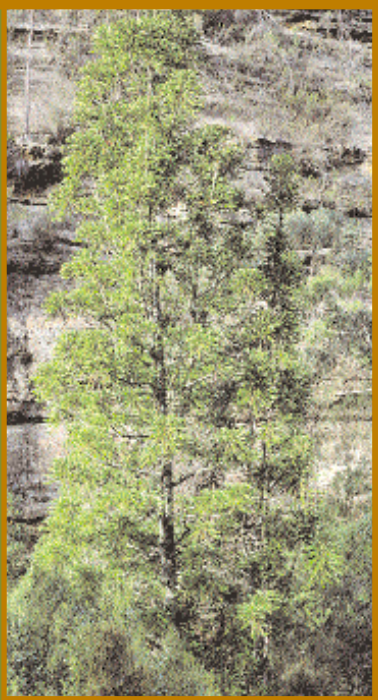
2004–2007

National Biodiversity and Climate Change Action Plan

Natural Resource Management Ministerial Council





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Landsat 2002 satellite image (Prepared by the Australian Greenhouse Office using Mosaic)

Porcupine and spinifex grass in mallee country, central New South Wales (Picture: Andrew Tatnell)

Pearson's tree frog, *Litoria pearsoniana* (Picture: HB Hines)

Rainbow (Picture: Mike Rosel, © Bureau of Meteorology).

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Further information

Further information about the action plan

The full action plan is available from the http://www.deh.gov.au/biodiversity/publications/nbccap/index.html website.

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Preface

Biodiversity underpins the ecosystem processes that make life possible and is critical to the ecological sustainability of our nation. Healthy ecosystems contribute positively to the air we breathe, the water we drink and the ability of our land to sustain production from agriculture, fisheries and forestry.

Over the 21st century, human-induced climate change may result in large-scale biodiversity loss on a global scale. In particular, climate change could cause dramatic shifts in species distributions and species extinctions, particularly across fragmented or vulnerable ecosystems. One recent study suggests that, on a worldwide sample, between 15 and 37% of species could be 'committed to extinction' by 2050 (Thomas et al 2004). Australia would not be immune.

Our biodiversity is among the most vulnerable of our assets under climate change and the health of these assets is critical to the sustainability of Australian landscapes.

During the 1990s, the world focused on strategies to reduce carbon emissions to lessen climate change. The United Nation's Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report (2001ab) concluded that human-induced climate change is already in-train and will continue into the future. It also highlighted the need for countries to develop climate change adaptation strategies in addition to greenhouse gas emission reductions.

The debate has now evolved. The response must be to address the causes of climate change by reducing greenhouse gases and, at the same time, implement strategies to adapt to climate change. This action plan is the first step along the pathway of adaptation for national biodiversity conservation.

The initial three-year planning horizon of this action plan will better equip Australia for the continuing journey as our landscapes begin to change. The action plan is intended for land and water managers and planners and policy makers, but the results of the actions in the plan should better inform land-holders and the Australian community of climate change issues and future directions.

In the 21st century, biodiversity conservation will have to address the challenges from past environmental degradation with a new overlay of pressures from climate change. These challenges are great, but they also provide us with new opportunities to improve stewardship of our biodiversity.

Executive summary

Changes to Australia's climate are already occurring over and above natural variability (eg long-term spatial and temporal changes in rainfall and temperature patterns) and these changes are expected to have an impact on Australia's biological diversity.

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2001b)[1] concluded that Australia will be vulnerable to the changes in temperature and rainfall that are projected to occur over the next 100 years. The report also identified that natural resources and biodiversity conservation are likely to be strongly affected by climate change, as climate change is likely to add to the existing substantial pressures on these sectors.

There is a reasonable scientific consensus about the expected types of impacts on species and ecosystems from future climate change, and a growing catalogue of documented changes that are consistent with climate change predictions. Nevertheless, there is much uncertainty about how individual species and ecosystems will respond to the combined impacts of future climate change and other pressures on biodiversity. Despite these uncertainties, there is a range of actions that can help reduce these impacts.

In 2001 *The Review of the National Strategy for the Conservation of Australia's Biological Diversity* (ANZECC 2001) identified the need to 'Plan to minimise the potential impacts of human-induced climate change on biological diversity'. In response to this, the *National Objectives and Targets for Biodiversity Conservation*[2] specified a target to develop a National Biodiversity and Climate Change Action Plan (the action plan). Australian governments subsequently agreed to develop this three-year action plan, to help focus efforts on minimising the impacts of climate change on species, communities and ecosystems.

The action plan will help coordinate the activities of different jurisdictions to address the impacts of climate change on biodiversity, and will be an important step in coordinating national, state and territory government's climate change impacts and adaptation programs. As well, strategies and actions in this action plan will be integrated into the development of broader biodiversity policies and programs.

The main intent of this three-year plan is to:

- identify priority areas for research and monitoring, and improve understanding of potential climate change impacts on biodiversity to a point where specific strategies can be developed
- use existing knowledge about the impacts of climate change and draw from ecological principles to review and amend current biodiversity conservation policies and strategies
- improve communication about the impacts of climate change on biodiversity between researchers, resources managers and decision makers
- raise community awareness of the potentially significant and specific impacts of climate change on biodiversity.

The action plan elaborates this approach and sets out specific objectives, strategies and actions that will be taken to reduce the impacts of climate change on Australia's native aquatic, semi-aquatic, marine, estuarine, coastal and terrestrial ecosystems, and to minimise the effect of alien invasive species on biodiversity in future climates. The development and implementation of these adaptation initiatives will complement government action to mitigate climate change.

The actions proposed in this document are aimed at reducing the impacts of climate change on each of these ecosystems, and promote in situ conservation of species and ecological communities to facilitate their natural adaptation, rather than the use of high-cost interventions such as translocation and captive breeding. Key strategies include promoting ecological connectivity to aid migration and dispersal of species, protecting refuges and creating specific management zones around important habitats.

This three-year plan is only the beginning. Programs will be reviewed in 2007 and a revised plan will be developed in light of new understanding and information.

[1] Convened under the United Nations Framework Convention on Climate Change.

[2] Environment Australia (2001) agreed by the Australian, New South Wales, Victorian, South Australian and West Australian governments: http://www.deh.gov.au/biodiversity/publications/objectives/index.html

Introduction

The *National Greenhouse Strategy: Strategic Framework for Advancing Australia's Greenhouse Response* (Commonwealth of Australia 1998), developed and endorsed by the Australian, state and territory governments, identified biodiversity as one of the key sectors sensitive to the effects of climate change and for which adaptation planning is needed.

In 2003, Australian governments agreed to develop the National Biodiversity and Climate Change Action Plan through the Natural Resource Management Ministerial Council. The action plan outlines a 'nationwide strategic approach to protect Australia's biodiversity from the impacts of climate change'.[3]

The agreement to develop the action plan builds on commitments made in:

- the *National Objectives and Targets for Biodiversity Conservation 2001–2005* (Environment Australia 2001) to 'minimise impacts of climate change on biodiversity'
- state and territory biodiversity and greenhouse strategies to address the impacts of climate change on biodiversity.

[3] Media release (26 August 2003). The Hon. David Kemp, MP, Federal Minister for the Environment and Heritage.

The action plan has been developed through an intergovernmental working group and relies on extensive consultation with stakeholders. The working group received over 40 submissions and held discussions with key stakeholder groups in October 2003. Stakeholders included scientists, environment nongovernment organisations, state/territory-based catchment management groups, state, territory and local governments and many other groups.

The action plan will help coordinate the activities of different jurisdictions to address the impacts of climate change on biodiversity, and will help coordinate national, state and territory government's climate change impacts and adaptation programs. As well, the strategies and actions outlined in this action plan will be integrated into the development of broader biodiversity policy and programs.

