyndgate, the Committee received briefings on the natural and cultural values of the area, impacts of recent droughts and related management responses, and programs to engage Indigenous communities in biodiversity conservation and the co-management of national parks.

Goolwa Barrages

- 3.21 Hindmarsh Island has freshwater on its northern shore and saltwater on the southern shores. The waters are separated by a series of barrages, constructed between 1935 and 1940, which are intended to maintain a consistent water level in the lakes and to protect agricultural areas from exposure to saltwater.
- 3.22 The five barrages – often collectively referred to as the Goolwa Barrages – span the Goolwa, Mundoo, Boundary Creek, Ewe Island and Tauwitchere channels. The Committee travelled over some of the barrages and received briefings on the design of the structures, the importance of fishways and water flow to the ocean, and the state of the Coorong and Murray Mouth.

The Coorong and Murray Mouth

- 3.23 The Coorong is a long, shallow, brackish to hypersaline lagoon more than 100 kilometres long. It is separated from the Southern Ocean by a narrow sand dune peninsula. The Coorong has been one of Australia's most important sites for shorebirds, but decreased environmental flows in recent decades have led to declines in many species.⁹ Nevertheless, BirdLife International identifies more than a dozen globally-important bird species supported by the Coorong, including threatened species such as the orange-bellied parrot, fairy tern, Australasian bittern, and hooded plover.¹⁰

⁹ BirdLife Australia, 'Birddata – Important Bird Area: Coorong', <<http://www.birddata.com.au/iba.vm>> viewed 27 September 2012.

¹⁰ BirdLife Australia, 'Birddata – Important Bird Area: Coorong', <<http://www.birddata.com.au/iba.vm>> viewed 27 September 2012.

- 3.24 During its inspections of the Coorong and Murray Mouth, the Committee received briefings on the biodiversity values of the area, water management policies, and the effects of drought.

Figure 3.2 Committee members at one of the Goolwa Barrages



Photograph courtesy of committee secretariat

Greenfields Wetlands, Adelaide

- 3.25 The City of Salisbury is located on the northern fringes of Adelaide and, with approximately 130 000 residents, is the second largest local government community in South Australia. The City has experienced rapid residential and commercial growth and is South Australia's most productive manufacturing region.¹¹
- 3.26 The City of Salisbury has established a stormwater recycling program that provides business and community customers with non-potable water. This has contributed to reducing Adelaide's overall reliance on the River Murray to meet its water requirements, and has delivered biodiversity benefits for the area and for adjacent marine ecosystems.
- 3.27 Greenfields Wetlands, which the Committee inspected on 17 May 2012, is one of over 50 constructed wetlands that help the City manage its water supply and improve water quality. During its inspection, the Committee

¹¹ City of Salisbury, *Salisbury city plan 2020: sustainable futures*, City of Salisbury, Salisbury, South Australia, September 2008, p. 7.

was briefed by Mr Colin Pitman, General Manager, City Projects, City of Salisbury. The Committee received the following documents:

- City of Salisbury, *Water fact sheets*:
 - ⇒ *The Salisbury Wetlands*.
 - ⇒ *The Benefits of Our Wetlands*.
 - ⇒ *Frogs and Froglets*.
 - ⇒ *Little Wetland Critters*.
 - ⇒ *Managing Mosquitoes*.
 - ⇒ *Stormwater Treatment*.
 - ⇒ *Harvesting Our Stormwater*.
 - ⇒ *Monitoring Water Quality*.

3.28 During the inspection, the Committee heard about: the contribution of constructed wetlands to the sustainable use of natural resources; connectivity between ecosystems; and building resilience in ecosystems.

Issues explored in South Australia

3.29 As noted earlier, the Committee's inspections in South Australia included a focus on freshwater biodiversity and sustainable natural resource use, and the impacts of these on human communities. The Committee received extensive briefings on: the threats to the biodiversity of the CLLMM region and how resilience is being built into the region's ecosystems and associated human communities; natural resource management in a complex governance framework; and the benefits of constructed wetlands in an urban environment.

Threats to biodiversity in the CLLMM region

3.30 During its site inspection program, the Committee was informed that there had been record low river flows to the CLLMM region, particularly due to water management practices throughout the Murray–Darling Basin. The Committee heard that the levels of water extraction for human use throughout the basin had left insufficient water for the environment.

3.31 More recently, extended drought and the early impacts of climate change had added to the site's ecological stress. The drought had exacerbated the results of years of land clearing and intensive agricultural use in the region.

- 3.32 In addition, climate changes – particularly higher temperatures, less autumn and winter rainfall, and higher levels of atmospheric carbon dioxide potentially affecting the water consumption of plants – are expected to result in reduced run-off in the Murray–Darling Basin, leading to lower environmental flows in the CLLMM region.
- 3.33 Together, the existing threatening processes in the region have resulted in a range of biodiversity impacts, including habitat loss through the drying out of wetlands, competition from pest species, and exposure of acid sulfate soils. These were the focus of briefings the Committee received during site inspections in the region.
- 3.34 The Committee heard that falling lake levels and lack of flow over the barrages into the Coorong lagoon have resulted in reductions in vegetation, the disconnection and drying out of wetlands, reductions in threatened fish species numbers, and significant decreases in shorebird numbers.
- 3.35 The Committee inspected Dunn’s Lagoon, which featured in news reports in 2009, when the wetland dried out completely. Water flow was restored in April 2010. In the interim, however, marine worms had moved into the area and colonised any available hard substrate. They encrusted the shells of eastern long-necked turtles, resulting in the death and injury of many turtles. The worms also moved into plumbing and water supply systems, blocking and damaging pipes and resulting in significant public infrastructure costs.
- 3.36 The Committee examined and received briefings on sulfuric soils in the region. Although such soils are a naturally occurring phenomenon, their exposure to oxygen can produce sulfuric acid, which can have detrimental effects on wetlands. When many parts of the CLLMM system dried out during the recent drought, acid sulfate soils were exposed to the air and there were concerns about the potentially devastating effect this could have on the region’s biodiversity. Indeed, the Committee heard that, had the drought continued for another one or two summers, the entire region’s ecosystems would have been on the verge of collapse.

Committee comment

- 3.37 The Committee notes the high biodiversity values of the CLLMM region. It appreciates there are challenges posed by periods of drought and the pressures from human water use requirements, and recognises the likelihood of climate change exacerbating existing threats to the region’s biodiversity. As climate change introduces more uncertainty, effective

water management and biodiversity conservation policies will be essential for responding quickly to the region's needs.

- 3.38 Although river flows have increased in recent years, resulting in higher water levels reaching the CLLMM region, the Committee heard that many of the issues affecting the region remain. If these are not remedied or managed effectively, there could be serious and irreversible environmental impacts. It is likely that appropriate intervention and management will be even more pressing considerations in light of projected climate changes.

Enhancing the resilience of ecosystems

- 3.39 During its site inspections, the Committee heard about the complex hydrodynamics of the CLLMM system. The environmental management of the region is further complicated by the mosaic of ecosystems within and surrounding the region, including: mallee ecosystems; woodlands, including grassy and open woodlands; peat swamp forests; freshwater, estuarine, coastal, and marine ecosystems; and riverine ecosystems. The diverse range of ecosystem types necessitates distinct management plans for each segment of the system.
- 3.40 It was noted that there is very little ecological resilience in the CLLMM system, and that management strategies have therefore focused on increasing this resilience to prepare for fluctuating levels of water availability. The Committee heard about the South Australian Government's Coorong Lower Lakes Restoration Project, which also receives funding through the federal government's Water for the Future program. One of the goals of the restoration project is to enhance the resilience of the region through extensive, community-based revegetation programs. In 2012 the project will require 350 000 plants from 130 different local native species – including one nationally endangered.¹² As the Committee travelled around the region, it had the opportunity to see some of these revegetation sites.
- 3.41 The aims of the extensive revegetation program are to reduce evaporation and lower soil temperature, increase soil moisture, and remediate metals in the soil. The program also helps ensure there is adequate, connected habitat to act as refugia for local species during times of drought. Extensive planting programs increase the organic carbon inputs into the

12 This was an increase compared to previous years: 120 000 plants from approximately 15 species planted in 2010, and 240 000 plants from approximately 90 species planted in 2011.

system, encouraging the activity of sulfate-reducing bacteria, thereby reducing acidity.

- 3.42 The Committee was informed that the DEWNR also treated acid sulfate soils by applying limestone to neutralise some of the acidity. Engineering solutions, such as reinforcing barrages, also help prevent saltwater inundation, which would have profoundly negative effects on the ecosystems of the CLLMM region.
- 3.43 The Committee also heard about localised interventions, such as those employed when the creek at Wyndgate dried out and Murray hardyhead and Yarra pygmy perch fish species declined. These species were captured, bred, and released back into the repaired ecosystem. The Committee heard that these were locally endemic species – biodiversity that would have been lost, had intervention not occurred.

Committee comment

- 3.44 The Committee notes the complexities associated with environmental management in the CLLMM region, and commends the extensive efforts to increase the resilience of the system to future disturbances. The building of ecological resilience is a worthy goal, given that the region is subject to variations in weather and hydrological patterns, which are expected to be heightened by future climate change.
- 3.45 Examples of direct, urgent interventions to conserve biodiversity at particular sites highlighted the importance of natural resource managers being aware of the tipping points of species and ecosystems, and being prepared to act quickly when needed. The Committee understands that such awareness requires adequate resources for research and monitoring.

Community resilience through engagement and empowerment

- 3.46 The economic, social and cultural values in the CLLMM region depend on a healthy and functioning wetland environment. In addition to enhancing ecological resilience, as discussed above, the Committee heard about the importance of building the resilience of local human communities. In the CLLMM region, initiatives have improved communication and collaboration between government and the local community, built environmental management capacity, and encouraged citizen science.
- 3.47 As noted earlier, the Lakes Hubs at Milang and Meningie were established to enhance collaboration between government and community members on environmental restoration projects in the CLLMM region. The Committee heard that the activities of the Hubs were very important,

- particularly at the height of the drought, because they allowed members of the local communities to be active participants in making decisions.
- 3.48 The Committee heard that there were some strong Landcare groups based in the region, and that the local community was very supportive of revegetation initiatives. The Lakes Hubs brought the communities and government agencies closer together and enhanced two-way communication, making use of the local community's expertise.
- 3.49 The Committee was advised that resilience was also built by increasing the community's capacity to engage in environmental management programs. The Community Advisory Panel (CAP) focuses on building the community's resilience to future drought episodes. Its membership is a broad range of 15 community leaders, who are involved in strategic level planning, disseminating information, and voicing community concerns. One of the outcomes of the CAP is to build community ownership of environmental programs so that communities carry on doing good work beyond the conclusion of government initiatives.
- 3.50 Programs carried out through the Lakes Hubs also helped create opportunities to improve the economy of the region, particularly through job creation and the provision of environmental management training. The native plant species used in the extensive revegetation programs discussed above are propagated and supplied by the Community Nurseries Network – a group of commercial nurseries in the CLLMM region. Local non-government organisations and community members have also been employed to deliver the revegetation programs. In addition, funds have been invested in conservation and land management training to increase natural resource management capacity in the region. Many of the students from these training courses have subsequently been employed by the Community Nurseries Network.
- 3.51 The Committee was informed that, in this region, the DEWNR had moved away from the traditionally volunteer-based, government-owned approach to natural resource management, and had instead redeployed many members of the community who had lost their jobs in the local viticulture and dairy industries as a result of environmental changes. These programs therefore delivered environmental benefits, while also stimulating and transforming the local economy, building resilience in the community, and ensuring local ownership of environmental programs.
- 3.52 The Committee heard briefly about a successful citizen science program run in the area, also through the Lakes Hubs. A program to monitor acid sulfate soils, overseen by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), provided the opportunity for

100 volunteers to be trained to collect soil samples over a period of time, from various sites in the region. The data were then fed back into the CSIRO's data collection for ongoing research.

