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Introduction to biodiversity and the inquiry

> Biodiversity is the variety of life. It includes not only the diversity of species of plants, animals, fungi, bacteria and viruses that inhabit our planet, but also the genetic material within those species, the diversity of ecosystems, habitats and communities within which they live, and the diversity of processes that are performed by genes and species and the interactions among them.[1]

1.1 Australia has a rich biodiversity, with between 7 and 10 per cent of all species on Earth occurring here.[2] There are between 600 000 and 700 000 species found in Australia, many of which are unique (endemic) to the country.[3] The main drivers affecting the state of the environment are recognised as being climate change, population growth and economic growth.[4]

1.2 In recognition of the immensity and relevance of these issues in current debates and challenges facing government in Australia and internationally, the Committee sought to conduct an inquiry into climate change impacts on biodiversity, and on 2 June 2011 adopted broad terms of reference, with a focus on nationally important ecosystems.

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1 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC), Canberra, 2011, p. 573.

2 W. Steffen, A.A. Burbidge, L. Hughes, R. Kitching, D. Lindenmayer, W. Musgrave, M. Stafford Smith, P.A. Werner, *Australia's biodiversity and climate change*, Commonwealth Scientific and Industrial Research Organisation (CSIRO) publishing, Collingwood, Victoria, 2009, p. 7.

3 DSEWPAC, 'Biodiversity hotspots', <http://www.environment.gov.au/biodiversity/hotspots/index.html> viewed 4 March 2013.

4 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 45.

Conduct of the inquiry

1.3 The Committee received 89 submissions, 14 supplementary submissions and 60 exhibits. Based on those submissions, public hearings and site inspections were held in each state and territory. In the course of these site inspections, the Committee received extensive and valuable evidence on aspects of climate change impacts in nationally important ecosystems. As a result, two interim reports were published in May and November 2012. The interim reports provide a useful platform on which this final report is based. Without duplicating the narrative of the interim reports, some themes are further developed in this final report, which takes a more strategic focus and makes recommendations for changes to administration and policy in biodiversity conservation and related areas.

1.4 The first interim report (May 2012) reviewed site inspections conducted in south-west Western Australia, an internationally recognised biodiversity hotspot; the Tasmanian Midlands and Central Plateau; the New South Wales Snowy Mountains region, and areas around Sydney, NSW, which included biodiversity conservation programs in urban areas.[5]

1.5 The second interim report (November 2012) reviewed museums and bird habitats in Victoria, water and biodiversity 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.[6]

1.6 In conducting such a comprehensive inquiry, the Committee focussed on the likely impacts of biodiversity if climate change projections are realised, and the resultant implications for management and policy-making in biodiversity conservation. The Committee did not focus on the causes of climate change or sustainable population growth as relating to biodiversity. As the terms of reference required, attention was given to 'nationally important ecosystems', although themes and issues considered by the Committee in its 2009 report into managing Australia's coastal zone continued to inform members' deliberations.[7]

Structure of this report

1.7 As noted earlier, both interim reports provided a platform; a means to explore themes common to more than one term of reference, and across

5 House of Representatives Standing Committee on Climate Change, Environment and the Arts (CCEA Committee), *Case studies on biodiversity conservation: volume 1*, May 2012.

6 CCEA Committee, *Case studies on biodiversity conservation: volume 2*, November 2012.

7 House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts, *Managing our coastal zone in a changing climate: The time to act is now*, October 2009.

nationally important ecosystems. For example, community engagement was a theme in projects in most states, and across most ecosystem projects, although some of the challenges faced by the projects may have related specifically to data-collection, or the nature of the threat from pests or invasive species. An inquiry of this breadth and complexity will inevitably produce many areas which 'overlap', and structuring the interim and final reports to reflect these complexities will inevitably result in intersecting discussions across some terms of reference.

1.8 The remainder of this chapter will follow the first term of reference, and examine the state of Australia's terrestrial, marine and freshwater biodiversity.

1.9 Chapter two considers the third term of reference, and examines the effects of biodiversity loss on human communities. Ecosystem services are discussed, and conclusions and recommendations are made in relation to national environmental accounts and citizen science initiatives.

1.10 Chapter three examines examples of the sustainable use of resources encountered by the Committee, particularly during site inspections. Considering the fifth and seventh terms of reference, the Committee acknowledges the importance of government support for such initiatives and the benefits for community engagement.