The goal of the action plan is to minimise the impacts of climate change on biodiversity. The plan sets out a series of adaptation strategies and accompanying actions to minimise the negative impacts of climate change on biodiversity by maximising the capacity of species and ecosystems to adapt to future climate change.

This action plan does not describe in detail the processes that contribute to climate change or the impacts of climate change on biodiversity. There are references in the bibliography that provide this information; however, key concepts have been defined in the glossary in order to reduce the possible ambiguity of some of the terminology used in this document.

Background

Climate change

Global climate change

The global climate has changed over the last century. Since 1900, the average surface temperature of the world has risen by 0.6 ± 0.2° C. In addition to the increase in global average temperature, there has been an increase in the number of heat waves, warming of the oceans, a retreat of glaciers and sea-ice, a rise in sea-level of 10–20 cm, an increase in heavy rainfall in many regions, and there have been fewer frosts (IPCC 2001ab). Since temperature records with adequate global coverage began in 1861[4], 1998 was the warmest year and the 1990s were the warmest decade globally.

There is now evidence and international consensus that increased concentrations of greenhouse gases in the atmosphere as a result of human activity are substantially responsible for driving recent climate change. With increasing emissions of greenhouse gases into the atmosphere, further climate change is forecast.

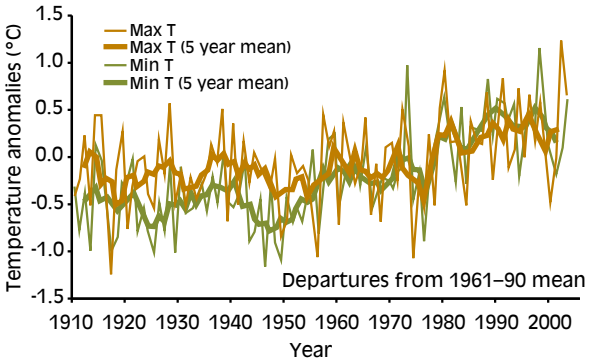
Australian climate change

Observational records reveal that Australia's climate has changed over the past century (Pittock 2003). Since 1910, the annual total rainfall averaged over all of Australia has shown a weak increase dominated by high year-to-year variability, partly due to the El-Niño Southern Oscillation cycle. The strongest increases in rainfall have occurred in tropical areas and in eastern New South Wales.

However, parts of eastern Queensland, the far southwest of Western Australia and isolated parts of the southern fringe of Australia show a decline in rainfall over the post-1900 period.

Australian annual mean temperatures since 1910 (data before this time are sparse and often recorded with nonstandard instruments) indicate that both maximum and minimum temperatures have increased, particularly since the mid-20th century. Increases in daytime maximum temperatures have been strongest in the western two-thirds of the country, with isolated parts of central and eastern New South Wales and southern Queensland having recorded weak cooling trends. Warming trends in overnight minimum temperatures have been stronger than for daytime temperatures, with all of the country having recorded an increase in overnight temperatures since 1910.

Annual temperature anomalies for Australia

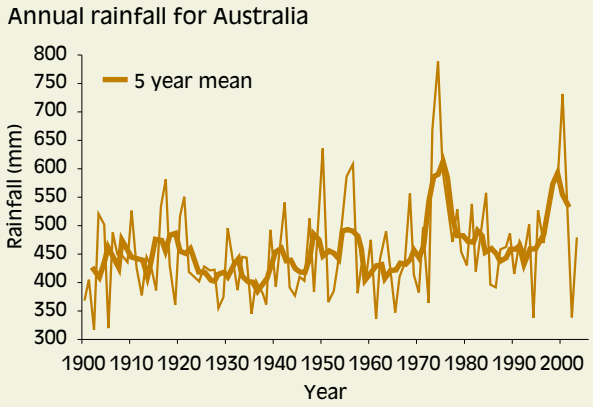


This diagram reflects the high variability in Australia's temperatures by illustrating mean, maximum and minimum temperature anomalies for Australia. Anomalies are determined with respect to the 1961–1990 average temperature range (*Bureau of Meteorology*).

[4] Actual temperature records extend back before 1861.

The CSIRO (Commonwealth Scientific and Industrial Research Organisation) has produced climate change projections for the Australian region using global climate model simulations. The latest projections of climate change, published in 2001, project the following changes for 2030 and 2070 relative to the average climate of 1990 (CSIRO 2001).

- Most of Australia may warm 0.4 to 2.0°C by 2030 and 1 to 6°C by 2070, with slightly less warming in some coastal areas and Tasmania, and the potential for greater warming in the northwest.
- Annual rainfall is predicted to generally decrease in the south and east (mainly winter/spring). Some inland and eastern coastal areas may experience wetter summers. Average annual rainfall is projected to decrease in the southwest (–20% to +5% by 2030 and –60% to +10% by 2070, rounded to the nearest 5%) and in parts of the southeast and Queensland (–10% to +5% by 2030 and –35% to +10% by 2070).
- Potential evaporation is projected to increase annually and for all seasons, ranging from 0% to 8% per degree of global warming over most of Australia, and up to 12% per degree over Australia's eastern highlands and Tasmania. These increases tend to be higher where there is a corresponding decrease in rainfall.
- Average decreases in annual water balance (the difference between potential evaporation and rainfall) are projected to range from about 40 to 120 mm per degree of global warming. These represent decreases of 15 to 160 mm by 2030 and 40 to 500 mm by 2070.
- Extreme rainfall and tropical cyclones could become more intense.



Annual total rainfall averaged across all of Australia between 1900 and 2003 (*Bureau of Meteorology*).

CSIRO has also been developing tools to project climate change on a local basis and has been undertaking projections of temperature, precipitation and potential evaporation for regions such as the Murray Darling Basin. There is a great deal of uncertainty associated with these local projections, which limits their value to natural resource managers.

Australian governments and scientific organisations are contributing to the international effort (see Appendix B) to improve climate change projections, and are working towards a better understanding of how Australia's climate may change. Strategies to adapt to climate change will need to be flexible to incorporate improved information about changes to Australia's climate as it becomes available.

A detailed review of current scientific knowledge about how climate change will affect Australia can be found in *Climate Change — An Australian Guide to the Science and Potential Impacts,* edited by Barrie Pittock and published by the Australian Greenhouse Office (Pittock 2003).

Box 1: The Australian Alps

The Australian Alps are considered to be one of the three most vulnerable ecosystems under potential climatic warming because of their restricted range and cold climate.

Brereton et al (1995) modelled the 'climatic envelope' of the mountain pygmy possum and found it 'disappeared' with an increase of +1°C in average annual temperature. Newell et al (2001) found that such an increase would have similar effects on the alpine endemic flora.

The pygmy possum hibernates under snow in winter. Predicted decreases in the amount and duration of snow cover in the future may affect the metabolic rate, behaviour and foraging of the possum (Geiser and Broome 1993). Changes in the behaviour of predators (Green and Osborne 1981), increased competition with other small mammals, and the potential impacts of warming on bogong moths (the possum's major food source) may also affect the population dynamics and survival of this vulnerable species.

Habitat of the mountain pygmy possum (*Picture: Linda Broom*).

Under climate change, species that are already vulnerable, such as those with limited ability to disperse, specialised habitat requirements, small populations and low genetic diversity will be most at risk. The mountain pygmy possum fits this category (*Picture: Linda Broom*).

Potential impacts of climate change on Australia's biodiversity

Key findings from the IPCC's Third Assessment Report

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2001ab) concludes that Australia has significant vulnerability to the changes in temperature and rainfall that are projected over the next 100 years. The report identifies natural resources and biodiversity conservation as two of the key sectors that are likely to be strongly affected by climate change. Key findings in the IPCC's Third Assessment Report include:

- Many Australian species have quite limited ranges of average climate, and their survival would be threatened if they are near the upper limit of their temperature range or in areas where migration/relocation is impossible due to clearing, soil differences, topography etc.
- Regions of particular vulnerability include the Australian Alps (see also Box 1), southwest Western Australia (see also Box 2), upland tropical rainforests (Wet Tropics) and coral reefs (eg the Great Barrier Reef, see also Box 3), arid and semiarid habitats, freshwater wetlands and riverine environments (IPCC 2001a).