Committee comment

- 3.53 The Committee commends the approach taken by the DEWNR in the CLLMM region, and notes the benefits of enhancing community resilience alongside ecological restoration. Evidence received from community members suggested that being part of the decision-making and implementation process had helped to empower the community.
- 3.54 The Committee considers the Lakes Hubs a model for a successful cooperative arrangement between government and the local community on issues of biodiversity conservation, delivering ecological outcomes while improving community resilience to future changes in the region.

Engaging Indigenous communities in biodiversity management

- 3.55 The CLLMM region and surrounding areas are the main homelands of the Ngarrindjeri people, and are central to the culture and spiritual beliefs of these Indigenous communities. Freshwater flows down the Murray-Darling system are seen as the lifeblood of the River Murray, Lower Lakes and Coorong, the health of which is linked to the wellbeing of the Ngarrindjeri people. The impacts of the drought were therefore significant for the Ngarrindjeri.
- 3.56 The Ngarrindjeri are committed to their country and have made significant efforts over the years to be part of managing the region's environment. During inspections, the Committee heard about the DEWNR's various environmental management programs, delivered in conjunction with the Ngarrindjeri community. Through engagement with the DEWNR, the Ngarrindjeri have had input into ecological decisions. Such decisions may include ensuring culturally appropriate plants are used in revegetation programs, for example, using plants that attract totemic animals or are used in cultural practices.
- 3.57 The Committee was briefed on the Ngarrindjeri Regional Authority's (NRA) governance arrangements, put in place in 2007 to bring together the community, voice the Ngarrindjeri's concerns, and more effectively engage and negotiate with other bodies. Cooperation between the NRA and State government is guided by a whole-of-government Kungun

Ngarrindjeri Yunnan Agreement (KNYA), made in 2009, which translates to 'listening to Ngarrindjeri people talking agreement'.¹³

- 3.58 The KNYA supports the full participation of the Ngarrindjeri in government-led environmental management projects in the region. It also sets out the rights and responsibilities of both parties to the agreement, and ensures that the Ngarrindjeri's cultural beliefs are considered in the formulation of government programs in the region.
- 3.59 The Committee heard about some of the complexities associated with intellectual property and copyright issues that came about during the negotiation of the KNYA. Cultural knowledge clauses in the agreement have built trust between the NRA and the government, and have given the Ngarrindjeri confidence that Indigenous knowledge shared with government is not used inappropriately.
- 3.60 One of the key outcomes of the KNYA has been the establishment of the Ngarrindjeri Partnerships Project by the DEWNR and NRA.¹⁴ The project seeks to support participation in natural and cultural resource management in the CLLMM region, and pledges long-term funding for regional environmental programs in which the local Ngarrindjeri people will play a central role.
- 3.61 The Committee heard about a taskforce, established by the NRA and South Australian Government, to build core capacities in the Ngarrindjeri community through: training and skills development initiatives; increasing employment; and encouraging effective engagement with government planning processes on land and water management.
- 3.62 The NRA has established companies that employ members of the Ngarrindjeri community. Such enterprise structures have enabled the Ngarrindjeri to successfully tender for natural resource management contracts. In turn, engaging in these initiatives provides training, knowledge and experience to members of the community, and builds confidence in individuals to engage in paid employment outside these structures.

13 DEWNR and NRA, *KNYA taskforce report 2010–11*, Government of South Australia, 2012, p. 8.

14 DEWNR, 'Ngarrindjeri engagement', <http://www.environment.sa.gov.au/Conservation/Rivers_wetlands/Coorong_Lower_Lake_s_Murray_Mouth/Ngarrindjeri_engagement> viewed 4 October 2012.

Committee comment

- 3.63 The Committee was pleased to hear about the benefits of incorporating Indigenous cultural considerations into environmental programs and policies. As advised by DEWNR officers, meeting cultural considerations will always satisfy environmental considerations as well, while an environmental approach alone will not necessarily fulfil cultural requirements.
- 3.64 The Committee commends the DEWNR for building a cultural heritage perspective into environmental programs, and for incorporating the expertise of Traditional Owners in formulating biodiversity management initiatives.

Governance arrangements

- 3.65 The complexity of governance arrangements across state borders and between various organisations was highlighted during the Committee's inspections of the CLLMM region. The Committee heard that the South Australian Government had developed a long-term plan for the region, incorporating input from community, scientists, industry, and other government stakeholders. The long-term plan is part of the \$610 million Murray Futures program, funded by the Australian Government's Water for the Future strategy.¹⁵ It aims to secure a future for the region as a productive and resilient wetland system of international importance, supporting the local economy and communities that depend on a healthy environment.¹⁶
- 3.66 However, the DEWNR's plans for the region do not exist in isolation. Commonwealth legislation, international agreements, the Murray–Darling Basin Plan, and activities upstream in other states present challenges for the governance framework supporting the environmental management of the CLLMM region.
- 3.67 Taking into account the unpredictable future climatic conditions and the complex governance framework, the South Australian Government's long-term plan for the region proposes an adaptive approach to

15 DEWNR, 'Lower Lakes and Coorong recovery plan', <http://www.environment.sa.gov.au/Conservation/Rivers_wetlands/Coorong_Lower_Lake_s_Murray_Mouth/Lower_Lakes_Coorong_recovery_plan> viewed 4 October 2012.

16 DEH, *Securing the future: a long-term plan for the Coorong, Lower Lakes and Murray Mouth*, Government of South Australia, Adelaide, 2010.

management.¹⁷ The aim is to develop strategies that can respond to changing conditions, as well as building ecological resilience into the region's ecosystems. It is intended that management strategies be informed by the best available science, and that the outcomes of interventions be closely monitored.

Committee comment

- 3.68 Noting the complexities involved with natural resource management in the CLLMM region, the Committee is pleased to note that there are plans in place to address the region's long-term needs. The South Australian Government's adoption of an adaptive approach to managing the ecosystems of the CLLMM region supports evidence the Committee has heard elsewhere: that such an approach to biodiversity management can deliver many benefits, particularly in the presence of uncertainty. The Committee considers that an adaptive approach may be relevant in many other parts of Australia, particularly as future climate scenarios introduce elements of uncertainty into the complex ecosystems being managed across the country.

Benefits of constructed wetlands in an urban environment

- 3.69 As noted earlier, the City of Salisbury's Greenfields Wetlands project is one of over 50 constructed wetlands within the local government area. During its inspection, the Committee heard about the relevance of the wetlands to key inquiry considerations, such as the sustainable use of resources, connectivity between ecosystems, and promoting resilience in ecosystems.
- 3.70 The Greenfields Wetlands are located approximately one kilometre inland from the sea, on a site that previously consisted of hypersaline soils. The area is slightly below high tide level, which has historically made residential and industrial development in the area problematic. Overdrawing from aquifers in the area had also resulted in depleted reserves, risking saltwater intrusion into aquifers.

17 DEH, *Securing the future: a long-term plan for the Coorong, Lower Lakes and Murray Mouth*, Government of South Australia, Adelaide, 2010.

Figure 3.3 Part of the Greenfields Wetlands, City of Salisbury



Photograph courtesy of committee secretariat

- 3.71 Constructed wetlands are a significant part of the City's stormwater recycling program. Urban stormwater run-off is treated in constructed wetlands through a range of natural processes, including the filtering of larger particles by riparian vegetation, aquatic plants and animals absorbing nutrients and organic matter, the effect of sunlight and oxygen on bacteria, and suspended clay particles settling on the bottom of the wetland. The Committee heard that horizontal flow wetlands such as the Greenfields Wetlands are able to remove approximately 90 per cent of pollutants and nutrients within a 24 hour period.
- 3.72 Treated stormwater is then either distributed throughout the City, mainly to government and industry consumers for irrigation and non-potable commercial use, or stored in depleted underground aquifers during the wet season for later use during the dry season.
- 3.73 The Committee was informed that one of the benefits of this system of wetlands is the reduced demand on the River Murray and Mount Lofty Ranges catchments. Wetlands also contribute to the City's water sensitive urban design, and deliver flood-mitigation services to local developments.
- 3.74 The Committee's inspections highlighted the degree of connectivity between terrestrial environments of the surrounding city, the freshwater

ecosystems of the wetlands, and the nearby estuarine and marine ecosystems. In the past, untreated stormwater entering the Gulf St Vincent had resulted in large meadows of seagrass dying off. These seagrass meadows had provided habitat for important marine species and helped buffer the shoreline from tidal activity.

- 3.75 Despite efforts to capture and re-use stormwater, most stormwater run-off is still discharged into the Gulf St Vincent. To avoid damage to the nearby marine ecosystem and important fish breeding habitats, the City of Salisbury has therefore adopted a policy to clean all stormwater run-off before it is released into the Barker Inlet, an estuary of the Gulf St Vincent. The City's key strategy in this regard is the use of wetlands to clean stormwater before it is released into the Barker Inlet.
- 3.76 The inspections of the Greenfields Wetlands also underscored the importance of constructed wetlands for increasing ecological resilience through the provision of habitats for native plant and animal species. The Committee heard about the many biodiversity benefits delivered by the wetlands, and the careful planning that went into their design. For example, the inclusion of 'beaches' and hollow logs into the design of the wetlands has created habitats for a range of bird populations. The City's wetlands provide habitat for many animal species, including numerous frog species, and aquatic macroinvertebrates such as insects, crustaceans and worms.

Committee comment

- 3.77 Having inspected the CLLMM region the previous day, and having heard about the stresses on the Murray–Darling system and the resultant adverse impacts on the local environment and community, the Committee was mindful of the need for sustainable water use and biodiversity conservation practices, particularly in the context of a changing climate. During its inspection of the Greenfields Wetlands, the Committee was pleased to hear about how urban stormwater – traditionally regarded as a problem – can be managed and harnessed through constructed wetlands. The Committee notes that such wetlands can contribute to the sustainable use of water resources, enhance urban design, deliver biodiversity benefits, and through the provision of recreational areas, help engage the community on issues of biodiversity conservation.
- 3.78 The Committee notes that, since the time of its visit to South Australia, the federal government has announced its support for other sustainable

stormwater harvesting and re-use projects around the country.¹⁸ The Committee commends programs that seek to use natural resources in a sustainable manner while supporting positive biodiversity outcomes.