1.11 Chapter four considers connectivity conservation as a management approach in a changing climate, following the second term of reference, and also explores community engagement and the National Reserve System.

1.12 Chapter five examines climate change adaptation strategies in relation to mitigation, resilience and adaptive management, as well as the resources required to support these strategies. In considering the fourth term of reference, conclusions and recommendations are made on a range of issues including funding, the National Plan for Environmental Information, and national biodiversity databases.

1.13 Chapter six considers the effectiveness of the natural resource management structure in Australia, including its funding and the need for regional approaches; these relate to the seventh term of reference.

1.14 Chapter seven assesses governance issues relating to the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), international obligations, cross-border management and integrated forest management, following the sixth term of reference, and makes recommendations accordingly.

1.15 Aspects of community engagement, as referred to by the seventh term of reference, are relevant to many areas of the report, and are therefore considered in chapters two, three, four and six.

The state of Australia's biodiversity

1.16 The Committee considered the state of biodiversity in terrestrial, marine and freshwater environments, as well as examining biodiversity 'hotspots'. The current state of these different environments and hotspots will be canvassed, followed by an outline of threats, and current and projected losses to biodiversity. Climate change is seen as an additional stressor on biodiversity in each of these environments, to varying extents and with varying effects. Some of the threats posed by climate change will then be discussed in general terms, followed by a specific focus on marine and freshwater ecosystems. At the conclusion of this chapter, observations of the Committee across its range of site inspections are summarised, demonstrating the range of impacts and the extent of variability.

Terrestrial

1.17 There are 85 bioregions in Australia, representing vast and diverse terrestrial ecosystems including deserts, rangelands, tropical monsoon rainforests, temperate grasslands, wet eucalypt forests, alpine regions, and sub-Antarctic and Antarctic regions in the external territories.[8]

1.18 As mentioned above, there are many endemic species in Australia's terrestrial environment, including:

- 1350 endemic terrestrial vertebrates
- 305 terrestrial mammal species, of which 85 per cent are endemic
- 89 per cent of reptile species
- 94 per cent of frog species
- 45 per cent of bird species
- 17 580 species of flowering plants, of which 91 per cent are endemic.[9]

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8 Australian Bureau of Statistics (ABS), '1301.0 – Year Book Australia, 2009-10', <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1301.0Feature+Article12009%E2%80%9310> viewed 5 March 2013.

9 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, , Canberra, 2011, p. 574, citing various sources; DSEWPAC, 'Biodiversity hotspots', <http://www.environment.gov.au/biodiversity/hotspots/index.html> viewed 4 March 2013.

1.19 The 2011 State of the Environment report assessed terrestrial plant species in 'high-altitude, remote and/or very dry parts of Australia' as in a good state, with adequate high-quality evidence and a high level of consensus supporting the assessment. Recent trends indicated that the assessment was stable, with limited evidence or limited consensus.[10]

1.20 The outlook was not as positive for terrestrial birds, reptiles and amphibians, which were all assessed as in a poor state, with recent trends indicating that state was deteriorating, with limited evidence or limited consensus on both the assessments and the trends. Terrestrial mammals fared even worse, being assessed as in a very poor state, with recent trends indicating that state was deteriorating, with limited evidence or limited consensus on both the assessments and the trends.[11]

1.21 Terrestrial invertebrates were assessed as in a poor state and the trend as being unclear, with evidence and consensus too low to make a confident assessment on both the state and trend.[12]

Marine

1.22 Australia's marine environment covers 16 million square kilometres and 37 000 kilometres of coastline, including Australia's Exclusive Economic Zone, the continental shelf and vast oceans incorporating tropical marine to sub-Antarctic ecosystems.[13] These ecosystems include coral reefs, seagrass plains, kelp forests, sand-bottomed habitats, seamounts, mangrove forests and abyssal plains.[14]

1.23 The Census of Marine Life, completed in 2010, identified that Australia has approximately 33 000 marine species recorded in the major marine databases, with a further estimated 17 000 species being likely to occur (as reported but not confirmed). Of the recorded species there are:

- 58 listed as threatened

10 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 615.

11 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 615.

12 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 615.

13 ABS, '1301.0 – Year Book Australia, 2009-10', <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1301.0Feature+Article12009%E2%80%9310> viewed 5 March 2013.