A detailed review of current scientific knowledge about how climate change will impact on Australia's biodiversity can also be found in *Climate Change Impacts on Biodiversity in Australia* (Howden et al 2003), published by the CSIRO and the National Biological Diversity Advisory Committee and in Hughes (2003).

Box 2: Southwest Western Australia

Dryandra is a plant genus that belongs to the Proteaceae family. Most species of *Dryandra* have specific soil requirements and occur on soils that are only found within a restricted area of southwest Western Australia.

Plant species whose current bioclimatic envelope is very small may be more vulnerable to relatively small increases in global temperatures, while species with larger bioclimatic envelopes are likely to be more tolerant.

Bioclimatic modelling suggests that many of the 92 species of *Dryandra* could be seriously threatened with a global temperature rise of as little as 1°C. Actions that may be required to mitigate future negative impacts of warming on vulnerable *Dryandra* species include increasing the connectivity in the landscape using corridors and habitat 'stepping stones'. Pouliquen-Young and Newman (2000) suggest managing 'east–west corridors along the southern coast between Esperance and the Albany region, and north–south corridors between the Northern Sandplains and the Darling Ranges east of Perth so as to allow species movement'.

The genus *Dryandra* has a number of species that are vulnerable to climate change, including *Dryandra kippistiana* (Picture: F Humphreys) *Dryandra formosa* (Picture: G McEwin) *Dryandra cisioides* and *Dryandra tridentate* (Pictures: M Fagg © Australian National Botanic Gardens).

Impacts on biodiversity

Temperature and rainfall play major roles in determining where individual species of plants and animals can live, grow and reproduce.

The effects of climate change on species and ecosystems can be both direct and indirect.

There are a number of direct impacts of climate change on species and ecosystems.

- *Reductions in the geographic range of species*: Many Australian species currently have distributions that are extremely limited in terms of climate. For example, 25% of Australian eucalypts have distributions that span less than 1°C of mean annual temperature (Hughes et al 1996). These restricted species may be very vulnerable to even modest changes in climate. A study by Pouliquen-Young and Newman (2000), for instance, suggests that a significant number of Western Australian frog, mammal and plant species could become restricted to small areas or could disappear altogether with a warming of only 0.5°C (see Box 2, Southwest Western Australia).
- *Changes to the timing of species' lifecycles*: There is mounting evidence, for example, that species are breeding earlier in many parts of the world as a result of recent warming.
- *Changes in population dynamics and survival*: Temperature and moisture availability directly affect the physiology of species (see Box 4, North Queensland rainforests).
- *Changes in the location of species' habitats:* Many species will tend to move south or upward in elevation (if suitable habitats exist) in order to keep pace with shifting climate zones. It is also likely that expanding (cool) boundaries and contracting (warm) boundaries will move at different rates, thus affecting the size of species ranges over time.

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Box 3: The Great Barrier Reef

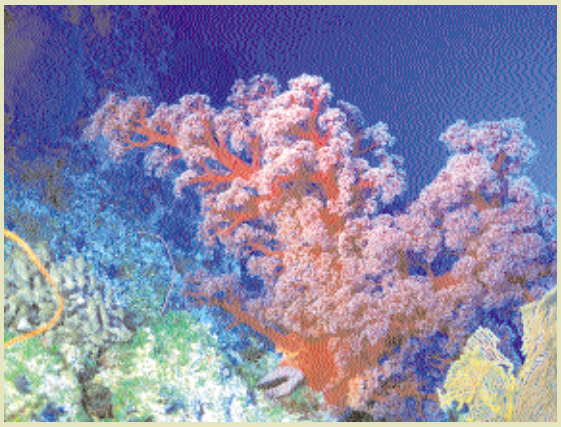
Coral bleaching associated with increased sea surface temperature is emerging as one of the most significant threats to the Great Barrier Reef (GBR) and to the regional communities, industries and economies that depend on the reef's health.

The GBR experienced major coral bleaching events in 1998 and 2002, with 60–95% of the GBR affected in the summer of 2001–02. Although corals can recover from bleaching, widespread coral death often results. Bleaching events are expected to increase in frequency and severity under predicted climate change scenarios (Hoegh-Guldberg 1999).

The Great Barrier Reef Marine Park Authority (GBRMPA) has established a comprehensive Coral Bleaching Response Program (Marshall 2003) that is being implemented in response to the threat of climate change. The program consists of five key elements: prediction, early warning, monitoring, communication and building resilience. These elements will help GBRMPA to:

- increase understanding about how the rate and extent of warming will impact the GBR
- ensure managers have timely and credible information on coral bleaching and its ecological implications for the GBR

A research scientist surveys benthic transects for coral bleaching at Magnetic Island (*Picture: R Berkelmans ©GBRMPA*).



Healthy coral produces a diversity of colours (*Picture: C Golino ©GBRMPA*).

- strengthen efforts to build coral reef resilience to climate change.

Efforts to build the resilience of the GBR ecosystem are a key focus of the management response to climate change. While the GBRMPA is unable to directly address global climate change, it is committed to increase the reef's chances of survival under climate change by supporting the reef's natural resilience.

The GBR may also be affected by the changing atmosphere because atmospheric carbon dioxide changes sea water chemistry in a way that reduces rates of coral calcification. Additionally, increased wave energy and any changes in the frequency and intensity of tropical cyclones, pest outbreaks and bleaching impacts may also have direct effects on reefs.

Indirect impacts, such as pressures from terrestrial run-off, over-fishing and losses in biodiversity, compromise the reef's resilience and, therefore, its ability to cope with climate-related stress. Through the Reef Water Quality Protection Plan, various fisheries plans and the Representative Areas Program, the GBRMPA aims to ensure that coral reefs are relieved from other pressures when exposed to coral bleaching stress, and are given a better chance to survive and recover from these events.

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- *Increases in the risk of extinction for species that are already vulnerable*: Species with limited climatic ranges (see Box 2, Southwest Western Australia), limited dispersal ability, specialised habitat requirements, small populations and/or low genetic diversity are typically the most vulnerable to extinction. These species include endemic mountain species (see Box 1, The Australian Alps) and biota restricted to islands, peninsulas, small reserves or coastal areas (see Box 3, The Great Barrier Reef). Species with extensive, nonpatchy ranges, long-range dispersal mechanisms, large populations and high genetic diversity are likely to be at less risk of extinction.
- *Increased opportunity for range expansion of invasive species:* Many weedy and pest species already possess characteristics that will allow them to take advantage of climatic changes (highly mobile, opportunistic breeding, wide climatic tolerance). Native communities under stress from climatic changes may be more susceptible to invasion and other disturbances.
- *Changes in the structure and composition of ecosystems and communities:* Changes in climatic factors such as temperature and rainfall will directly affect the distribution, phenology (lifecycles), physiology, habitat use and extinction rates of individual species. In turn, these changes will alter interactions between species (eg competition and predation), leading to changes in the structure and composition of communities and ecosystems as we know them today.
- *Changes in coastal and estuarine habitat due to rising sea levels*: Mangroves, coastal wetlands, and seagrass communities will be affected in various ways, depending on erosion, depositional processes and coastline relief.

In addition to climatic changes, the associated increase of the carbon dioxide concentration in the atmosphere will lead to changes in plant growth, nutrient composition, plant–animal interactions and ecosystem nutrient cycles. This will interact with temperature and rainfall changes.

Climate change is also expected to exert an indirect effect by influencing the intensity and magnitude of existing stresses, such as invasive species and fire regimes, on biodiversity and ecosystem structures, functions and processes. For example, changes in climate can influence fire regimes by altering the frequency, intensity and extent of fire events.