Concluding remarks

- 3.79 The Committee's site inspections in South Australia focused on freshwater biodiversity and underlined the impacts of biodiversity loss on human populations. The inspections also provided a worthwhile opportunity to witness the benefits of communication, consultation and cooperation between governments and local communities, engaging the public on issues of biodiversity conservation, and utilising local expertise and insights. The Committee benefited from seeing firsthand projects that provide simultaneously for the sustainable use of natural resources and biodiversity conservation outcomes.
- 3.80 The Committee wishes to record its thanks to all the individuals it met with during its site inspections in South Australia. The Committee extends its appreciation to the South Australian Department of Environment, Water and Natural Resources for its assistance, and in particular to Mr Russell Seaman for facilitating the Committee's visit and for his extensive briefings throughout the site inspections in the CLLMM region. The Committee also expresses its appreciation to Mr Colin Pitman from the City of Salisbury for providing briefings and assisting with the Committee's inspection of the Greenfields Wetlands.

¹⁸ Senator the Hon. Don Farrell (Parliamentary Secretary for Sustainability and Urban Water) and Mr Nick Champion MP (Member for Wakefield), *\$42.5 million for stormwater and reuse projects*, media release, Parliament House, Canberra, 8 August 2012.

4

Kakadu, Northern Territory

- 4.1 Several submissions to the inquiry identified the wetlands of Kakadu as a nationally important ecosystem that the Committee should consider as a case study for its inquiry. The Committee was told that, not only are these wetlands iconic and of high biodiversity value nationally and internationally, they are also at risk of significant damage due to future climate change.
- 4.2 Kakadu National Park (KNP) is listed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a World Heritage Area for both its cultural and natural values. It is located 200 kilometres east of Darwin in the wet-dry tropics of the Alligator Rivers region, and covers an area of 19 798 square kilometres. The park has a high degree of connectivity with adjacent areas – Arnhem Land (Indigenous land) to the east, Nitmiluk National Park to the south, pastoral properties to the west, and the Arafura Sea to the north. Landforms and habitats in the park include the sandstone plateau and escarpment, extensive areas of savanna woodlands, open forest, floodplains, mangroves, tidal mudflats, coastal areas, and monsoon forests.
- 4.3 KNP is jointly managed by its Traditional Owners and the Australian Government, under the direction of a Board of Management, which has an Indigenous majority representing the Traditional Owners. Day-to-day management of the park is carried out by Parks Australia, a division of the federal government Department of Sustainability, Environment, Water, Population and Communities.
- 4.4 Key issues canvassed during the Committee's site inspections in KNP on 3 July 2012 included: existing threats to biodiversity; expected impacts of climate change; the complexity of climate considerations in the Yellow Water Wetlands; co-management of the park; the impact of biodiversity loss on human communities; and research and monitoring needs in the region.

Committee activities

Kakadu National Park

- 4.5 The Committee was accompanied by, and received briefings from, the following representatives from Kakadu National Park:
- Mr Michael Bangalang, Traditional Owner, and Member, Kakadu National Park Board of Management;
 - Ms Sarah Kerin, Park Manager; and
 - Mr Steve Winderlich, Manager, Natural and Cultural Programs.
- 4.6 Throughout the visit, the Committee received the following documents:
- *A shared vision for tourism in Kakadu National Park*, Kakadu Board of Management, 2005.
 - *Wetland tourism: Australia – Kakadu Ramsar site*, Ramsar secretariat, 2012.
 - *Kakadu National Park: Climate change strategy 2010–15*, Director of National Parks, 25 May 2010.
 - *Economic Activity of Australia's World Heritage Areas: Final report*, Department of Environment, Water, Heritage and Arts, July 2008.
 - *Kakadu: Vulnerability to climate change impacts*, Department of Climate Change and Energy Efficiency, 2011.
 - *An-garregegen: A strategy for cultural heritage management in Kakadu National Park*, Kakadu Cultural Heritage Working Group, 2011 –
 - ⇒ *Volume 1: The strategy*.
 - ⇒ *Volume 2: Appendices*.
 - *Kakadu National Park management plan 2007–14*, Director of National Parks, 2007.
 - *Kakadu National Park visitor guide*, Director of National Parks, 2008.
 - *The impacts of climate change on Australian tourism destinations: Developing adaptation and response strategies – A scoping study*, Cooperative Research Centre for Sustainable Tourism, 2009.
 - *The impacts of climate change on Australian tourism destinations: Developing adaptation and response strategies*, Cooperative Research Centre for Sustainable Tourism, 2009.
- 4.7 The Committee was briefed on issues relating to the management of KNP, including existing threats to biodiversity and how these might be affected by changes in climate, co-management of the park, and research and monitoring needs.

Yellow Water Wetlands

- 4.8 KNP's landscapes comprise coastal ecosystems to the north, stone country to the south, and extensive wetlands. In response to submissions to the inquiry, the focus of the Committee's site inspection was the wetlands.
- 4.9 The Yellow Water Wetlands include Yellow Water Billabong and Yellow Water Floodplains. During the dry season, the area consists of a series of large billabongs, which become connected during the wet season, becoming a free-flowing system. Yellow Water Billabong is located at the end of Jim Jim Creek, a tributary of the South Alligator River. The river system, which is the largest in Kakadu, contains extensive wetlands that include river channels, floodplains and backwater swamps.
- 4.10 Accompanied by the KNP representatives listed above, the Committee inspected parts of the Yellow Water Wetlands and received detailed briefings from local guides. The briefings centred on the biodiversity and complexity of the wetlands system, and the potential consequences of climate-induced biodiversity loss for human communities dependent on the wetlands.

Figure 4.1 Yellow Water Wetlands, with floodplains and melaleuca woodlands in the distance



Photograph courtesy of committee secretariat

Issues explored in Kakadu

- 4.11 Inspections of the Yellow Water Wetlands raised issues relating to the complexity of the system and how it might be affected by future climate change, and the impacts of biodiversity loss for human communities that rely on healthy ecosystems. Discussions during the Committee's visit also addressed broader issues of park management in a changing climate, co-management and engagement with Indigenous communities, and research and monitoring needs in the region.

Key threats to biodiversity in Kakadu National Park

- 4.12 The Committee was informed that KNP has been progressively inscribed as a national park since 1979. The park is locally, nationally and internationally significant with respect to its biodiversity. It is home to approximately 2000 plant species, 271 bird species (over one third of Australia's bird species), 77 mammal species (about one quarter of Australia's land mammals), 132 reptile species, 27 frog species and 246 fish species.¹ The Committee heard that the southern parts of KNP, especially the highlands, have particularly high levels of endemism, with many species being unique to the area and not found anywhere else in the world. This was suggested to be due to the highly fractured landscape, which has created ecological niches for species.
- 4.13 Losses in biodiversity have occurred for various reasons. For example, the Committee heard about a dramatic decline in species of small mammals, although the cause is unclear. The pattern of decline has been consistent with disease, although the fact that some species have not been affected suggests there may be an alternative explanation. Fire regimes, predation, and off-park grazing have been identified as other possible causes.
- 4.14 More broadly, the Committee heard that there was some resilience in the landscape, due to it being subject to wet-dry seasonality and periodic disturbances from extreme weather events such as tropical cyclones. However, the resilience of Kakadu's ecosystems to future climate change could be improved through the effective management of feral animals, weeds, and fire. The Committee heard about some of these existing threats to biodiversity, as well as the possible effects of climate change. These are discussed below.

¹ Director of National Parks, *Kakadu National Park: climate change strategy 2010–15*, Department of the Environment, Water, Heritage and the Arts, Canberra, 2010, p. 1.

Feral and pest animals

- 4.15 The Committee heard that feral and pest animals have had a detrimental impact on the ecosystems of KNP. These animals include Asian water buffalo, cattle, pigs, horses, donkeys, dogs, cats, European bees, cane toads, and introduced ants.²
- 4.16 The Committee was briefed on the history of ecological damage from Asian water buffalo in KNP. Water buffalo had been introduced to the Northern Territory from Indonesia in the 1800s.³ Over many years, feral populations had damaged floodplains and eroded the banks of freshwater river systems. This had facilitated saltwater intrusion and resulted in the death of trees and other vegetation that provided habitat for naturally and culturally important animal species. The activity of buffalo had also exacerbated the spread of weeds.
- 4.17 The Committee heard that the Brucellosis and Tuberculosis Eradication Campaign of the 1990s removed most buffalo from KNP, allowing damaged areas to recover over time. However, buffalo numbers have since increased gradually. Strategies now used to manage many feral animals, including water buffalo, consist mainly of aerial shooting, although some opportunistic shooting also takes place, often in conjunction with weed and other land management activities.
- 4.18 The Committee was interested to hear about the presence of cane toads in KNP. Cane toads started to colonise the park in the 1990s and quickly became a threat to lizards, goannas, and quolls. These species have continued to do well in the stone country, where cane toads have not been as pervasive. The Committee heard that efforts to eradicate cane toads are usually inefficient and ineffective, and such programs are therefore generally not pursued. The Committee was interested to note, however, that early results from a University of Sydney program to train quoll young to avoid cane toads suggested some success in adaptive learning.
- 4.19 The difficulty of isolating the impact of invasive species was noted. For example, quoll populations in KNP were declining before the arrival of the cane toad, but the presence of the cane toad had certainly exacerbated existing threats, leading to a more rapid decline in quoll numbers.

2 Director of National Parks, *Kakadu National Park management plan 2007–14*, Australian Government, Darwin, 2007, p. 79.

3 Northern Territory Department of Primary Industry and Fisheries, 'Buffalo – Primary Industry', <http://www.nt.gov.au/d/Primary_Industry/index.cfm?newscat1=Other%20Animals&newscat2=&header=Buffalo> viewed 16 October 2012.

Weeds

- 4.20 The Committee was briefed on the management of weeds in KNP. *Mimosa pigra* is an aggressive floodplain weed with a very long period of seed viability: germination is possible for up to 25 years for each seed. Once a seed germinates, growth is very rapid. The Committee was pleased to hear that, as a result of significant, early investment in weed management, KNP was largely free from *Mimosa pigra*. However, in view of the weed's long period of seed viability, management is an ongoing challenge.
- 4.21 The Committee heard about two other floodplain weeds that are significant in KNP: olive hymenachne (*Hymenachne amplexicaulis*) and salvinia (*Salvinia molesta*). Olive hymenachne is a prolific seeder, and seeds are spread by water, including during flooding events, and through mud by animals.⁴ Feral animals and more frequent extreme weather events due to climate change may therefore result in greater adverse impacts in the Kakadu wetlands.
- 4.22 Salvinia, which is a free-floating, mat-forming fern that has invaded KNP's wetlands, reproduces by fragmentation and is characterised by very prolific growth. The Committee had an opportunity to view parts of the Yellow Water Wetlands covered in salvinia during its site inspection. Management of the weed has been a major undertaking in KNP, and the Committee was pleased to hear that the salvinia weevil had provided some control over the spread of the plant under certain conditions.
- 4.23 The Committee was also briefed about two types of grassy weed, Para grass (*Urochloa mutica*) and Mission grass (*Pennisetum polystachyon*), which are native to the African tropics and were introduced to Australia to be trialled as pasture grasses.⁵ However, both species have since established themselves in the Northern Territory as invasive weeds. The Committee was informed that these weeds tend to quickly dominate and create monocultures in the ecosystems they invade, and have the potential to significantly alter fire regimes due to the resultant increased fuel loads.

4 Northern Territory Government, 'Olive hymenachne (*Hymenachne amplexicaulis*)', <<http://www.nretas.nt.gov.au/natural-resource-management/weeds/find/?a=13313>> viewed 21 October 2012.