14 ABS, '1301.0 – Year Book Australia, 2009-10', <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1301.0Feature+Article12009%E2%80%9310> viewed 5 March 2013; CSIRO, *Submission 23*, p. 8.

- an unknown number being endemic
- 8525 species of mollusc
- 6365 species of crustacean
- 5184 species of fish.[15]

1.24 Further, '[i]t is crudely estimated that there may be as many as 250 000 species (known and yet to be discovered) in the Australian EEZ [Exclusive Economic Zone]'.[16] The Australian Marine Sciences Association stated that 'there is a serious underestimate of our known marine biodiversity', especially in northern Australia and in deeper waters.[17]

1.25 The 2011 State of the Environment report stated that knowledge of distribution and taxonomy of Australia's marine species remains patchy.[18] The report gave an assessment of the overall state of marine species and ecosystem as in good condition, with recent trends indicating that good condition as stable, with limited evidence or limited consensus on both the assessment grade and trend. The report further assessed a few areas, specifically coastal places and areas on the continental shelf and upper slope, as in very poor condition due to the effects of specific human activities. The recent trend indicated that very poor condition as deteriorating, with limited evidence or limited consensus on both the assessment grade and trend.[19]

Freshwater

1.26 Freshwater ecosystems incorporate, among others, lakes, swamps, wetlands, waterways and rivers. The Australian Bureau of Statistics' (ABS) 2009-10 Year Book identified a likelihood of high levels of locally endemic

15 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 382-83, citing AJ Butler, T Rees, P Beesley, NJ Bax, *Marine biodiversity in the Australian region*, PLoS ONE 2010;5(8):e11831. For further discussion on the Census of Marine Life, see CCEA Committee, *Case studies on biodiversity conservation: volume 2*, November 2012, pp. 7-8.

16 A.J. Butler, T. Rees, P. Beesley, N.J. Bax, *Marine biodiversity in the Australian region*, PLoS ONE 2010;5(8):e11831.

17 Australian Marine Sciences Association, *Submission 17*, p. 1.

18 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 382.

19 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 616.

freshwater species, and some species with limited distribution, including crayfish, dragonflies and mountain stream frogs.[20]

1.27 In terms of monitoring the biodiversity of freshwater ecosystems, an example given in the 2011 State of the Environment report highlighted that 'only 17 [per cent] of Australia has comprehensive mapping of wetlands'.[21] The Water Resources and Freshwater Biodiversity Adaptation Research Network also indicated that for large parts of Australia, including 75 per cent of WA:

> … there is limited mapping of freshwater ecosystems or information about freshwater system values, typology, hydrology or variability. Even less knowledge exists about groundwater-dependent ecosystems in Australia.'[22]

1.28 The ABS 2009-10 Year Book also stated that many of Australia's aquatic [marine and freshwater] species are endemic and that 'there are likely to be many more aquatic species in Australia than are currently described'.[23]

1.29 The 2011 State of the Environment report assessed the state and trends of aquatic species and ecosystems in northern and central Australia and in southern, eastern and south-western Australia. The freshwater ecosystems in northern and central Australia were assessed to be in good condition, with adequate high-quality evidence and a high level of consensus on the assessment grade. The trend was assessed as stable, with limited evidence or limited consensus on the trend.

1.30 The southern, eastern and south-western Australian freshwater ecosystems were assessed as being in a poor condition and deteriorating in recent trends in areas heavily developed for agriculture. The assessment summary also indicated that 'information on wetlands is limited but there is good evidence of losses and poor health of rivers in large areas of south-

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20 ABS, '1301.0 – Year Book Australia, 2009-10', <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1301.0Feature+Article12009%E2%80%9310> viewed 5 March 2013.

21 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 612.