Scientific evidence is rapidly mounting that many of the changes listed above are already occurring, consistent with the warming trends over the past century (reviewed in Hughes 2000, 2003; Parmesan and Yohe 2003; Root et al 2003). These changes are expected to accelerate and become more obvious over the next few decades, though the precise nature and rate of change for individual species and ecosystems is uncertain.

Box 4: North Queensland rainforests

Ringtail possums inhabiting the rainforests of north Queensland have limited altitudinal ranges and it has been suggested that thermal tolerances may set those limits (Winter 1997; Kanowski 2001). The body temperature of the green ringtail possum rises apparently uncontrolled at ambient temperatures above 30°C. Exposure to high temperatures during heat waves lasting from several days to a week could result in mass mortality over large areas of the possums' range. As models of climate change predict not only rising temperatures, but also more frequent extreme climatic events, the marsupial folivores such as the green ringtail possum are likely to be particularly affected by climate change. In addition, plant-feeders such as the green ringtail may be affected by future reductions in leaf quality because plants grown at increased concentrations of carbon dioxide have reduced amounts of nitrogen (Kanowski 2001).

An option for providing protection to temperature-sensitive species, such as the green ringtail possum, is to identify and preserve natural refuges that have the potential to maintain temperature gradients amidst climate change and to which species can successfully migrate.

Female green ringtail possum (*Pseudochirops archeri.*) with baby (*Picture: Andrew Krockenberger*).

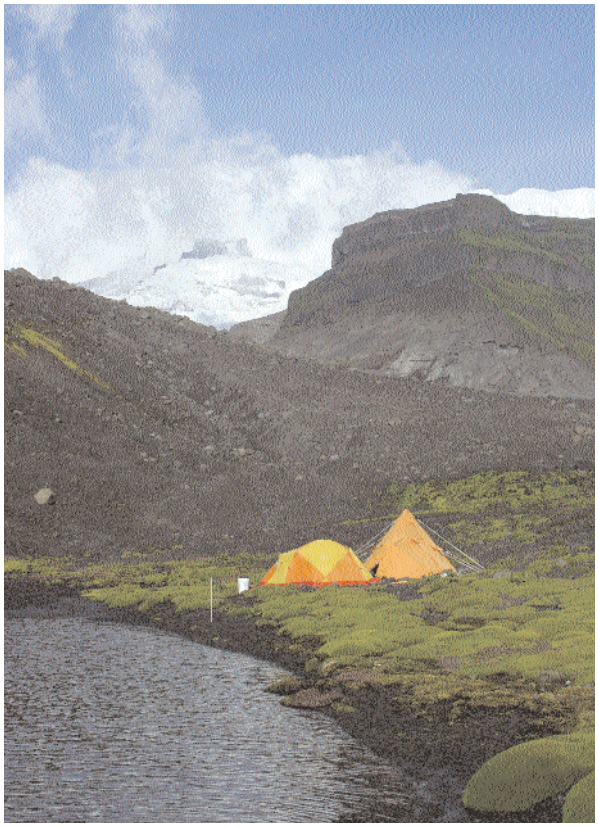
Principles underpinning the National Biodiversity and Climate Change Action Plan

Principle	Rationale
1 Actions need to be implemented at a range of management levels.	Measures designed to address climate change impacts on biodiversity need to be implemented at levels appropriate for maximising outcomes, which may include delivery at one or more of the following levels: national, state/territory, regional and local.
2 Actions need to rely on sound forward planning and make investments in adaptation secure.	Sound forward planning is essential if future investments in conservation are to be effective.
3 Objectives and actions need to be integrated with other biodiversity policies and with natural resource management (NRM) using existing government structures.	Integration will facilitate achieving outcomes through comprehensive coverage of the issues and coordinated effort. Implementation needs to be coordinated with existing and future biodiversity policy objectives and natural resource management and planning processes. Actions need to be focused on conservation of biodiversity in a globally changing climate, but in the context of existing threatening processes and conservation priorities. To achieve multiple benefits and gain efficiencies from existing policies/programs/legislation, many of the actions can be delivered through existing instruments at all levels of operation/government.
4 Planning and management for NRM activities needs to be adaptive and incorporate new information.	NRM decisions managing the impacts of climate change on biodiversity is not made once, but will be continually revised in the future as our understanding evolves through a process of adaptive management.
5 A risk-management approach is fundamental to adaptation planning.	The risk management process is about reducing the likelihood of the risks and being ready to manage the consequences should the risk materialise.
6 Actions need to be targeted to maximise biodiversity conservation outcomes.	There is a need to conserve areas where: • biodiversity is under immediate threat from climate change impacts • the conservation effort will significantly improve adaptation opportunities for species.
7 Ecosystem change and species evolution is natural and biodiversity management can accommodate these changes.	Ecosystem disruptions (for the most part caused by natural climate changes) have occurred throughout the earth's recent history. The changes are relatively abrupt, but species eventually settle down for periods of stability. Human-induced climate change has the potential to increase the rate and magnitude of these changes beyond the capacity of ecosystems to adapt. Adaptation measures can aim to increase the resilience of ecosystems, increasing the likelihood of successful adaptation and decreasing the risk of ecosystem collapse.
8 Critical thresholds of species and ecosystems need to be taken into consideration when managing biodiversity.	For all species/ecosystems there is a need to understand the temperature and other climatic and ecological thresholds that will result in significant change.

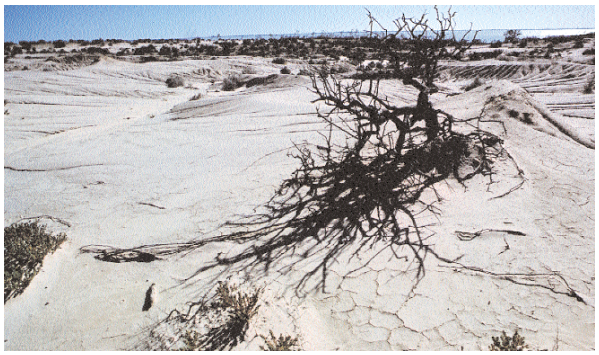
Objectives, strategies and actions

The objectives and associated actions set out in this action plan can roughly be seen as three main steps: gathering knowledge (see Objectives 1 and 2), minimising impact on biodiversity (see Objectives 3, 4, 5 and 6) and incorporating knowledge and harm-minimisation strategies into natural resource and land-use management (see Objective 7).

While each of the objectives addresses a specific area in which actions will be taken, there are also strong links between the actions listed under different objectives. Appendix A provides a list of the related actions, presented under crosscutting themes.



Phenological study being conducted out of a satellite field camp at the base of Scarlet Hill (410 m) on Heard Island (*Picture Kate Kiefer, © Australian Antarctic Division*)



Torndirrup National Park, Western Australia (*Picture: Annie Boutland*), Dorrigo and Kinchega National Parks, New South Wales (*Picture: S Ruming and: K Gillet*), reflect some of the different ecosystems that Australia's national parks protect.

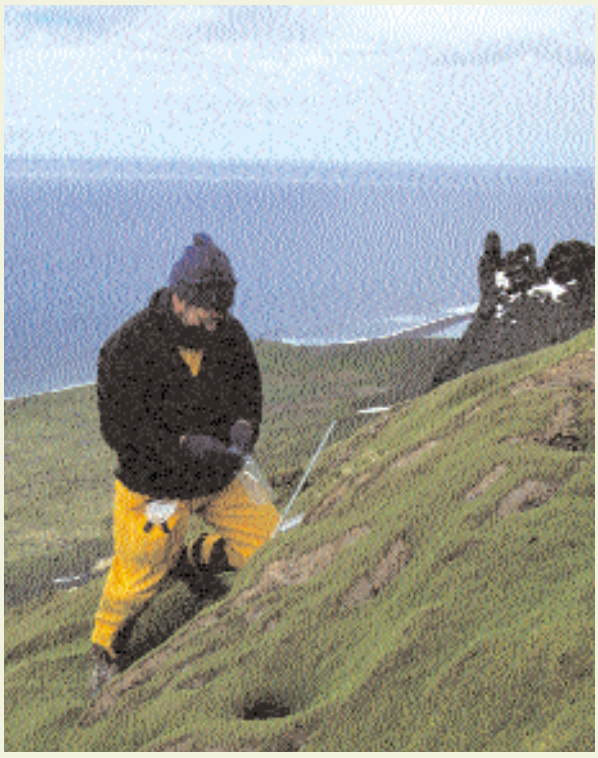
Objective 1: To improve our understanding of the impacts of climate change on biodiversity

Human-induced climate change is having an impact on biodiversity. To make informed decisions about objectives and priorities for investment in biodiversity conservation, we must improve our understanding of the potential effects of climate change and climate variability on biodiversity, so that new information can be used for natural resource and conservation planning.