5 Department of Primary Industry, Fisheries and Mines, *Management of mission grass*, Agnote, no. F38, Northern Territory Government, Darwin, 27 June 2006; MM Douglas, SE Bunn, RJW Pidgeon, PM Davies, P Barrow, RA O'Connor and M Winning, *Weed management and the biodiversity and ecological processes of tropical wetlands: draft final report*, National Wetlands R&D Program, Environment Australia, and Land and Water Australia, 2001.

Figure 4.2 Salvinia (foreground) at the edges of the Yellow Water Wetlands



Photograph courtesy of committee secretariat

Fire management

- 4.24 The Committee heard that fire is a significant issue in KNP, the landscape having adapted in the presence of fire over many thousands of years. The approach taken by park management is based on Indigenous methods, where burning was traditionally carried out to increase hunting opportunities, improve access to the land, and to facilitate communication.
- 4.25 In KNP, a program of burning is undertaken annually, although the fire interval varies according to ecosystem type. In the early fire season, patch or mosaic burning is carried out at low intensities, which reduces the risk of wildfires caused by lightning strikes later in the season. The Committee heard that the shift from late, highly destructive wildfires, to early, cooler season fires had introduced greater biodiversity into KNP's ecosystems by allowing a diversity of plant species to flourish.
- 4.26 In addition to the traditional reasons for burning and modern hazard reduction purposes, fire is currently also used to manage specific species. For example, Leichhardt's grasshopper is a species found in only three places in the world, including Kakadu. It is also important in Indigenous mythology. The grasshopper relies almost exclusively on one type of plant (pityrodia) throughout most parts of its life cycle. Any loss of pityrodia is therefore likely to be accompanied by declines of Leichhardt's grasshopper. Understanding these interrelationships enables fire regimes

to be used to protect the habitat of species that are important for ecological and cultural reasons.

Climate change

- 4.27 The Committee was informed that, in the context of geological timeframes, the region had adapted to many changes. For example, the freshwater floodplains in the region were estimated to be 4000 years old. Prior to that, the area was completely inundated with saltwater. The biodiversity of the area has therefore adapted over time to significantly different landscapes. However, climate change is likely to demand more rapid adaptation than may be possible. This was therefore one of the challenges in managing the park to ensure resilience to relatively rapid changes in climate.
- 4.28 As the Committee heard during this site inspection, and previously throughout the inquiry, one of the most effective ways of building resilience to climate change is by managing existing threats, such as those discussed above. However, it is also necessary for land managers to be aware of the possible impacts of climate change in order to anticipate how these might affect system dynamics in a given ecosystem.
- 4.29 The predicted effects of climate change in Kakadu include sea level rise, temperature rises, variation in the amount and pattern of rainfall, and changes in the frequency and intensity of extreme weather events. The related threats to KNP's biodiversity are discussed below.
- 4.30 Saltwater intrusion into freshwater ecosystems may transform landscapes, particularly in the wetlands where even very small rises in sea level could have significant consequences. The Committee heard that, although there had been some suggestion that the effects of rising sea levels had already been observed in some places, it was unclear whether there were other causes, such as past damage by water buffalo.
- 4.31 Predicted temperature rises could have direct impacts on the viability of crocodiles and other reptile species with temperature-dependent sex determination. Sex ratios could be altered, resulting in nesting failure and species decline. Temperature rises are also predicted to result in changes to fire regimes, which could transform ecosystems.
- 4.32 The frequency and severity of extreme weather events is expected to have detrimental impacts on the biodiversity of KNP. More intense storms are likely to contribute to the changes in fire regimes discussed above, particularly due to more frequent lightning strikes. The Committee viewed photographs illustrating the devastating effects of tropical cyclones in the region, and heard about the increased risk of invasive species being spread during severe weather events.

4.33 Aside from the direct impacts, climate change is likely to exacerbate existing threats to biodiversity in Kakadu. For example, the Committee was advised that predicted changes to a number of aspects of climate, including temperature and precipitation patterns, would provide more favourable conditions for weeds. The Committee heard that grasses ordinarily make up approximately six to eight per cent of woodland ecosystems in the region. However, this proportion is two to three times greater in woodland ecosystems that are invaded by grassy weeds such as para grass and mission grass. Should this disparity be amplified by climate change, there is potential for dramatic changes in ecosystem dynamics and the diversity of plant and animal life supported by these ecosystems.

Committee comment

- 4.34 The Committee notes the range of threats currently facing the biodiversity of Kakadu, including feral and pest animals and invasive weeds. The Committee is also mindful of the need for careful management of fire regimes in the Northern Territory in particular, where many landscapes have evolved in the presence of fire over many thousands of years.
- 4.35 The Committee was pleased to hear that there is some resilience built into the ecosystems of Kakadu, due to the landscapes having had to evolve over long periods of time to starkly different conditions. However, the Committee notes advice that current environmental management challenges are likely to be exacerbated by climate change, as ecosystems may be transformed and conditions may become more favourable for pest species. Of concern is the suggestion that climate change may require much more rapid adaptation than will be possible for many ecosystems.
- 4.36 The Committee was pleased to hear acknowledgment by park management that threatening processes do not recognise arbitrary boundaries, and that KNP is therefore managed at a landscape scale. The Committee was also pleased to find a culture of constructive collaboration with Traditional Owners, allowing management to benefit from the traditional knowledge of local Indigenous communities.

Complexity of the Yellow Water Wetlands ecosystem

- 4.37 As discussed earlier, the Yellow Water Wetlands are part of the South Alligator River system, the vast size of which makes it a very important area to monitor for climate change impacts, due to the far-reaching consequences of any adverse impacts.
- 4.38 During its site inspection, the Committee received briefings on, among other things, the biodiversity of Kakadu. Local wildlife includes saltwater

crocodiles, buffalo on the floodplains, snakes, and a range of endemic flora. Kakadu is home to about one third of Australia's bird species, and at least 60 species are found in the wetlands.

- 4.39 The Committee was also briefed on the complex climatic conditions of KNP. Kakadu's climate is monsoonal, characterised by two main seasons: the dry season (May to October) and the wet season (November to April). Local Indigenous communities recognise six different seasons, as well as subtle variations that signpost the transition from one season to another:
- *Gudjewg*: Monsoon season, December to March;
 - *Banggerreng*: Knock 'em down storm season, April;
 - *Yegge*: Cooler but still humid season, May to June;
 - *Wurrgeng*: Cold weather season, June to August;
 - *Gurrung*: Hot dry weather, August to October; and
 - *Gunumeleng*: Pre-monsoon storm season, October to December.⁶
- 4.40 The understanding of these six seasons informs expectations regarding rainfall, temperature, humidity, wind and stormy conditions, abundance and location of plant and animal life, the timing of life cycle events (phenology), and the condition of wetlands. It provides guidance on how and when land management practices such as burning should be carried out. In the past, it also helped Traditional Owners determine when to move camp from the floodplains to the stone country, to seek shelter from violent storms.⁷
- 4.41 In addition to these seasonal variations, the Committee heard that KNP is subject to other periodic climate patterns, such as the El Niño–Southern Oscillation (ENSO), and episodic disturbances, such as tropical cyclones and other extreme weather events. These longer-term and episodic variations have meant that Kakadu's ecosystems have a level of ecological resilience built into them. For example, the wet–dry seasonality allows the floodplains to act as refugia for animals during dry periods.
- 4.42 However, these complexities also make the management of KNP more challenging. And, because climate change is an additional threat to biodiversity while also interacting with the range of existing threats, all of

6 Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC), 'Kakadu National Park—Six seasons of Kakadu', <<http://www.environment.gov.au/parks/kakadu/nature/seasons.html>> viewed 25 October 2012.

7 DSEWPAC, 'Kakadu National Park—Six seasons of Kakadu', <<http://www.environment.gov.au/parks/kakadu/nature/seasons.html>> viewed 25 October 2012.

these variables make it more difficult to predict the effects that climate change is likely to have in Kakadu.

Committee comment

4.43 The Committee notes the complexity of the wetlands ecosystems in Kakadu, particularly in relation to reliably predicting the impacts of climate change in the region. The Committee's inspection of the Yellow Water Wetlands and briefings from local experts highlighted the importance of land managers having a thorough and nuanced understanding of the dynamics of the specific ecosystems involved, supported by insights from traditional knowledge and scientific research and monitoring.

Co-management of Kakadu National Park

4.44 The Indigenous people of Kakadu—the Bininj in the north and Mungguy in the south—have leased their land to the Australian Government for the formation of the national park.⁸ The Committee heard about the approach taken to managing KNP and co-management structures, which combine traditional culture and modern practice.⁹ The Committee was also briefed on some of the benefits of working with Traditional Owners, as well as some of the issues that need to be managed.

4.45 As with discussions in South Australia regarding co-management of national parks with the Ngarrindjeri in the Coorong, Lower Lakes and Murray Mouth region, the visit to KNP underscored the inseparability of nature and culture for Indigenous communities and highlighted the relevance of this to the way the park is managed.

4.46 Briefings were provided on KNP's co-management structure, which involves a Board of Management that includes Traditional Owner representatives, the Director of National Parks, and nominees from the tourism and environmental sectors. The Committee was informed that just under half of KNP is subject to Indigenous land claims, but that the park is consciously managed as though all of the park is Indigenous land. As a result, there would be little practical impact on the way the park is managed should pending claims be successful. The Committee heard that the resolution of land claims would, however, assist with the co-management of KNP by providing both management and Traditional

8 Kakadu Board of Management, *A shared vision for tourism in Kakadu National Park*, Australian Government and Northern Territory Government, 2005, p. 3.

9 Kakadu Board of Management, *A shared vision for tourism in Kakadu National Park*, Australian Government and Northern Territory Government, 2005, p. 3.

- Owners with more clarity on the appropriate representatives for each part of the park.
- 4.47 Briefings addressed the approach taken to managing KNP, which includes the integration of natural and cultural resource management. The Committee was told about cultural programs that included working with Traditional Owners out on country to collect oral history, with the aim of sharing and recording some of the customary knowledge of country. KNP representatives also discussed clan-based projects that seek to link customary knowledge and traditional practices on the one hand, with scientific information and modern methods on the other. Through these cultural programs, the environmental knowledge of Traditional Owners is able to be incorporated into management plans, while scientific knowledge can enhance management approaches and on country practices, particularly as climate change introduces uncertainty and variability into ecosystem processes.
- 4.48 The Committee was also informed about KNP's cultural heritage strategy, which results, among other things, in park management benefiting from the knowledge of Traditional Owners. Much of the cultural information held by Traditional Owners also has ecological applications. For example, the Committee heard about traditional knowledge that recognises phenologically linked relationships between species, such as observed flowering of one plant species coinciding with the nesting behaviour of a particular, otherwise unrelated, animal species.
- 4.49 One aspect of the KNP's cultural heritage strategy includes the establishment of a 'cultural information management system'. The database facilitates the collection, retention and retrieval of cultural information relating to the park, with access restrictions to ensure information is collected from and shared with only the appropriate people. The Committee heard about the need to protect culturally sensitive information, while ensuring effective knowledge transfer and reducing the risk of losing important cultural heritage information.
- 4.50 KNP management also benefits from the knowledge of Traditional Owners through consultation processes in relation to the management plan for the park, as well as other specific plans. Community meetings are also held on an ongoing basis, allowing further consultation with Traditional Owners on matters directly relating to their immediate geographical area.