22 Water Resources and Freshwater Biodiversity Adaptation Research Network, *Submission 22*, p. [4].

23 ABS, '1301.0 – Year Book Australia, 2009-10', <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1301.0Feature+Article12009%E2%80%9310> viewed 5 March 2013.

eastern and south-western Australia'. There was limited evidence or limited consensus on both assessment of the state and trend.[24]

Biodiversity hotspots

1.31 Australia is one of 17 'megadiverse' countries, with 15 national biodiversity hotspots across the continent.[25] National biodiversity hotspots were first identified in 2003 as areas:

- that 'support natural ecosystems that are largely intact and where native species and communities associated with these ecosystems are well represented'
- with high levels of locally endemic species
- where the levels of stress or future threat were considered to be high.[26]

1.32 The Committee visited the Tasmanian Midlands national biodiversity hotspot and one in the south-west of WA—the Busselton-Augusta national biodiversity hotspot—during its site inspection program. The south-west WA hotspot is the only one of the national hotspots to have been designated one of 34 global biodiversity hotspots.[27] Global biodiversity hotspots must contain at least 1500 endemic species of vascular plants and must have lost at least 70 per cent of its original habitat.[28]

1.33 The south-west of WA is a 'flat, stable highly weathered low plateau dominated by old landscapes with nutrient-deficient soils', an area in which fire plays a major role. The south-west of WA displays a number of notable statistics:

- more than 7400 named plant taxa and an estimated 6500 vascular flora species, with greater than 50 per cent being endemic

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24 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, p. 616.

25 DSEWPAC, 'Biodiversity hotspots', <http://www.environment.gov.au/biodiversity/hotspots/index.html> viewed 4 March 2013.

26 DSEWPAC, 'Biodiversity hotspots', <http://www.environment.gov.au/biodiversity/hotspots/index.html> viewed 4 March 2013.

27 Conservation International, 'Overview', <http://www.conservation.org/where/priority_areas/hotspots/asia-pacific/Southwest-Australia/Pages/default.aspx> and <http://www.conservation.org/where/priority_areas/hotspots/hotspots_revisited/key_findings/Pages/key_findings.aspx> viewed 4 March 2013.

28 Conservation International, 'Hotspots defined', <http://www.conservation.org/where/priority_areas/hotspots/Pages/hotspots_defined.aspx> viewed 4 March 2013.

- approximately 20 per cent of plant species are listed as threatened, rare or poorly known
- approximately 100 species of vertebrates are endemic
- sixty-three wetlands of national significance are located in the region
- in 2007 there were 82 threatened ecological communities, 351 threatened plant taxa (111 critically endangered) and 69 threatened non-marine animal taxa in the region.[29]

Threats to biodiversity

1.34 There are many threats to Australia's biodiversity, including:

- land-use practices and changes
- grazing pressure
- habitat fragmentation
- climate change including pollution
- invasive species
- fire regime change
- hydrology change
- consumption of natural resources.[30]

1.35 The impacts of these threats vary across the continent, as the Committee discovered throughout its site inspection program, with some examples given below.

1.36 **Land use** poses a threat to biodiversity. Land clearing for timber harvesting, urban expansion, mining, agriculture and tourism can impact negatively on biodiversity. In some areas, such as the south-west of WA, there has been extensive clearing for agricultural and urban use, creating small pockets of remnant vegetation thereby making conservation management and species movement difficult.[31]

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29 W. Steffen, A.A. Burbidge, L. Hughes, R. Kitching, D. Lindenmayer, W. Musgrave, M. Stafford Smith, P.A. Werner, *Australia's biodiversity and climate change*, CSIRO publishing, Collingwood, Victoria, 2009, p. 55, citing Andrew A Burbidge.

30 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, pp. 617-18.

31 W. Steffen, A.A. Burbidge, L. Hughes, R. Kitching, D. Lindenmayer, W. Musgrave, M. Stafford Smith, P.A. Werner, *Australia's biodiversity and climate change*, CSIRO publishing, Collingwood, Victoria, 2009, p. 55, citing Andrew A Burbidge.

1.37 **Invasive species** can have a devastating impact on ecosystems, like phytophthora dieback has on native forests.[32] The myrtle rust disease has spread on windborne spores up the east coast of Australia, threatening to infect over 200 plant species in the wet tropics of Queensland.[33] Invasive weeds like para grass in the Northern Territory quickly dominate and create monocultures in the ecosystems they invade, having the potential to alter fire regimes due to the resultant increased fuel loads.[34]

1.38 **Fire** poses a threat to biodiversity, making fire management an important land management tool for biodiversity and ecosystem protection. Fire management in Kakadu National Park is based on Indigenous methods for burning, hazard reduction, and for managing species, with the interrelationships being used to protect the habitat of species that are important for ecological and cultural reasons.[35]

Biodiversity losses

1.39 The many threats to Australia's biodiversity have resulted in losses in biodiversity, with more losses predicted in future. The 2011 State of the Environment report included a number of national assessments of species, with statistics on biodiversity losses which included:

- small mammals in northern Australia are declining, with modern mammal extinctions having mostly occurred in central and northern bioregions, with up to 12 taxa having been lost
- up to 25 per cent of known species for reptiles are threatened
- many amphibian species have become regionally extinct in the past decade
- 90 per cent of floodplain wetlands in the Murray-Darling Basin have been lost.[36]

1.40 The ABS reported that:

> Australia has experienced the largest documented decline in biodiversity of any continent over the past 200 years. Under the EPBC Act, more than 50 species of Australian animals have been listed as extinct, including 27 mammal species, 23 bird species, and 4 frog species. The number of known extinct Australian plants

32 CCEA Committee, *Case studies on biodiversity conservation: volume 1*, May 2012, pp. 11-12.

33 CCEA Committee, *Case studies on biodiversity conservation: volume 2*, November 2012, p. 59.

34 CCEA Committee, *Case studies on biodiversity conservation: volume 2*, November 2012, p. 44.

35 CCEA Committee, *Case studies on biodiversity conservation: volume 2*, November 2012, pp. 45-46.

36 State of the Environment 2011 Committee, *Australia State of the Environment 2011: An independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, DSEWPAC, Canberra, 2011, pp. 602, 610, 612.

> is 48. Australia's rate of species decline continues to be among the world's highest, and is the highest in the OECD.[37]

1.41 A number of species have been declared as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act); as at March 2009 there were 1318 threatened plant species and subspecies and 402 threatened animal species and subspecies listed under the EPBC Act.[38]

1.42 In January 2010, the ABS reported on the increase in threatened species and communities in the ten years between the introduction of the EPBC Act in 1999 to 2009:

> [During this period] … the number of threatened fauna has risen by 35%, from 315 to 426 in 2009. In 2009, almost half (47%) the species on the list were vulnerable, 40% were endangered or critically endangered, and 13% were extinct or extinct in the wild.
>
> Together, birds and mammals accounted for the majority of vulnerable and endangered species, and almost half the extinct species were mammals.
>
> Since the commencement of the EPBC Act, the number of listed threatened flora has risen by 15%, from 1,147 in 2000 to 1,324 in September 2009. In 2009, there were 24 eucalypt species listed as endangered and 49 listed as vulnerable. Two species of wattle were listed as extinct, three as critically endangered, 29 as endangered and 44 as vulnerable.
>
> The number of threatened communities rose from 21 in 2000 to 46 in 2009. However, these increases may reflect improved information and field investigations and do not necessarily represent a change in conservation status of ecological communities.[39]

1.43 The Australian Coral Reef Society stated in its submission that, globally, 19 per cent of coral reefs have been lost and 35 per cent are threatened, mostly due to human activity.[40]

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37 Liz Burton, *Submission 85*, pp. 22-23, quoting the ABS, '1301.0 – Year Book Australia, 2009-10'.

38 W. Steffen, A.A. Burbidge, L. Hughes, R. Kitching, D. Lindenmayer, W. Musgrave, M. Stafford Smith, P.A. Werner, *Australia's biodiversity and climate change*, CSIRO publishing, Collingwood, Victoria, 2009, p. 44. Section 179 of the EPBC Act categorises listed threatened species into six categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, and conservation dependent.

39 ABS, '4613.0 - Australia's Environment: Issues and Trends, Jan 2010', <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/DD486E7A8C8F95A4CA2576C000194E09?opendocument> viewed 5 March 2013.

40 Australian Coral Reef Society, *Submission 63*, p. [2].

1.44 The Water Resources and Freshwater Biodiversity Adaptation Research Network stated that 'freshwater systems have the highest rates of extinction of any ecosystem, with estimates of at least 10 000—20 000 freshwater species extinct or at risk'.[41]

Impacts of climate change

1.45 Climate change is expected to act as an additional stressor on biodiversity, at the same time interacting with existing threats to exacerbate pressure and transform ecosystems, presenting managers with novel ecosystems and challenges.