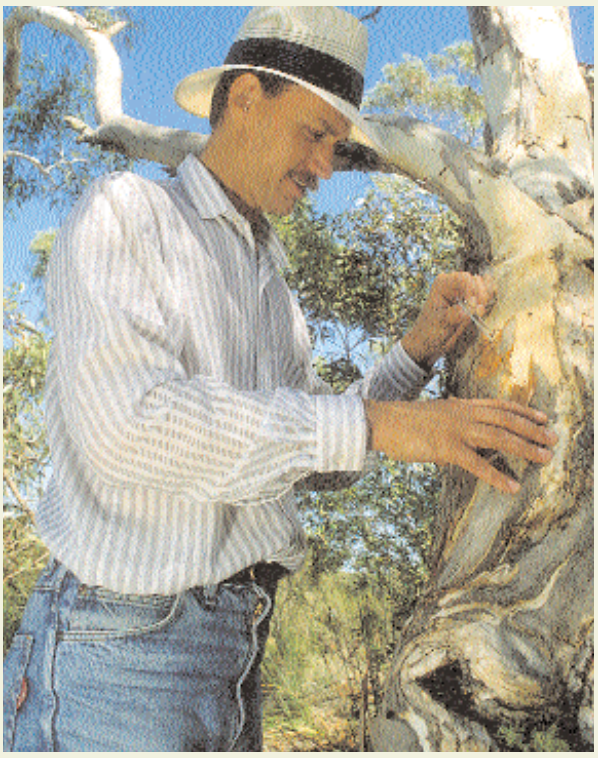
This will require gap-filling research. Researchers will need data and models to predict the impacts of climate change on biodiversity and to predict the potential effects of different adaptation strategies. Such research will require long-term monitoring of biodiversity responses to climate change and to climate variability under different management regimes. It will also require testing and refining of initial predictions, and feedback on the effectiveness of the management programs — in short, a rigorous approach to adaptive management.

Over the next three years all jurisdictions will:

- identify and address gaps in their knowledge and data, needed to predict the impacts of climate change on biodiversity and to design and evaluate adaptation strategies in consultation with researchers, planners and managers
- use reliable data, models and ecological theory to predict impacts and guide management responses, within a risk-assessment framework
- identify the long-term monitoring programs needed to assess the impacts of climate change on biodiversity over time and to evaluate the long-term effectiveness of adaptation strategies and actions
- improve and increase their capacity to assess the potential economic costs and benefits of climate change impacts on biodiversity, ecosystem processes, functions and services.



A biologist collects mites from *Azorella* cushion carpet at Fairchild Beach, in the subantarctic Heard Island, 2001 (*Picture: K Kiefer © Australian Antarctic Division*).



Fieldwork is an important part of ecological modeling. CSIRO scientist inspecting a eucalyptus tree at Duck Island, southwest of Keith, South Australia (*Picture: © Copyright CSIRO Land and Water*).

Objective 1: To improve our understanding of the impacts of climate change on biodiversity

Strategy 1.1		**Addressing important gaps in our knowledge about climate change impacts on biodiversity, and on the cumulative effects of other threatening processes whose impacts on biodiversity will be exacerbated by climate change, at scales relevant to adaptation planning.**	
Actions	1.1.1	Identify the most important gaps in knowledge that limit the ability of policy makers, planners and managers to design and implement climate change adaptation strategies for species and ecological processes and functions (all jurisdictions*).	2006
	1.1.2	Give priority to addressing identified gaps in NRM and ecological research and development programs (all jurisdictions*).	2007
Strategy 1.2		**Maintaining and improving capacity to predict climate change impacts on biodiversity.**	
Actions	1.2.1	Improve capacity of models to predict climate change impacts on biodiversity, including regional shifts,at scales relevant to NRM programs, reserve design and management programs, and species management and recovery programs (all jurisdictions*).	Ongoing
	1.2.2	Develop nationally agreed ecological criteria for identifying those species and ecosystems at greatest risk from climate change (all jurisdictions*).	2006
	1.2.3	Use the criteria developed in 1.2.2, together with existing information and predictive modelling capacity, to map those species and ecosystems at greatest risk from climate change and identify priority habitats that will be important to manage for vulnerable species (all jurisdictions*).	2007
	1.2.4	Identify limitations in the current modelling of climate change impacts on biodiversity including uncertainties in: • species distribution changes • changes in species interactions • ecosystem responses (all jurisdictions*).	
Strategy 1.3		**Increasing capacity to monitor impacts on biodiversity and evaluating the effectiveness of adaptation strategies and actions.**	
Actions	1.3.1	Through expert consultative processes, identify information requirements and priorities for long-term monitoring of climate change impacts on biodiversity (all jurisdictions*).	2006
	1.3.2	Incorporate monitoring requirements into the national NRM monitoring and evaluation framework including to assess future impacts of climate change on biodiversity and its vulnerable components (all jurisdictions*).	2007
	1.3.3	Implement high priority monitoring programs and case studies (all jurisdictions*).	2007
Strategy 1.4		**Addressing information needs of NRM managers and decision makers involved in developing and implementing strategies to minimise the loss of biodiversity due to climate change.**	
Action	1.4.1	Establish a climate change and biodiversity website for NRM managers and decision makers to facilitate information exchange about the actual and potential impacts of climate change and relevant, policies, strategies and programs (Australian Government).	2005
Strategy 1.5		**Improving and increasing capacity to assess environmental, economic and social costs and benefits of taking action.**	
Actions	1.5.1	Improve and increase capacity to assess the potential economic costs and benefits of climate change impacts on biodiversity, ecosystem processes and the ecosystem services provided by native biodiversity (all jurisdictions*).	2006
	1.5.2	Establish a long-term capacity to undertake integrated environmental, economic and social cost/benefit analysis of possible biodiversity adaptation actions (all jurisdictions*).	2006
	1.5.3	Undertake regional case studies to demonstrate the costs and benefits of adaptation options including a do-nothing option. (all jurisdictions*).	2006

* This denotes a shared responsibility between spheres of government, but may not be relevant to all jurisdictions

Objective 2: To increase awareness of climate change impacts and our capacity to respond

Given the current low level of understanding of climate change issues in the Australian community, there needs to be a significant effort to improve communication about climate change, particularly about its potential impacts. Future projections of climate change need to be explained in the context of climate variability and this will require effective communication of concepts such as risk and uncertainty. Communication about climate change activities between stakeholder agencies will also need to be improved.

By stimulating informed public discussion of the impacts of climate change on biodiversity, appropriate policy responses will be more widely supported. Currently, the main source of public information about climate change and biodiversity is through the media, which may not provide adequate coverage of scientific knowledge on the subject. The need for better public information could be addressed at a minimum cost using existing education and public awareness programs.

Communication activities must also support regional initiatives to deliver natural resource management (NRM) outcomes. This will improve the capacity of natural resource managers to undertake adaptation activities to protect biodiversity. Stakeholders who could be supported in this capacity include:

- Landcare and other NRM-related community groups
- land-holders
- the tourism and mining industries
- Indigenous communities.