Committee comment

- 4.51 The Committee notes that there are some challenges associated with the co-management of national parks. This may be particularly true in the Northern Territory, where the Committee heard there are social, economic and political dynamics that need to be taken into account.
- 4.52 Nonetheless, the Committee sees value in the co-management of national parks with Indigenous communities where appropriate, and considers that the combination of traditional wisdom and modern approaches can provide real ecological and cultural benefits for all stakeholders. The Committee commends KNP's governance bodies for their efforts towards collaboration, inclusion, and the engagement of local Indigenous communities.

Biodiversity loss and its impact on humans

- 4.53 The Committee heard that KNP's biodiversity has a direct impact on local communities, particularly as many Traditional Owners rely on local plant and animal species as food sources, for cultural activities, and to provide habitat for totemic species. For example, the Committee heard about some of the important food sources in the Yellow Water Wetlands, including lilies, melaleuca trees, and magpie geese. The Committee also heard about some of the cultural applications of the paperbark from melaleuca trees, including as an aid to food preparation and fishing.
- 4.54 Apart from the intrinsic value of Kakadu's iconic, nationally important ecosystems, the Committee heard that many local communities are dependent on the tourism industry for their livelihoods. In turn, the industry relies on the unique biodiversity of the region in order to attract visitors.
- 4.55 Gagudju Dreaming, which is an Indigenous owned collection of Kakadu cruises, tours, cultural experiences, and accommodation, is the largest collection of facilities catering to tourism in Kakadu.¹⁰ Among its goals is positive Indigenous outcomes, particularly for the Bininj people of KNP. Principal stakeholders include the federal government's Indigenous Business Australia, and the Traditional Owners are represented through Kakadu Tourism.¹¹

¹⁰ Gagudju Dreaming, 'The spirit of Kakadu: Gagudju Dreaming – Overview', <<http://www.gagudju-dreaming.com/About-Us/Overview.aspx>> viewed 22 October 2012.

¹¹ Gagudju Dreaming, 'The spirit of Kakadu: Gagudju Dreaming – Indigenous experience', <<http://www.gagudju-dreaming.com/Indigenous-Experience/Overview.aspx>> viewed 22 October 2012.

- 4.56 As part of the charter for the operation of Gagudju Dreaming, an Indigenous Employment Program (IEP) exists to create opportunities for local Bininj to train and interact with the tourism industry. The Committee notes that part of KNP's charter is to only develop tourism at a pace that is comfortable for and set by the Traditional Owners of Kakadu.¹²
- 4.57 The conservation of Kakadu's rich biodiversity is both directly and indirectly important for communities that rely on the landscape for cultural and economic reasons. The loss of biodiversity due to climate change would therefore have significant repercussions for the local Indigenous communities in particular.

Committee comment

- 4.58 The Committee notes that nature and culture are inseparable for Kakadu's Traditional Owners. Apart from the intrinsic value of KNP's biodiversity, local communities depend on healthy ecosystems for cultural as well as economic reasons. The Committee therefore notes the significance of efforts to manage and conserve biodiversity in KNP, particularly in a changing climate.

Research and monitoring

- 4.59 The Committee heard about the importance of research and monitoring in Kakadu to provide land managers with adequate information about the impacts of climate change on biodiversity. The Committee was informed of some of the current research gaps, as well as some of the challenges associated with carrying out research in KNP.
- 4.60 During the Committee's inspection program, KNP representatives identified the expansion of its research and monitoring program as one of the park's most pressing needs in responding to the threat of climate change. KNP management emphasised the importance of collecting baseline data to ensure that climate change impacts can be reliably assessed in future.
- 4.61 Although there had been an ongoing debate about the relevance of long-term biodiversity monitoring, its value has now become more apparent. With the uncertainties associated with climate change impacts, and the move towards a more adaptive approach to biodiversity management, there is an increasing need for reliable, thorough, and long-term baseline data on the abundance, distribution and conditions of

12 Gagudju Dreaming, 'The spirit of Kakadu: Gagudju Dreaming – Indigenous experience', <<http://www.gagudju-dreaming.com/Indigenous-Experience/Overview.aspx>> viewed 22 October 2012.

species and ecosystems. This would enable land managers to monitor changes closely, and would provide better guidance on the type and timing of appropriate interventions.

- 4.62 The Committee heard that the size of Kakadu, its remote location, and access to adequate resources posed challenges for the collection of such data. The Committee was advised that KNP management is constrained to an extent regarding the type and scope of research it can initiate on its own. For example, the Committee heard that there had been varied reports of observed changes in the timing of the seasons in Kakadu, such as earlier or later than usual flowering of particular plants. The Committee heard that there would be benefit in carrying out research into the timing of sightings of migratory birds in the region, to determine whether climate changes are driving any systematic shifts in arrival or departure times. However, there was no capacity for KNP management to carry out this research internally.
- 4.63 KNP management has therefore adopted a cooperative approach to ensuring adequate and appropriate research and monitoring is carried out in Kakadu. The Committee was briefed on some of the mechanisms by which research is carried out, including the roles of the Kakadu Research Advisory Committee (KRAC) and the National Environmental Research Program (NERP) Northern Australia Hub. The KRAC contributes to identifying research priorities, with research being carried out by partner organisations. Research outcomes are then used to guide KNP management decisions. The NERP Northern Australia Hub was established with federal government funding and is hosted by Charles Darwin University. The Hub brings together research partners from across the country to ‘improve biodiversity conservation in northern Australia through sound planning, innovative policy and strong partnerships’.¹³

Committee comment

- 4.64 As with several other site inspections, briefings in KNP underscored the importance of thorough research and long-term baseline environmental data to help guide environmental management decisions. The Committee notes that such data will play an even more significant role in biodiversity conservation as the need to respond to climate change impacts becomes greater.
- 4.65 The Committee acknowledges the challenges facing KNP management in collecting such data, due to the park’s size and location and the
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¹³ DSEWPAC, ‘National Environmental Research Program: research hubs’, <<http://www.environment.gov.au/biodiversity/science/nerp/hubs.html>> viewed 20 October 2012.

availability of resources. The Committee therefore considers the collaborative approach taken by KNP to be beneficial and appropriate given the circumstances.

Concluding remarks

- 4.66 The Committee appreciated the opportunity to inspect Kakadu's iconic ecosystems, including the wetlands identified by submissions as an example of an ecosystem of national importance. The Committee also valued hearing about some of the existing threats to Kakadu's biodiversity and how these might be affected by climate change. Valuable discussions were had regarding the management of a national park in complex circumstances, and KNP representatives' insights about the need for research and monitoring were also useful. By seeing parts of the Yellow Water Wetlands firsthand, the Committee gained a more thorough understanding of the ecosystem's complexity and the threats it faces.
- 4.67 The Committee wishes to extend its thanks to Kakadu National Park management for facilitating the visit and for making representatives available to provide extensive briefings and supporting material during the site inspection. The Committee is also grateful for the assistance and insights of local guides who it met with during its inspection.

Tropical North Queensland

- 5.1 On 5 and 6 July 2012, the Committee held a public hearing in Townsville and visited various sites in Townsville and north of Cairns. The focus of the visit was to consider the vulnerability of marine coral reef ecosystems and terrestrial wet tropical ecosystems to climate change, as highlighted in submissions presented to the inquiry.
- 5.2 Tropical North Queensland is home to both the Great Barrier Reef World Heritage Area, and the Wet Tropics of Queensland World Heritage Area. The Great Barrier Reef Marine Park covers an area of approximately 344 400 square kilometres along 2300 kilometres of Queensland's coastline, from the tip of Cape York south to Bundaberg.¹ Many different habitat types exist within this area, including coral reefs, seagrass meadows, tidal wetlands, open waters and islands.² Climate change has been identified as the greatest threat facing the Great Barrier Reef ecosystem.³
- 5.3 The Wet Tropics of Queensland World Heritage Area covers some 8944 square kilometres, spanning over 450 kilometres along the north-east coast of Australia, from just south of Cooktown to just north of Townsville.⁴ The 'wet tropics' is the most biodiverse terrestrial region of Australia.⁵ The main vegetation type is wet tropical rainforests, fringed by sclerophyll forests, woodlands, swamps and mangrove forests; there are

1 The Marine Park makes up over 99 per cent of the World Heritage Area. Great Barrier Reef Marine Park Authority (GBRMPA), 'Great Barrier Reef outlook report 2009', *Exhibit 23 to Submission 28*, pp. 3, 135.

2 GBRMPA, *Submission 28*, p. [1].

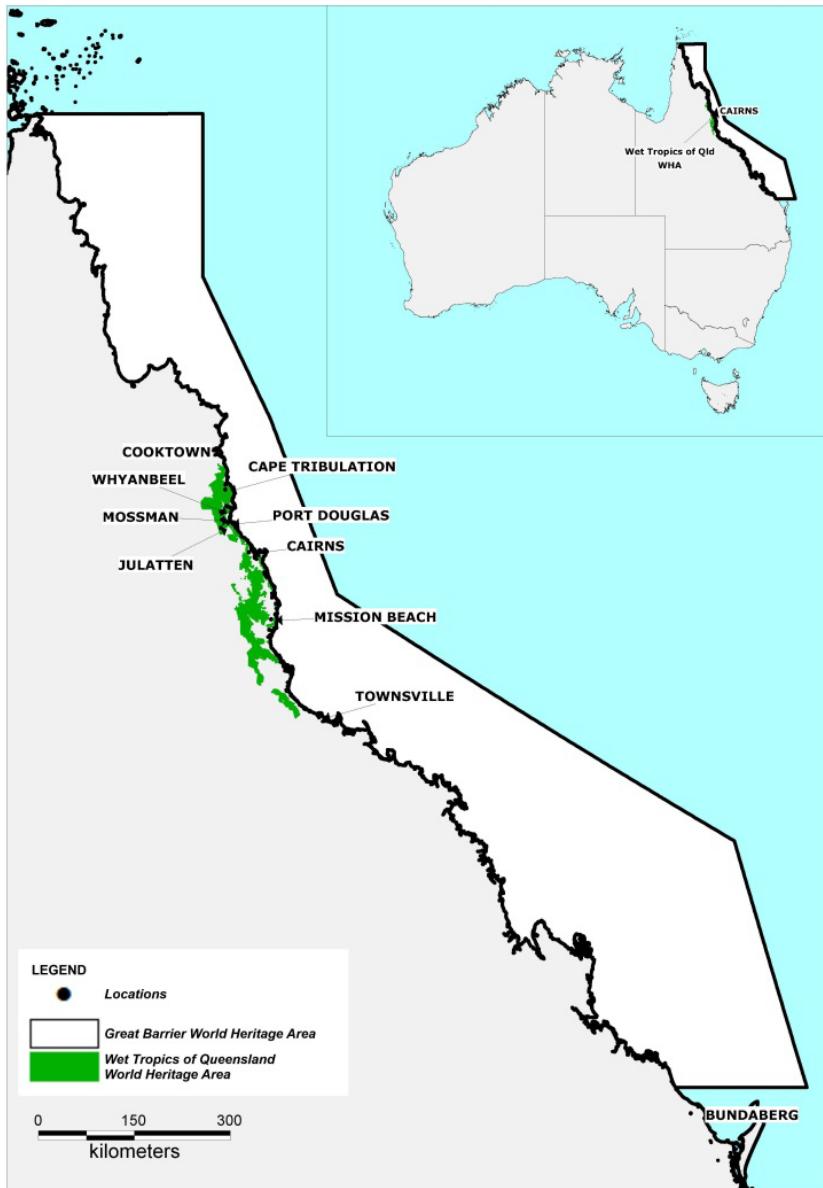
3 GBRMPA, 'Great Barrier Reef outlook report 2009', *Exhibit 23 to Submission 28*, p. 172.