1.46 The 2012 State of the Climate report highlighted a number of key changes that have occurred in the climate, and the predicted impacts of those changes, as follows:

- both natural and human influences have affected climate over the past 100 years
- human activities have also influenced ocean warming, sea-level rise, and temperature extremes
- it is clear that increasing greenhouse gas concentrations will result in significant further global warming
- further uncertainties relate to tipping points in the climate system, such as the break-up of ice-sheets, which can lead to rapid climate change.[42]

1.47 The Committee heard from Professor Will Steffen that climate is 'not just another environmental issue,' and that:

> … climate actually affects the basic physical and chemical underpinning of life …
>
> It changes temperature, it changes rainfall, it changes water availability, it changes CO2 and, of course, plants are affected by that because it is indeed a plant food and they react to that. We change the acidity of the ocean and the land and so on. These are the very fundamental basic underpinnings of life.
>
> … the rate of change is unprecedented at least since the last mass extinction event about 60 million to 65 million years ago.[43]

41 Water Resources and Freshwater Biodiversity Adaptation Research Network, *Submission 22*, p. [3].

42 Australian Government, 'State of the Climate 2012', Bureau of Meteorology, Commonwealth Scientific and Industrial Research Organisation, Canberra, 2012, pp. 4, 12.

43 Professor Will Steffen, Executive Director, Australian National University Climate Change Institute, *Transcript of evidence*, 13 October 2011, p. 2.

1.48 Changes in temperature, rainfall, extreme weather events and sea level rise, among others, have already affected Australia's biodiversity. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) stated, in a terrestrial biodiversity context, that climate change is predicted to affect almost all aspects of biodiversity conservation, as well as amplify and further complicate the management of existing threats to biodiversity, such as those described earlier.[44] The CSIRO also highlighted that:

> Species and ecosystems are very likely to be affected directly by impacts cascading from individuals to populations to ecosystems and indirectly via changes to the interactions between species, provision of habitat, regulation of ecosystem processes and feedbacks on the climate.[45]

1.49 The National Climate Change Adaptation Research Facility (NCCARF) Terrestrial Biodiversity Network stated that:

> Australia's biodiversity is unique and there is strong evidence to demonstrate that negative impacts due to climate change are already occurring across many taxonomic groups and environmental processes, and that these impacts will continue to get significantly worse in the future. Consequently, Australian natural ecosystems are highly vulnerable to global climate change and it is recognised that they have a lower capacity to adapt compared to other settings such as agricultural and urban environments … These negative trends compound the pressures on ecosystems that are already stressed by invasive species, habitat loss and fragmentation, fire, feral animals and natural climate variability.[46]

Impacts on marine and freshwater biodiversity

1.50 The CSIRO stated that:

> Marine, coastal and estuarine biodiversity is already, or highly likely to be, affected by sea level rise, increased ocean storm intensity, ocean acidification, increasing sea surface temperatures, the southern penetration of the East Australia Current … These effects are expected to cascade throughout food chains with flow-on effects that cannot fully be anticipated.[47]

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44 CSIRO, *Submission 23*, p. 7.

45 CSIRO, *Submission 23*, p. 7.

46 National Climate Change Adaptation Research Facility (NCCARF), National Adaptation Research Network - Terrestrial Biodiversity, *Submission 20*, p. [2].

47 CSIRO, *Submission 23*, p. 9.

1.51 The CSIRO gave examples of how 'human, land and resource use pressures are likely to interact with climate change to exacerbate the impacts on marine systems':

- poor water quality (e.g. due to terrestrial runoff at the coast) increases coral bleaching risk
- coastal development may limit landward migration of estuarine habitats as sea levels rise
- fishing pressures may limit the capacity of species to repopulate habitats following disturbance events.[48]

1.52 The 2012 Marine climate change in Australia report card highlighted a number of key changes that have already occurred in the marine environment due to increasing sea temperatures, as follows:

- sea temperature increases of between 2 and 4 degrees Celsius on the west coast (in early 2011), with changes in the local abundance and distribution of seaweeds, abalone, and fish species reported, and a shift towards a more tropical fish community observed, providing insight to possible long-term change
- a demonstrated southwards retreat of macroalgae (a foundation species that supports marine life) by 10 to 50 kilometres per decade, being likely to affect entire marine ecosystems
- changes in sex ratios of sea turtles, more frequent bleaching of corals, changes in abundance of fish species, and ocean acidification leading to a potential reduction in coral calcification
- southwards movements of seaweeds, phytoplankton, zooplankton and some fish species have been documented.[49]

1.53 The report card also indicated that increasing sea temperatures are likely to impact on the distribution of marine mammals and seabirds, with species likely to move southwards.[50] Sea level rise was stated to be increasing at 3mm per year, which will threaten coastal systems.[51]

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48 CSIRO, *Submission 23*, p. 9.