Children learn about their local community (*Picture: Dept of Foreign Affairs and Trade*).

Biodiversity policy makers and program administrators need to integrate climate change considerations into the management of all other threats to biodiversity. To achieve this, they need relevant information at various levels of biological and jurisdiction management on the impacts of climate change on biodiversity, as well as tools to assist them in interpreting the information and manage the impacts.

Finally, it is important that conflicting objectives and imperatives, institutional barriers and poor information infrastructure do not impede the flow of information between researchers, policy makers and natural resource managers.

Objective 2: To increase awareness of climate change impacts and our capacity to respond

Strategy 2.1		**Improving information systems and flows between key groups.**	
Actions	2.1.1	Identify gaps in existing methods of communicating information between researchers, policy makers, planners and natural resource managers and develop better systems of information flows (all jurisdictions*).	2005
	2.1.2	Undertake internal awareness raising, within jurisdictions to communicate the impacts of climate change on biodiversity and information about adaptation strategies (all jurisdictions*).	2006
Strategy 2.2		**Developing a targeted communication strategy to promote awareness in the broader community.**	
Actions	2.2.1	Identify key groups whose support is critical to implementing adaptation measures identified in the plan (all jurisdictions*).	2006
	2.2.2	Develop communication strategies to engage the support of key stakeholders for adaptation measures identified in the plan (all jurisdictions*).	
	2.2.3	Identify effective delivery mechanisms such as: • include information on climate change impacts on biodiversity in existing communication material (all jurisdictions*). • incorporate studies on climate change impacts on biodiversity (in the context of natural history) into school curricula (state and territory governments). • develop targeted information packages and tool kits about monitoring impacts and potential adaptation actions for biodiversity policy makers and managers. (Links to 1.4 and 1.5) (all jurisdictions*).	
Strategy 2.3		**Increasing capacity of NRM and environmental planners and decision makers to manage dynamic systems.**	
Actions	2.3.1	Develop decision support tools and information networks to assist managers and decision makers in managing uncertainty and risk to improve biodiversity adaptation outcomes. (Links to 1.4 and 1.5) (all jurisdictions*).	2007
	2.3.2	Undertake case studies (including in coastal regions) to help identify: • information required by NRM managers and decision makers to address impacts of climate change on biodiversity in different regions (all jurisdictions*). • monitoring required to assess the impacts of climate change and climate variability on biodiversity within a region (all jurisdictions*).	
	2.3.3	Based on agreed ecological principles and to address climate change impacts on biodiversity, develop best practice technical requirements to be incorporated (if appropriate) in the design, monitoring and evaluation of NRM programs, reserve design and management programs and species management and recovery programs (all jurisdictions*).	

* This denotes a shared responsibility between spheres of government, but may not be relevant to all jurisdictions

Objective 3: To minimise the impacts of climate change on inland aquatic and semi-aquatic ecosystems

Lagoons and lakes can be important habitat for flora and fauna vulnerable to climate change. Kakadu National Park, Northern Territory (*Picture: John Baker*).

Climate change may alter hydrological cycles, thus affecting species and ecosystems that are dependent on inland rivers, wetlands and groundwater systems. However, projected changes in rainfall are highly uncertain and vary from region to region (CSIRO 2001).

Climate change projections suggest that there will be a tendency towards a reduction in rainfall over many areas of southern Australia. This tendency will be more evident in spring, winter and, for the far south, in autumn (CSIRO 2001). If these changes occur there will be consequent reductions in the mean flow of many rivers (IPCC 2001b). The projected drying may seriously affect many inland wetlands, threatening the reproduction of migratory birds that depend on wetlands for their breeding cycle (Hassall and Associates 1998).

Projections also suggest a potential increase in extreme daily rainfall in many regions, even where average rainfall will decrease (CSIRO 2001). If these trends eventuate in the north, this will increase the risk of flooding and increase sediment loads, nutrients and pollutants in northern Australian rivers (IPCC 2001b). Any of these impacts could negatively affect the biodiversity of riverine environments, as well as estuaries and coastal wetlands.

Inland aquatic and semi-aquatic species and ecosystems could also be affected by projected increases in temperature. Such changes in the climate may potentially alter the distribution of fish species, lead to loss of habitat for cold and cool-water fish, and increase the habitat of warm-water fish (IPCC 2001b). Some freshwater invertebrate species and riparian vegetation could also potentially be threatened by temperature changes.

Current environmental stresses on aquatic and semi-aquatic ecosystems, such as modified flow regimes (from dams, weirs and irrigation), habitat destruction, altered patterns of salinity, eutrophication, algal blooms and invasive organisms, will potentially increase the vulnerability of freshwater biodiversity to climate change.

Over the next three years all jurisdictions will begin to identify the potential impacts of climate change on inland aquatic and semi-aquatic species and ecosystems. Each jurisdiction will identify and undertake conservation measures to protect and restore streams, rivers and wetlands in order to conserve species and ecosystems that could potentially experience a negative impact under future climates.

Riparian vegetation provides an important buffer to critical wetlands from the impacts of climate change (*Picture: Trevor Preston*).

Objective 3: To minimise the impacts of climate change on inland aquatic and semi-aquatic ecosystems

Strategy 3.1		**Building capacity to predict the impact of climate change on aquatic and semi-aquatic species and ecosystems.**	
Actions	3.1.1	Extend existing modelling of catchment hydrology, as information becomes available, to incorporate climate change projections and the potential impacts on biodiversity (all jurisdictions*).	2006
	3.1.2	Provide targeted information for managers and policy makers about the possible effects of climate change on inland aquatic and semi-aquatic species and ecosystems and potential adaptation actions. Links to 2.2.3 (all jurisdictions*).	
Strategy 3.2		**Integrating consideration of the impacts of climate change on biodiversity into water allocation and management strategies that deal with hydrological systems.**	
Actions	3.2.1	As information becomes available develop a spatially referenced database of inland aquatic and semi-aquatic species communities and ecosystems that are vulnerable to climate change (including degree of threat) to help water management authorities plan for future environmental flows and water resource management (all jurisdictions,* Australian Government lead).	2007
	3.2.2	Undertake stakeholder consultations with water managers and users on the integrated management of prioritised areas that have aquatic and semi-aquatic species, communities and ecosystems that are vulnerable to climate change (all jurisdictions*).	
	3.2.3	Identify and prioritise protection of future habitats that will assist the change in the distribution and abundance of inland aquatic and semi-aquatic species and ecosystems (all jurisdictions*).	
Strategy 3.3		**Maximising the resilience of inland aquatic and semi-aquatic ecosystems to manage the impacts of changes in catchment hydrology resulting from climate change.**	
Action	3.3.1	Incorporate targets into catchment management plans to ameliorate the impacts of other threatening processes on inland aquatic and semi-aquatic species and ecosystems that are vulnerable to climate change (all jurisdictions*).	2007
Strategy 3.4		**Reviewing reserve acquisitions to strengthen the capacity of the reserve system to act as refuges for vulnerable inland aquatic and semi-aquatic species and communities and to encompass bioclimatic gradients.**	
Action	3.4.1	Incorporate assessment of climate change impacts on biodiversity into the guidelines for identifying and selecting reserves to protect aquatic and semi-aquatic species and ecosystems (all jurisdictions*).	2007

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Objective 4: To minimise the impacts of climate change on marine, estuarine and coastal ecosystems

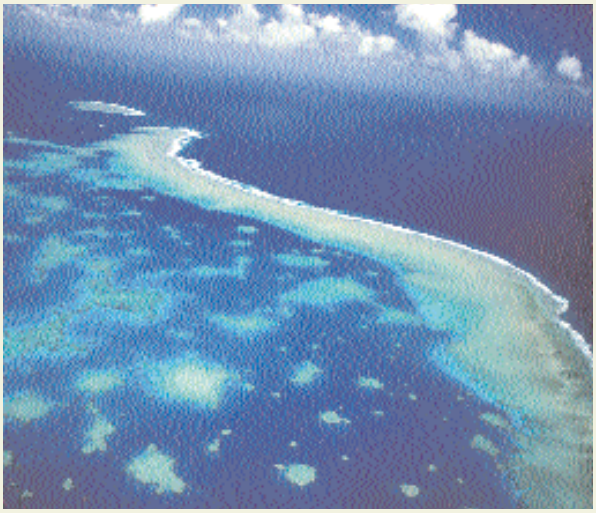
Extreme rainfall and tropical cyclones could become more intense under climate change, particularly on the coast (*Picture: John Baker*).