4 United Nations Educational, Scientific and Cultural Organization (UNESCO), 'Wet Tropics of Queensland', <<http://whc.unesco.org/en/list/486>> viewed 31 July 2012.

5 Wet Tropics Management Authority (WTMA), *Submission 2*, p. 1.

also several endemic species including the lemuroid ringtail possum.⁶ Climate change is predicted to result in changes in species abundance and distribution, increased vulnerability to pests and weeds,⁷ and high levels of extinction in the wet tropics of Queensland.⁸

Figure 5.1 Location of the Wet Tropics of Queensland World Heritage Area and the Great Barrier Reef World Heritage Area



Source Parliamentary Library © Commonwealth of Australia 2012

⁶ UNESCO, 'Wet tropics of Queensland', <<http://whc.unesco.org/en/list/486>> viewed 31 July 2012.

⁷ WTMA, 'Climate change in the wet tropics—Impacts and responses: state of the wet tropics report 2007-08', *Exhibit 3 to Submission 2*, p. 10; WTMA, *Submission 2*, pp. 5-6.

⁸ R Garnaut, *The Garnaut climate change review: final report*, Cambridge University Press, Port Melbourne, 2008, p. 142.

5.4 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 local and international coral reef and wet tropical ecosystems. The key issues identified by the Committee during the site inspections included the impacts of invasive species, ocean acidification, increasing temperatures, and increasing intensity of extreme weather events.

Committee activities

5.5 The Committee's visit to Tropical North Queensland included inspections and briefings at Reef HQ Great Barrier Reef Aquarium in Townsville (Reef HQ), and in wet tropics areas north of Cairns. These activities provided an insight into the distinct ecosystem types existing in close proximity to each other, and the common challenges faced in the region due to climate change.

Reef HQ Great Barrier Reef Aquarium

5.6 Reef HQ in Townsville is the National Reef Education Centre for the Great Barrier Reef Marine Park Authority (GBRMPA),⁹ and houses the world's largest coral reef aquarium. The Great Barrier Reef is home to approximately 1500 species of fish, 400 species of hard coral, one third of the world's soft corals, and six of the seven species of sea turtle.¹⁰ Reef HQ's 2.5 million litre tank displays a coral reef exhibit with approximately 150 species of fish and 120 species of coral found on the Great Barrier Reef.

5.7 On 5 July 2012, the Committee inspected Reef HQ's research and community awareness projects, and gained an insight into how Reef HQ's interactive aquarium setting engages the community on the challenges faced by the Great Barrier Reef. At the time of the Committee's visit there were 28 living exhibitions showing reef supporting ecosystems and the biodiversity of the region. The Committee met with Mr Fred Nucifora, the Director of Reef HQ, and received briefings on the threats to biodiversity in reef ecosystems due to climate change; the research projects being undertaken at Reef HQ by Australian Institute of Marine Science (AIMS)

⁹ GBRMPA was established in 1975 as a federal government statutory authority responsible for managing and protecting the Great Barrier Reef Marine Park.

¹⁰ C Reid, J Marshall, D Logan and D Kleine, *Coral reefs and climate change*, CoralWatch, The University of Queensland, Brisbane, 2009, p. 83.

and James Cook University researchers; the *Great Barrier Reef Marine Park Zoning Plan 2003*; and GBRMPA's Reef Guardian program.

The wet tropics of Queensland

- 5.8 As noted earlier, the wet tropics of Queensland is the most biodiverse terrestrial region of Australia.¹¹ The Committee visited the Daintree Rainforest Observatory (DRO), which lies about 140 kilometres north of Cairns in the Cape Tribulation region. Whilst travelling through the wet tropics, and once at the DRO, the Committee received briefings from the following organisations:
- Wet Tropics Management Authority (WTMA), represented by:
 - ⇒ Dr Steve Gooseem, Principal Scientist; and
 - ⇒ Mr Andrew Maclean, Executive Director; and
 - James Cook University (JCU), represented by:
 - ⇒ Mr Peter Byrnes, Site Manager, Daintree Rainforest Observatory;
 - ⇒ Dr Susan Laurance, Senior Lecturer, School of Marine and Tropical Biology;
 - ⇒ Mr Bradley Smith, Research Strategy and Special Projects Manager, Division of Research and Innovation; and
 - ⇒ Mr Andrew Thompson, Research Worker/Canopy Crane Operator.
- 5.9 Some of the briefings throughout the day focused on local rainforest connectivity projects, research projects measuring the effects of climate change on species abundance and adaptability, and long-term baseline data collection necessary for measuring changes over time.
- 5.10 During the inspections, the Committee received the following documents:
- *Cairns to Daintree field trip map*, WTMA, July 2012.
 - *Port Douglas to Daintree Rainforest Observatory*, trip notes, Dr Steve Gooseem, July 2012.

Issues explored in Tropical North Queensland

- 5.11 Throughout its Queensland site inspection program, the Committee gathered evidence on how invasive species, ocean acidification, increasing temperatures and extreme weather events are posing threats to the biodiversity of Australia's reefal and wet tropical ecosystems. The Committee also gathered evidence on sustainable management practices,
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11 WTMA, *Submission 2*, p. 1.

research and connectivity programs, and education and community awareness projects supported in the area.

Invasive species and species decline

- 5.12 During the course of the inquiry, the Committee has heard about the risks invasive species pose to biodiversity. In Western Australia and Sydney, for example, the Committee heard about phytophthora dieback and myrtle rust as emerging threats to biodiversity.¹² In Tropical North Queensland, the Committee was advised that over 200 plant species in the wet tropics are at risk of being infected by myrtle rust. The Committee heard that, as a windborne pathogen, there is little possibility of preventing the spread of the disease once it has taken hold.
- 5.13 The spread of invasive weeds also presents threats to biodiversity in the wet tropics. Outbreaks of weeds, such as miconia and Koster's curse, have been observed in the Whyanbeel area just north of Mossman.¹³ These weeds are subject to eradication, as part of a nationally coordinated program managed by the Queensland Government. They are considered weeds because of their potential to damage the native and agricultural lands in Tropical North Queensland, and infest tropical areas of other states.¹⁴
- 5.14 The predicted increase in the frequency and intensity of cyclones will assist in spreading invasive weeds in hard to reach places such as rainforested hillsides. High winds, heavy rains and flooding associated with cyclone activity create disturbances that make ecosystems more susceptible to invasion, while also helping to spread the seed of invasive species. The spread of invasive weeds, particularly into inaccessible locations, will make management of these species difficult and expensive.
- 5.15 Species decline is an additional challenge to biodiversity in wet tropics areas. During the Daintree Rainforest Observatory (DRO) site inspection, the Committee heard that the world is currently experiencing the sixth mass extinction, and that 25 per cent of species in the Australian wet tropics are projected to become extinct.
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12 House of Representatives Standing Committee on Climate Change, Environment and the Arts (CCEA Committee), *Case studies on biodiversity conservation: volume 1*, May 2012, pp. 11-12, 58. There is controversy surrounding the correct scientific classification for myrtle rust in Australia, therefore only the common name has been included.

13 See figure 5.1 above, p. 56.

14 Department of Agriculture, Fisheries and Forestry (DAFF), 'National eradication programs – Exotic weeds', <<http://www.daff.gov.au/animal-plant-health/pests-diseases-weeds/weeds/eradication>> viewed 24 October 2012.

5.16 The Committee has previously heard about the potential for loss of species adapted to living in high altitudes in alpine regions, due to increased temperatures.¹⁵ The Committee heard about a similar phenomenon in the high altitude regions of the wet tropics, affecting the threatened lemuroid ringtail possum (*Hemibelideus lemuroides*). An endemic possum in the wet tropics, lemuroids are very sensitive to high temperatures and poorly adapted for regulating their body temperature. In the 1980s, lemuroids were commonly found living above 1000 metres on the Carbine Tableland. Since then, there has been a significant decline in lemuroid numbers in the area. Furthermore, since 1999, lemuroids have been observed living at higher altitudes of above 1200 metres. The Committee was advised that this population decline and range shift has been partly attributed to the extreme, extended heat wave experienced in the region in the summer of 2005.

Committee comment

5.17 The Committee understands that the spread of myrtle rust is of concern in the wet tropics. At an earlier site visit to the Australian Botanic Garden at Mount Annan, the Committee heard about the rapid spread of myrtle rust along the east coast of Australia.¹⁶ The full impacts of myrtle rust on the resilience of the wet tropics ecosystem are unknown, and there is little way of preventing its spread. The Committee acknowledges some views expressed about the spread of myrtle rust and possible ways to reduce its impact, including identification of the vulnerabilities of different parts of the forest to myrtle rust, and localised quarantine over important areas.¹⁷

5.18 There are numerous national management plans for invasive species,¹⁸ setting targets for reducing the impacts of invasive species on various ecosystems.¹⁹ The Committee recognises these plans and targets as useful tools in the management of invasive species, and acknowledges the importance of cooperation between all levels of government towards a

15 CCEA Committee, *Case studies on biodiversity conservation: volume 1*, May 2012, p. 38.

16 CCEA Committee, *Case studies on biodiversity conservation: volume 1*, May 2012, pp. 58-9.

17 Mr Andrew Maclean, WTMA, *Transcript of evidence*, 5 July 2012, p. 27; CCEA Committee, *Case studies on biodiversity conservation: volume 1*, May 2012, pp. 58-9.

18 See DAFF, *Submission 73*, pp. 2, 9, which lists: Australia's Biodiversity Conservation Strategy 2010-30; Caring for Our Country; the Clean Energy Futures Package; Australian Weeds Strategy; and the Australian Pest Animal Strategy as examples.

19 See, for example, Natural Resource Management Ministerial Council 2010, *Australia's biodiversity conservation strategy 2010-30*, Department of Sustainability, Environment, Water, Population and Communities, Canberra, p. 46.

national quarantine system which may limit the spread of diseases and invasive weeds in the future.²⁰

- 5.19 Should the high levels of projected species extinction in the wet tropics and worldwide be realised, the effects on the biodiversity of the wet tropics region would be significant. Increased temperatures, extreme weather events and changes in rainfall patterns contribute to the loss of rainforests. In these circumstances, species like the lemuroid ringtail possum are forced to move to higher altitudes to survive. Those species already living at those higher altitudes, however, will have nowhere to go. Policies currently being pursued to combat projected species extinctions include minimising climate change, protecting tropical forests and increasing habitat connectivity – issues the Committee explores later in this chapter.