49 E.S. Poloczanska, A.J. Hobday and A.J. Richardson (editors), *Marine climate change in Australia: impacts and adaptation responses – 2012 report card*, CSIRO Climate Adaptation Flagship, NCCARF Marine Biodiversity and Resources Adaptation Network, Fisheries Research and Development Corporation, Canberra, 2012.

50 E.S. Poloczanska, A.J. Hobday and A.J. Richardson (editors), *Marine climate change in Australia: impacts and adaptation responses – 2012 report card*, CSIRO Climate Adaptation Flagship, NCCARF Marine Biodiversity and Resources Adaptation Network, Fisheries Research and Development Corporation, Canberra, 2012.

51 E.S. Poloczanska, A.J. Hobday and A.J. Richardson (editors), *Marine climate change in Australia: impacts and adaptation responses – 2012 report card*, CSIRO Climate Adaptation Flagship, NCCARF Marine Biodiversity and Resources Adaptation Network, Fisheries Research and Development Corporation, Canberra, 2012.

1.54 The Australian Institute of Marine Science stated that the trend of increasing carbon dioxide in the atmosphere:

> … means that the threat from ocean warming and acidification to Australia's coral reefs will grow significantly stronger over the coming decades. Predictions are more intense coral bleaching events, more frequent severe cyclones and declining capacity for damage repair.[52]

1.55 The Great Barrier Reef Marine Park Authority stated that climate change is likely to be the greatest influence on the long-term outlook for the Great Barrier Reef.[53]

1.56 The Australian Marine Sciences Association (AMSA) stated that:

> … extinction risk is highest for endemic species and those that have narrow distributional ranges … As the ocean warms, these [endemic] species will increasingly be restricted to a smaller portion of Australian waters, and range shifts will be limited by the southern extent of our coastline.'[54]

1.57 AMSA also discussed how climate change will affect key physical processes in the marine environment, as follows:

> … the increased frequency and severity of catastrophic events such as cyclones will damage marine coastal habitats impairing their function and, in turn, impacting biodiversity. These habitats will be among the first and most severely affected by sea level rise … Rising sea levels will affect the distribution of wetlands and seagrasses and drown intertidal habitats which are critical to biodiversity because of their nursery ground value and their role in translocation of nutrients to offshore habitats. In some cases these communities will migrate to follow rising sea levels, but in many situations this movement will be blocked by human structures such as training walls and roadways.[55]

1.58 In terms of climate change impacts on freshwater biodiversity, CSIRO advised the Committee that:

> Freshwater aquatic biodiversity is predicted to be altered by climate change via direct and indirect pathways. The direct pathways that are predicted to affect water quality and quantity are:

52 Australian Institute of Marine Science, *Submission 59*, p. 2.

53 Great Barrier Reef Marine Park Authority, *Submission 28*, p. [1], as referring to the *Great Barrier Reef Outlook Report 2009*.

54 Australian Marine Sciences Association, *Submission 17*, p. 2.

55 AMSA, *Submission 17*, pp. 2-3.

- changes in global air and sea temperature are reflected in equivalent changes in water temperatures of streams, lakes, wetlands, etc;
- an increase in air temperature will result in increased water temperature, longer stratification periods in reservoirs and lakes, as well as advances in spring events and delays in autumn events;
- intensification of coastal winds mainly due to higher cyclonic activity increase shore erosion, alter mixing patterns, and lead to changed salinity conditions in coastal lakes and estuaries;
- changes in precipitation and evaporation will result in changes of hydrological cycles, river flow regimes, sediment and nutrient transport, and can promote salinisation;
- changes of flow regime classes due to decrease in precipitation;
- reduction of water availability in large parts of Australia;
- sea level rise will result in inundation of coastal freshwater ecosystems, saltwater intrusion in coastal groundwater systems, and upstream movement of the tidal influence; and
- increased CO2 absorption will result in fresh water becoming more acidic, in some cases an increase in phytoplankton productivity or a decrease in, for example molluscs, is possible.

Indirect pathways by which freshwater biodiversity is predicted to be affected include:

- levels of dissolved oxygen tend to decrease due to increasing temperature, possibly decreasing wind speeds, and possible increase in eutrophication
- changes in air temperature will lead to changes in evaporation impacting mainly shallow water bodies and wetlands by reducing water levels.