Changes in ocean temperature and currents affect many aspects of ocean biology. As the climate warms, it is possible that the distribution of many marine species will change, with populations contracting or expanding at the edge of their climatic range (IPCC 2001ab). In the northern hemisphere, there is evidence that the deep ocean circulation is weakening in response to recent warming (Hakkinen and Rhines 2004). Oceanographic modelling indicates that the subsidence of cold and super-saline water in the Antarctic may reduce or cease completely with substantial global warming (Bi et al 2001). This would significantly change deep ocean chemistry and dynamics as well as affect marine life (IPCC 2001ab). For example, it could affect populations of species such as copepods that spend part of the year in the deep ocean and migrate seasonally to the surface where they form the basis of many marine food chains (IPCC 2001ab).

Climatic and atmospheric change has the potential to directly affect the Great Barrier Reef (GBR) and other coral reefs globally, either directly or by exacerbating the effects of other pressures (Hughes 2003) (see also Box 3, The Great Barrier Reef). There is not enough information currently available to project the impact of climate change on the productivity of Australian fisheries. However, studies that have examined the relationship between climate variation and the recruitment of some fish species indicate that Australian fisheries will be sensitive to climate change (IPCC 2001b). Recent observations of seabird population dynamics indicate that impacts on fish populations are already occurring and are having flow-on effects to marine predators (Dunlop and Wooller 1990; Dunlop 2001).

Changes to catchment hydrology, such as increases in summer rainfall in northern Australia (see Objective 3), will potentially also affect coastal wetlands and estuaries due to the increased risk of floods (IPCC 2001b). Many coastal freshwater wetlands, including wetlands in Kakadu National Park, are also at risk from saltwater inundation as sea levels rise (Mulrennan and Woodroffe 1998). Existing pressures that threaten marine, coastal and estuarine ecosystems, such as fishing, tourism, invasive organisms, pollution and coastal development, are likely to make these systems more vulnerable to the impacts of climate change.

Over the next three years, all jurisdictions will begin to identify marine, coastal and estuarine species and ecosystems that are vulnerable to climate change, and consider ways to protect these species and ecosystems and to reduce the impacts of threatening processes.



The coastal areas of Australia are rich with biodiversity that may be vulnerable to climate change. Aerial photograph of the reefs near Cairns (*Picture: L Zell © GBRMPA*).

Objective 4: To minimise the impacts of climate change on marine, estuarine and coastal ecosystems

Strategy 4.1		**Building capacity to predict the effects of climate change (including sea level change and resulting storm surges) on marine, coastal and estuarine species and ecosystems in ecological and socioeconomic terms.**	
Actions	4.1.1	Incorporate climate change projections into catchment hydrology models and flood risk assessments in order to better predict impacts on estuarine and other nearshore ecosystems (all jurisdictions*).	2005
	4.1.2	Using case studies, model impacts of increased frequency and intensity of extreme events (eg storm surges) on estuarine and other nearshore ecosystems (all jurisdictions*).	
	4.1.3	Undertake a risk assessment analysis to determine priority species and ecosystems for management response (all jurisdictions*).	2007
	4.1.4	Provide targeted information for managers and policy makers about the possible effects of climate change on marine, estuarine and coastal ecosystems and potential adaptation actions (all jurisdictions*).	
Strategy 4.2		**Identifying and integrating into marine, coastal and estuarine management strategies (particularly for Marine Protected Areas — MPAs), activities that minimise the impacts of climate change (and sea level change) on vulnerable marine, coastal and estuarine species and ecosystems.**	
Actions	4.2.1	Identify natural refuges for marine, coastal and estuarine species that are vulnerable to climate change (all jurisdictions*).	2007
	4.2.2	Identify transition habitats (ecotones) that will provide for shifts in the distribution and abundance of species and ecosystems (all jurisdictions*).	
Strategy 4.3		**Maximising the resilience of marine, coastal and estuarine species and ecosystems to climate change impacts.**	
Actions	4.3.1	Identify the impacts of erosion on marine, coastal and estuarine ecosystems resulting from storm surges and changes in sea level and surface water flow (and changed nutrient loads) as a consequence of projected climate change (all jurisdictions*).	2007
	4.3.2	Identify other threatening processes on marine, coastal and estuarine species and ecosystems that may change as a result of climate change (all jurisdictions*).	
	4.3.3	Identify and begin implementation of strategies to maximise resilience of particularly vulnerable ecosystems and species (all jurisdictions*).	
Strategy 4.4		**Protecting nearshore species and ecosystems from changes to catchment hydrology resulting from climate change.**	
Actions	4.4.1	Identify and prioritise estuaries and coastal wetlands (for conservation effort) that are vulnerable to changes in surface water flows as a result of changed rainfall patterns (all jurisdictions*).	2007
	4.4.2	Revise catchment management plans to protect vulnerable estuaries and coastal wetlands from climate change impacts (all jurisdictions*).	
Strategy 4.5:		**Considering the impacts of climate change on marine, estuarine and coastal biodiversity when selecting new marine protected areas (MPAs) and for management planning and monitoring regimes.**	
Action	4.5.1	Incorporate impacts of climate change on biodiversity into the guidelines for identification and selection of MPAs and MPA zoning plans (all jurisdictions*).	2007

* This denotes a shared responsibility between spheres of government, but may not be relevant to all jurisdictions

Objective 5: To minimise the impacts of climate change on native terrestrial species, communities and ecosystems

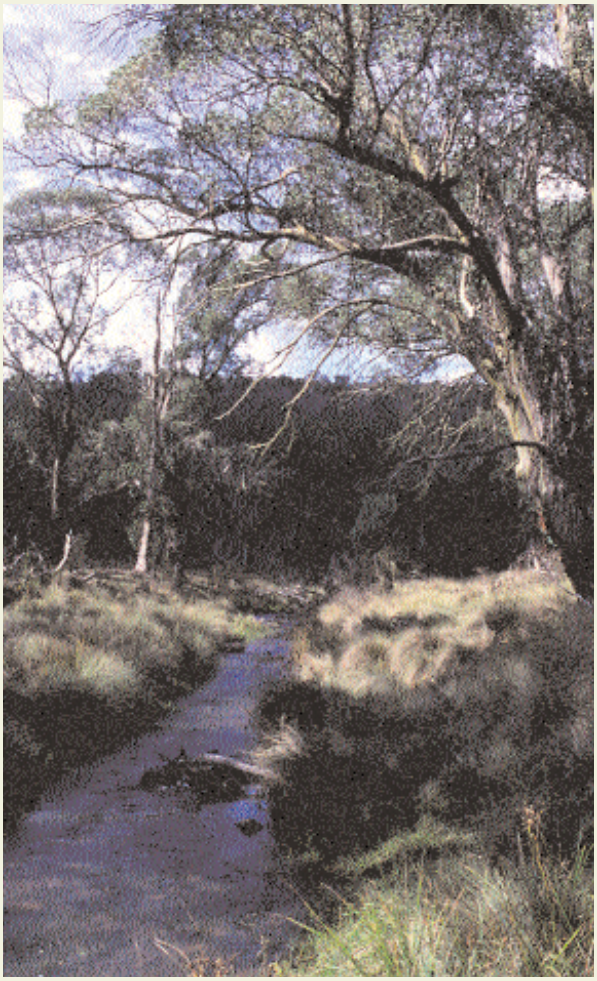
Climate change will potentially alter the abundance and distribution of species and the distribution and composition of terrestrial ecosystems. Indeed, the survival of some species may depend on changes to their distribution. The likelihood that these shifts will occur will be determined by the rate and degree of warming, the ability of species to disperse, and the existence of suitable alternative habitats within modified landscapes. Additionally, maintenance of populations in situ and successful establishment of new populations and assemblages will be constrained by the effects of land degradation, competition from invasive organisms and altered fire regimes.