Climate change threats to biodiversity

- 5.20 Ocean acidification has been identified as a serious threat to the biodiversity of coral reef ecosystems. The coral reef exhibition at Reef HQ, containing thousands of reef creatures, is exposed to the same weather elements which occur in natural reefs. During its inspection, the Committee heard about the detrimental impacts of a more acidic ocean on corals. As levels of atmospheric carbon dioxide increase, the amount of carbon dioxide absorbed by the ocean also increases, causing the ocean to become more acidic.²¹ This affects the ability of coral reefs to grow, which could in turn reduce the capacity of the Great Barrier Reef to repair itself after natural disturbances, including damage from cyclones and storms, or human induced disturbances, including damage from marine vessels and visitors.
- 5.21 Coral bleaching is another threat to reef ecosystems that can inhibit coral reproduction and lead to mortality. Put broadly, coral bleaching can occur as a result of sea temperature increases, and the ability of corals to recover from such events depends upon the length and severity of the temperature increase and the resilience of the reef. When waters are more acidic, corals have been found to bleach at lower temperatures,²² demonstrating that the combined effect of ocean acidification and coral bleaching can be greater than the effect of each phenomenon alone.
- 5.22 In a survey of the Great Barrier Reef, carried out by AIMS scientists and published in 2009, a 14.2 per cent decrease in coral growth since 1990 was
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20 CCEA Committee, *Case studies on biodiversity conservation: volume 1*, May 2012, p. 58.

21 C Reid, J Marshall, D Logan and D Kleine, *Coral reefs and climate change*, CoralWatch, The University of Queensland, Brisbane, 2009, p. 68.

22 Dr S Ward, *Submission 63*, p. [4].

observed, with the rate of decline being influenced by increased sea surface temperatures and ocean acidification.²³ The Committee also heard that the strength and frequency of cyclones is expected to intensify, in part due to a warming ocean, which would put added pressure on coral growth through increased damage to coral cover.

- 5.23 The Committee was interested to see the research facilities Reef HQ provides to local researchers. Reef HQ has previously supported researchers from The University of Queensland, who were assessing the factors affecting the vulnerability of coral reefs to ocean acidification. At the time of the Committee's visit, Reef HQ was supporting researchers from JCU, who were conducting experiments on the impacts of ocean acidification on coral strength.
- 5.24 The Committee heard that increased temperatures and changes in hydrological patterns are also posing a threat to the biodiversity of wet tropical ecosystems. During briefings given at the DRO, the Committee was informed that current climate change research in tropical forests is focused on the effects of increased temperatures, droughts and storms, and how they interact with land use.
- 5.25 Thornton Peak is an upland refugial area of the wet tropics, with fern forests at the summit that rely on cloud stripping to contribute large amounts of water to the forest system and the upper catchments. The rainforests capture water directly from the clouds and then release the water slowly, which maintains stream flows in the dry season. The Committee understands that cloud stripping contributes up to 70 per cent of the total water input into the forest system in the dry season and 10 to 20 per cent in the wet season. The Committee heard that an increase in average temperature by one degree Celsius would likely raise the cloud base by 100 metres, reducing the level of cloud stripping and causing significant stress to the ecosystem.²⁴

Committee comment

- 5.26 Throughout its visit to Tropical North Queensland, the Committee heard about the current and future effects of increased temperatures and increased levels of atmospheric carbon dioxide on the local ecosystems. The Committee was pleased to hear about the research being supported by Reef HQ, investigating the impacts of ocean acidification on reef
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23 AIMS, 'Declining coral growth on the Great Barrier Reef', <<http://www.aims.gov.au/docs/research/climate-change/declining-coral-growth.html>> viewed 7 August 2012, citing G De'ath, J Lough and K Fabricius, 'Declining coral calcification on the Great Barrier Reef', *Science*, vol. 323, 2009.

24 Dr S Goosem, 'Port Douglas to Daintree Rainforest Observatory', trip notes, July 2012, pp. 3, 5.

ecosystems. The partnerships between the local universities and Reef HQ appear mutually beneficial for improving the understanding of the effects of climate change from a scientific perspective, and for engaging and educating the community on what individuals can do to combat the effects of climate change on Australia's biodiversity.

- 5.27 The adverse impacts of ocean acidification, increased temperatures, and changes in hydrological patterns discussed above reinforce the need to build resilience into ecosystems to help them withstand changes in climate.

Sustainable management of reef and rainforest

- 5.28 The Committee's visit to Reef HQ highlighted the importance of sustainable management practices to the protection of the Great Barrier Reef and the wet tropical rainforests of Queensland.

Sustainability at Reef HQ

- 5.29 Reef HQ demonstrates sustainable management through its coral propagation program, the results of which are displayed in the aquarium. The coral propagation program was explained to the Committee as operating in a similar way to that of growing new plants from mature ones in a garden; the donor mother colony is left in place in the research facility, with the fragments taken from it placed in the right conditions for them to grow. Traditionally, in order to carry out research, corals would be collected from the reef and translocation would sometimes kill the coral. The Committee was informed about the long-term goal of requiring little to no collection of coral from the Great Barrier Reef in order to carry out the coral propagation program. This would mean that the corals appearing in the displays at Reef HQ could be regenerated through the coral propagation program, with no adverse effect on the Great Barrier Reef.

- 5.30 The Committee heard that the sustainable use of resources at Reef HQ aims to reduce energy consumption. Aspects of the air conditioning and chilled water system, and the pump and filtration system design, are contributing to lower energy consumption. A lighting replacement program aims to transition to the use of energy efficient LED lighting, and improvements have been made to building insulation and building management systems for monitoring and control. The aquarium features a 153 kilowatt roof mounted array of photovoltaic solar panels, with an initial offset of 15 to 20 per cent in annual energy use, and a 260 tonne

reduction in annual greenhouse gas emissions expected.²⁵ The Committee heard that the aim is to reduce its energy use by 50 per cent of 2006 levels by the end of 2012.

Figure 5.2 Members inspecting Reef HQ's coral propagation program



Photograph courtesy of committee secretariat

Rainforest management

Land use

- 5.31 Black Mountain Corridor is a strip of rainforest along the top of the Macalister Range that connects the northern and southern rainforest sections of the wet tropics. The Committee heard that the Julatten area—a strip of agricultural lands and rural residential subdivisions—has separated the Black Mountain Corridor from the Mount Lewis and Carbine Tableland northern section of the wet tropics. The Committee was informed about the progress and success of local management groups in re-establishing this connection, for example, through a tree-planting scheme that has been operating for the past six years, supported by the local community. The Committee understands that there is a long history of community-based rainforest tree-planting organisations also operating north of the Daintree River.
- 5.32 Another area of the rainforest that has suffered due to changing land use arrangements is north of the Daintree River in the Daintree region, home to around 100 threatened species. Much of the lowlands in this region

25 Reef HQ, 'Energy management', <<http://www.reefhq.com.au/education-at-reef-hq-aquarium/reef-research-and-internships/energy-management>> viewed 8 August 2012.

were subdivided for development in the 1980s. Many of the subdivisions were targeted for buy-back as part of the mid-1990s local, state and federal government Daintree Rescue Program. The Committee heard about the ongoing restoration projects, including wildlife corridors and rainforest connectivity revegetation projects, to repair and link these subdivisions to the rainforest once again. These projects are aimed at making the rainforest more resilient, increasing wildlife habitat and decreasing invasive weed encroachment.

Road design

- 5.33 The Committee noted that the narrow, winding Cape Tribulation Road has been designed with large speed bumps in order to slow traffic and reduce wildlife roadkill. These traffic calming devices are designed to help protect wildlife such as cassowaries from further decline, after the significant loss of population further south in the Mission Beach area due to three cyclones in recent years.²⁶ The Committee heard that the Mission Beach area could benefit from more speed bumps to better protect local cassowaries, given that the area is fragmented and therefore more at risk of local extinction should further disturbances such as cyclones contribute to species decline.
- 5.34 The narrowness of the road allows for vegetation to grow close to it, the rainforest canopy to grow over the top of it, and rainforest fauna to move over it, contributing to rainforest connectivity from the lowlands through to the Thornton Peak uplands. Minimising disruption to the connectivity of the rainforest allows for resilience to be increased, which in turn strengthens its capacity to withstand climate changes.

Committee comment

- 5.35 The Committee commends the progress being made by Reef HQ toward the goal of requiring no collection of coral from the Great Barrier Reef for research or display purposes, and sees this as an important goal for research institutions in order to maintain as little human disruption to the structure of the reef as possible.
- 5.36 The Committee also commends Reef HQ's efforts towards the sustainable use of resources through the adoption of reduced energy use targets. The exhibitions and research being supported by Reef HQ are contributing to the publicly available information on the reef and the sustainable management of reef resources.
- 5.37 The Committee heard about the history of land use in the region, leading to the fragmentation of the rainforest. This highlighted the need for
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26 See figure 5.1 above, p. 56.

regional planning for landscape resilience in the wet tropics of Queensland. The Committee also heard about the reasons for maintaining the Daintree Ferry; slowing traffic in the area; and incorporating connectivity measures into the road designs, and sees all of these as positive ways of promoting resilience in the ecosystem and promoting sustainable practices in the local human community. The Committee was informed of various road design features that assist with biodiversity conservation and sees merit in such measures being implemented in other areas of ecological significance.

- 5.38 The Committee heard repeatedly about the importance of building resilience into ecosystems to assist them to better withstand climate changes, and was interested to hear about the variety of connectivity projects in the Wet Tropics of Queensland World Heritage Area and Daintree region involving the local community working toward this goal. Government buy-back initiatives and community projects are making an important contribution towards reconnecting the rainforest, thereby increasing wildlife habitat and decreasing invasive weed encroachment. Such initiatives are intended to help protect the region from climate change impacts.

Research and training facilities and projects

- 5.39 Research conducted at Reef HQ involves collaboration between local universities and GBRMPA. The Reef HQ turtle hospital opened in August 2009, and is supported by the JCU School of Veterinary and Biomedical Science. One of the aims of the hospital is to enhance community engagement by raising awareness of these threatened species and encouraging changes in behaviour to ensure a sustainable future for turtles.²⁷ The facility allows visitors to see the turtles up close, and learn about their conditions and how they are being rehabilitated. In 2010-11, the hospital cared for 57 turtles, and had over 23 900 visitors.²⁸

27 GBRMPA, *Annual report 2010-11*, GBRMPA, Townsville, 2011, p. 72.

28 GBRMPA, *Annual report 2010-11*, GBRMPA, Townsville, 2011, p. 72.

Figure 5.3 Members inspecting the turtle hospital at Reef HQ



Photograph courtesy of committee secretariat

- 5.40 The wet tropics of Queensland occupies 0.26 per cent of Australia's landmass, yet supports large proportions of its native plant and animal species, including 40 per cent of its bird species, 30 per cent of its marsupial species and 65 per cent of its fern species.²⁹ The Terrestrial Ecosystem Research Network's Rainforest Supersite in Far North Queensland comprises two sectors, the first being the lowland Daintree Rainforest Observatory (DRO) in the Cape Tribulation region. The second is the upland Robson Creek site, located northeast of Atherton. The locations of these two sites enable monitoring across a range of altitudes, temperature variations, and rainfall patterns.
- 5.41 The DRO opened in 1998, established with funding from the Australian Research Council. The Committee heard that further funding to develop the site as an educational and research centre had been provided by the federal government, increasing the amount of accommodation for students and the number of laboratories. Federal government funding had also been secured for remote sensing devices and equipment able to automatically monitor the environment through a wireless sensor network. The data collected through the network will be made available electronically to researchers offsite, making valuable information easily accessible.