The net effect of these factors is that freshwater ecosystems are likely to be significantly affected by climate change; however, in general the research base here is poorer than in other environments.[56]

1.59 The Water Resources and Freshwater Biodiversity Adaptation Research Network outlined a number of ways that freshwater ecosystems are expected to be affected by climate change, including by changes in hydrological regime, global warming, sea level rise, and aquatic chemistry through groundwater and sub-surface water exchange.[57]

56 CSIRO, *Submission 23*, pp. 9-10.

57 Water Resources and Freshwater Biodiversity Adaptation Research Network, *Submission 22*, p. [3].

Variable impacts of climate change nationally

1.60 The Committee observed variations in climate change impacts across the country, as displayed in different regions and different ecosystem types, including terrestrial, marine and freshwater. Much of this variation is described following observations and evidence from site inspections which resulted in the Committee's two interim reports:

- the decline of woodland tree species due to hotter and drier conditions, combined with an increased susceptibility to existing stressors such as diseases
- likely increase in threats from pests and diseases due to projected temperature rises
- a shift in bird ranges further south in general, and upslope in alpine areas, due to increasing temperatures
- possibility of alteration of sex-ratios and species decline of reptile species with temperature-dependent sex determination due to predicted temperature rises
- loss of species adapted to living in high altitudes due to increased temperatures
- coral bleaching of reef ecosystems that can inhibit coral reproduction, due to increased sea temperatures
- a drying trend and reduced groundwater levels due to changed rainfall patterns in southwest WA
- the decline in tree species due to reduced rainfall in the Tasmanian Midlands
- the spreading of invasive weeds into inaccessible locations due to the predicted increase in the frequency and intensity of cyclones
- loss of bird habitats due to inundation of roosting sites by sea level rise
- negative impacts on the Indigenous communities of Kakadu National Park resulting from loss of biodiversity due to climate change.

1.61 Further to the climate change impacts listed above, the Committee made several observations relating to fire regimes and increased temperatures in different ecosystems. Alpine ecosystems, such as in the Tasmanian Central Plateau, have evolved largely in the absence of fire, whilst the ecosystems in northern Australia, such as are present in Kakadu National Park, have adapted in the presence of fire over thousands of years.

1.62 The Committee observed that inappropriate fire regimes had been implemented in the alpine ecosystems of Tasmania, contributing to the decline of some species (such as the miena cider gum). On the other hand,

the Committee noted that fire management in Kakadu National Park was based on traditional Indigenous fire burning methods, hazard reduction, and for managing species (as noted above). In both cases, the Committee noted the importance of fire management for ecological and safety reasons, as well as for cultural reasons in the ecosystems of Kakadu National Park.[58]

1.63 In terms of variable impacts arising from increased temperatures, the Committee observed the impacts of species decline in alpine regions as compared to wet tropical regions. In the NSW Snowy Mountains region the Committee heard about the potential for loss of species adapted to living in high altitude conditions due to small increases in the average temperature. In the wet tropics of Queensland region, the Committee heard about the decline in numbers of the endemic lemuroid ringtail possum, partly due to an extreme, extended heat wave experienced in the region in 2005.

1.64 In the NSW Snowy Mountains region, the Committee noted the complexity of interactions taking place in the alpine environment in response to climate change, and that precise outcomes for individual species were difficult to predict but that some species would be threatened with extinction. The Committee also observed changes to the level of the alpine tree line due to increasing temperatures. In the wet tropics of Queensland, the Committee noted the potential for species adapted to living in high altitude conditions having to move to higher altitudes to survive.[59]

1.65 Having assessed in this chapter the state of Australia's biodiversity, the threats to biodiversity and biodiversity losses, and the variable impacts of climate change, the Committee will, in the next chapter, discuss the effects of biodiversity loss on human communities.

58 CCEA Committee, *Case studies on biodiversity conservation: volume 1*, May 2012, pp. 25-26; CCEA Committee, *Case studies on biodiversity conservation: volume 2*, November 2012, pp. 45-46.

59 CCEA Committee, *Case studies on biodiversity conservation: volume 1*, May 2012, pp. 38-40; CCEA Committee, *Case studies on biodiversity conservation: volume 2*, November 2012, pp. 60-61.