29 WTMA, *Annual report and state of the wet tropics report 2010-2011*, WTMA, Cairns, 2011, p. 60.

- 5.42 The Committee inspected the complex mesophyll vine forest at the DRO site, viewing some of the 170 dendrometer bands placed at chest-height around the tree trunks. Dendrometer bands are used to collect and establish baseline data through measuring stem incremental growth, litter trap and leaf area index.³⁰ One of the purposes of collecting the data is 'to report on the risks and threats to lowland rainforest canopy trees under changing rainfall and temperature scenarios'.³¹
- 5.43 The Committee also inspected the canopy crane at the DRO. Identification tags are placed on all trees with a diameter at chest height of greater than 10 centimetres, within the arc of the crane; some 680 trees are closely monitored through the use of the canopy crane.³² Access is made available to researchers from across the globe to carry out canopy-related research that can be shared. The DRO also provides access to the weather data that has been collected for over 10 years from the tower of the crane and in the clearing adjacent to the rainforest.

Figure 5.4 Committee members in the canopy crane with crane operator (left); and an example of the identification tags placed on trees around the DRO site (right)



Photographs courtesy of committee secretariat

- 5.44 The Committee heard about four main areas of climate change research currently being undertaken in tropical forests, namely:

30 JCU, 'Current research—JCU', <http://www.jcu.edu.au/canopycrane/informationfor/JCUPRD_047095.html> viewed 7 August 2012.

31 JCU, 'Current research—JCU', <http://www.jcu.edu.au/canopycrane/informationfor/JCUPRD_047095.html> viewed 7 August 2012.

32 JCU, 'Researchers—JCU', <http://www.jcu.edu.au/canopycrane/informationfor/JCUPRD_046932.html> viewed 7 August 2012.

- examining changes in long-term plot data – to be conducted at the DRO site through long-term altitudinal gradient monitoring;
- remote sensing of drought and fire patterns – the DRO will set up remote sensor towers to measure various environmental factors;
- modelling of species distribution; and
- studying the ability of individuals to adapt to changes in the environment. In situ experiments can study the impacts of climate change on tropical rainforests, where sections of the rainforest can be manipulated to simulate drought conditions to see how species will respond.

Committee comment

- 5.45 The DRO operates as a scientific and educational facility; one of many similar sites around the world. The Committee was impressed by the extent of collaboration and knowledge-sharing between research institutions, and by the proposal for data collected on-site to be made accessible to researchers off-site. This will allow researchers to incorporate the data more readily into projects measuring the impacts of climate changes on biodiversity in the region.
- 5.46 The importance of collecting essential baseline data, useful for measuring the effects of climate change on our ecosystems, was a common theme that arose during the public hearing in Townsville and at the site inspections in the wet tropics. The Committee considers this an increasingly important focus for research funding bodies.

Education and community awareness projects

- 5.47 Reef HQ has a formal education program for school students, which saw 11 945 students participate in 2010-11.³³ Reef HQ also has an educational videoconferencing program that reached 5855 students nationally and internationally during 2010-11, a figure the Committee heard had increased in 2011-12.³⁴ The Committee was informed that the videoconferencing program consists of sea-diving conferences connecting to classrooms all over the world, including in places like New York City and Canada, where school children can talk to scuba divers in the coral reef exhibition about the effects of climate change on reef ecosystems. At the time of the Committee's visit, this program was being used at the World Expo 2012 in South Korea, where the reef divers were connecting daily to people in the Australian pavilion.

33 GBRMPA, *Annual report 2010-11*, GBRMPA, Townsville, 2011, p. 72.

34 GBRMPA, *Annual report 2010-11*, GBRMPA, Townsville, 2011, p. 73.

- 5.48 The Committee heard that visitor numbers to Reef HQ had increased markedly in 2011-12, up from 121 731 in 2010-11.³⁵ The rise in memberships and the growing Townsville population is said to have contributed to the significant increase.
- 5.49 During its visit to Reef HQ, the Committee was briefed on the *Great Barrier Reef Marine Park Zoning Plan 2003* and heard about the increase in the highly protected, marine national park (green) zones from 4.5 per cent to 33 per cent of the Great Barrier Reef Marine Park.³⁶ This rezoning was prompted by the recognition in the mid-1990s that existing levels of protection were inadequate to protect the biodiversity and therefore maintain the resilience of the Great Barrier Reef. The zoning plan was developed in consultation with the community in order to protect a minimum of 20 per cent of each of the 70 identified major habitat types in the Great Barrier Reef region. A notable positive change that has resulted from the rezoning is the recovery of fish populations.³⁷
- 5.50 The Committee also heard about GBRMPA's Reef Guardian program, which commenced in 2003 with 25 schools committed to the protection and conservation of the Great Barrier Reef. The number of participating schools across the Great Barrier Reef catchment has increased to 285, with over 113 000 children focused on managing resources, conducting projects in school and in the community, and educating the wider community. This program encourages people in the community to be environmentally active and work together as Reef Guardians.³⁸
- 5.51 The Reef Guardian program has since been extended to councils, farmers, fishers and graziers, in order to spread the conservation and protection efforts to more parts of the community through various mechanisms.

Committee comment

- 5.52 The Reef Guardian program has grown rapidly and, with the expansion to other parts of the community, it is an effective way of educating and encouraging community engagement and participation in caring for the biodiversity of the Great Barrier Reef ecosystem. The Committee sees the value in extending the Reef Guardian program to other Australian reefs, and also adapting the concept to other areas and ecosystem types, as was
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35 GBRMPA, *Annual report 2010-11*, GBRMPA, Townsville, 2011, p. 71.

36 GBRMPA, 'Great Barrier Reef outlook report 2009', *Exhibit 23 to Submission 28*, p. 126.

37 GBRMPA, 'Great Barrier Reef outlook report 2009', *Exhibit 23 to Submission 28*, p. 126.

38 GBRMPA, 'Reef Guardians', <<http://www.gbrmpa.gov.au/our-partners/reef-guardians>> viewed 6 August 2012; GBRMPA, 'Great Barrier Reef outlook report 2009', *Exhibit 23 to Submission 28*, p. 103.

canvassed by the Wet Tropics Management Authority at the public hearing in Townsville.³⁹

Concluding remarks

- 5.53 Among the issues arising across the Committee's consideration of reef and wet tropical ecosystems, the most significant is the impacts of increased temperatures. The Committee was also interested to hear about the issue of invasive species expansion into the wet tropics, having heard about similar issues during previous site inspections.
- 5.54 The Committee was encouraged by the cooperative relationships displayed between researchers and management groups, and the acknowledgments between management groups of the reef and the wet tropics of the successful measures used in both areas to understand and build resilience to the effects of climate change. The Committee was particularly impressed with the Reef Guardian program, acknowledged by other management groups as a good mechanism for enhancing community engagement. In light of its success, there may be merit in this and similar programs being extended to other ecosystems.
- 5.55 The Committee would like to thank Ms Olivia McKenna and Mr Fred Nucifora for facilitating the Committee's visit to Reef HQ. The Committee would also like to thank Dr Steve Goosem, Mr Andrew Maclean and Mr Bradley Smith for facilitating the Committee's visit to the DRO, and all others who assisted the Committee during its site inspections in Tropical North Queensland.

**Mr Tony Zappia MP
Chair
November 2012**

39 Mr Maclean, WTMA, *Transcript of evidence*, 5 July 2012, p. 29.

Glossary of terms

The following definitions have been used by the Committee throughout the course of the inquiry.

adaptive management	Management practices that accommodate and respond to uncertain future events.
biodiversity	A word derived from 'biological diversity'. The variety of all life forms: the different plants, animals and micro-organisms, their genes and the communities and ecosystems of which they are part.
biogeography	The study of the distribution of species, organisms and ecosystems in geographic space and through geological time.
bioscience	The study of nature, behaviour, and uses of living organisms. (Also <i>life science</i> .)
brackish	A term used to describe water that has more salinity than fresh water, but not as much as seawater.
citizen science	Scientific research that is carried out, in whole or in part, by amateur or nonprofessional scientists.
community ecology	Study of the organisation and functioning of communities, which are assemblages of interacting populations.
connectivity	The extent to which particular ecosystems are joined with others of similar kind; the ease with which organisms can move across the landscape.
conservation	Prudent management of natural resources in order to preserve and protect them.
coral bleaching	The whitening of a coral colony, indicative of environmental stress, whereby the coral expels symbiotic algal cells (<i>zooxanthellae</i>) from its body.

cropping	Cutting and collecting mature produce from the land.
ecological niche	The relational position of a species or population within an ecosystem, with respect to both its role and the space it inhabits.
ecology	The scientific study of the distribution and abundance of life on Earth, and the interactions between organisms and their environment.
endemic	Occurring only in the stated area.
estuary	A partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea.
fauna	Animal life.
fire regime	The combination of fire frequency, intensity, interval and season.
floodplain	Flat land adjacent a stream or river that is naturally subject to flooding.
flora	Plant life.
gene technology	Activities concerned with understanding the expression of genes, taking advantage of natural genetic variation, modifying genes, and transferring genes to new hosts.
grazing	A type of feeding where herbivores eat grass or other low vegetation.
hydrodynamics	The study of liquids in motion.
hydrology	The study of the movement, distribution and quality of water.
hypersaline	Salt levels surpassing that of ocean water.
in situ	A Latin phrase which translates literally to 'in position'. In ecological terms it refers to an organism in its natural habitat.
intertidal	The foreshore or littoral region that is above the low-water mark and below the high-water mark.
invertebrate	An animal lacking a backbone (spinal column).
monoculture	A single, homogenous culture without diversity; a system with low diversity.
monsoon	A wind system that reverses with the seasons.

oology	The study of bird eggs, nests, and breeding behaviour.
phenology	The study of periodic plant and animal life cycle events and how these are influenced by seasonal and interannual variations in climate.
photovoltaic	Technology for converting sunlight directly into electricity, usually with photovoltaic (solar) cells.
phylogeny	The evolutionary development and history of a species or higher taxonomic group of organisms.
potable	Fit or suitable for drinking; drinking water.
propagate	To cause an organism to multiply by processes of natural reproduction from parent stock.
refugia	Areas where special environmental circumstances enable a species or community of species to survive after extinction in surrounding areas.
remnant	A remaining portion of natural habitat.
resilience	The capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain function, structure, identity and feedbacks; the extent to which a system is able to change in response to a disturbance.
riparian	Relating to the interface between land and a watercourse.
substrate	A surface or substance upon which an organism grows or is attached.
systematics (biological)	The study of diversification of living forms, past and present, and the relationships among living things through time.
taxonomy	The science of identifying and classifying species.
tidal mudflats	Coastal wetlands that form when mud is deposited from tides or rivers.
tidal zone	An area subject to tidal action.
tipping point	The point at which a relatively small change in external conditions causes a rapid change in an ecosystem, often leading to an abrupt change in ecosystem health. (Also <i>critical threshold</i> or <i>ecological threshold</i> .)
totem	An object or natural phenomenon (often an animal or plant) that serves as a token or emblem of a family, clan or group.

tributary	A stream or river that flows into a main or parent river or lake. A tributary does not flow directly into a sea or ocean.
vertebrate	An animal with a backbone (spinal column), including: sharks and rays; bony fish; amphibians; reptiles; birds; and mammals.
viticulture	The science, production and study of grapes and their culture; Grape-growing.
zooxanthellae	Parasitic or symbiotic yellow or brown algae living in various marine invertebrates (such as corals).