Any increase in the duration, intensity and frequency of droughts, storms, fires and floods has the potential to negatively affect terrestrial biodiversity. For example, extended drought periods could reduce the soil moisture that is necessary to support plant growth.

Responses to individual species threatened by climate change may include translocation to new areas that are likely to be more climatically suitable. However, this is a risky and highly expensive alternative and may result in funds not being available for other actions. Therefore, for most species, the preferred and most practical option is to retain, restore and protect their existing habitat, so that their whole ecosystem becomes more resilient.

A paddock containing remnant vegetation (© *CSIRO*).

Over the next three years, all jurisdictions will use the best available research, information and models to design NRM programs, establish terrestrial reserves and management programs, and apply them to species management and recovery programs.



Namadgi National Park in the ACT, which is part of the broader alpine network, has both latitudinal and longitudinal gradients. National parks like Namadgi provide opportunities for mobile species to migrate (*Picture: John Houldsworth, Australian Heritage Photo Library*).

Objective 5: To minimise the impacts of climate change on native terrestrial species, communities and ecosystems

Strategy 5.1		**Identifying and incorporating into vegetation management strategies across all tenures, ongoing activities to improve the opportunity for species at risk from climate change to adapt.**	
Actions	5.1.1	Within each Natural Heritage Trust (NHT) and National Action Plan (for salinity and water quality, (NAP) region, identify natural refuges (priority habitats) and habitat linkages that have the potential to be important in maintaining vulnerable species and increasing the possibility of successful migration of those species whose distribution will change (all jurisdictions*).	2006
	5.1.2	Include in catchment management plans: • targets for maintaining and increasing ecological connections linkages (or connectivity) between priority habitats (all jurisdictions*) • strategies to build ecological resilience to buffer the habitats of vulnerable species and populations against the additional pressure of climate change by putting in place measures (ie zones of complementary management) to reduce the existing impacts of threatening processes such as invasive species, altered fire regimes and over grazing (all jurisdictions*) • strategies to reduce physical barriers to movement to facilitate the migration and dispersal of terrestrial species and communities that are vulnerable to climate change (all jurisdictions*).	2007
	5.1.3	Incorporate actions to minimise the impacts of climate change on biodiversity, ecological processes and ecosystem services into regional programs to maintain and restore biodiversity and ecosystem resilience, including invasive species control, fire management and dryland salinity management (state and territory jurisdictions).	
	5.1.4	Identify and implement opportunities to re-establish native vegetation and enhance habitat for vulnerable species on private land through revegetation, vegetation management and land use change programs (all jurisdictions*).	
Strategy 5.2		**Reviewing reserve acquisitions to strengthen the capacity of the reserve system to act as refuges for vulnerable terrestrial species and integrate reserve planning and management with broader landscape protected area networks to allow the movement of species across bioclimatic gradients.**	
Actions	5.2.1	Review current reserve system plans and guidelines to include consideration of identified priority areas that could be used to assist migration or provide natural refuges for vulnerable terrestrial species under future climate regimes (all jurisdictions*).	2007
	5.2.2	Incorporate consideration of climate change into programs to voluntarily acquire new land for reserves for conservation purposes (all jurisdictions*).	
	5.2.3	Build on the national programs to retain and restore native vegetation and protect habitat by promoting voluntary partnerships between government and land-holders to develop strategic protected area networks at landscape and larger scales to provide linkages and stepping-stones to assist biodiversity adaptations (all jurisdictions*).	
Strategy 5.3		**Conserving threatened species that have the potential to become extinct as a result of climate change impacts.**	
Actions	5.3.1	Consider listing species whose status is threatened by climate change as per 7.3 (all jurisdictions*).	2007
	5.3.2	Ensure that terrestrial species at highest risk of extinction in the wild as a result of climate change are preserved in zoological and botanical gardens, and germplasm/seed banks. Include the consideration of the genetic diversity for each species collected (all jurisdictions*).	

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Objective 6: To minimise the impact of invasive organisms on biodiversity in future climates

The introduction and spread of alien invasive organisms poses a significant threat to Australia's terrestrial, marine and freshwater biodiversity. Climate change is expected to increase the risk of invasion by alien organisms, including pests, weeds and diseases from neighbouring territories (IPCC 2001b). Climate change may also favour some established alien and native organisms that are currently restricted in range, causing them to become invasive (Baskin and Baskin 1998). As climatic zones shift, invasive organisms that are capable of rapid dispersal and establishment will have the potential to invade new areas, increasing the threat to native species and ecosystems.

There is evidence that climate change is already increasing the impact of alien invasive species on biodiversity. For example, on subantarctic Macquarie Island, rats are being found in upland herb fields, where they were previously unrecorded, and are now having a negative impact on native plant species (Bergstrom 2003).

Climate change may increase the risk of invasion by alien organisms, including weeds. An employee of Burdekin Shire, Queensland, spraying Chinese apple on a Woodhouse property, near Clare (© *CSIRO Land and Water*).

Invasive pests such as foxes and feral cats have large climatic tolerances, which allow them to thrive in a wide range of habitats (*Pictures: Brent Johnson and C Potter*).

As it is almost impossible to eradicate species once they become invasive, it is critical that species that could potentially become invasive with climate change are not introduced into Australia. Introductions that could pose such a problem include ornamental plants, fish or other animals; commercial species; diseases or pathogens.

Over the next three years, all jurisdictions will work with regions to improve their understanding of how potentially invasive organisms can establish and disperse in future climates.

Objective 6: To minimise the impact of invasive organisms on biodiversity in future climates

Strategy 6.1		**Building capacity to predict the effects of climate change on the distribution of new and established alien invasive organisms.**	
Actions	6.1.1	Incorporate current and potential future climate change scenarios into alien invasive species modelling (all jurisdictions*).	2005
	6.1.2	Incorporate the modelling of alien invasive species under climate change into risk assessment procedures and protocols (for alien invasive species) (all jurisdictions*).	2007
Strategy 6.2		**Considering implications of native species becoming invasive, and incorporating this information as appropriate into invasive species and threatened species programs.**	
Actions	6.2.1	Analyse potential impacts of native species becoming invasive as a result of climate change and incorporate into relevant management strategies (as per 6.4.1 and 6.4.2) (all jurisdictions*).	2007
Strategy 6.3		**Preventing the establishment of new alien invasive organisms in Australia, which could be attributed to climate change.**	
Actions	6.3.1	Incorporate climate change considerations in preborder risk assessment in a national system to reduce the risk of introduction of alien invasive species and vectors for disease (Australian Government).	2006
	6.3.2	Incorporate climate change considerations into import risk analyses and the development and review of import conditions (Australian Government).	
Strategy 6.4		**Reviewing priority alien invasive organisms for management action and re-evaluating alien invasive organism management strategies, taking into account the potential effects of climate change on their distribution.**	
Actions	6.4.1	Update the Weeds of National Significance (WONS), Alert List for Environmental Weeds and priority lists for alien invasive organisms (including plants, animals and diseases) (all jurisdictions *).	2006
	6.4.2	Update alien invasive organism management strategies, including threat abatement plans and strategies, for example to manage WONS and Alert List weeds (all jurisdictions *).	2007

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Objective 7: To factor the impacts of climate change on biodiversity into natural resource management and land-use planning

Australia's biodiversity conservation and natural resource management policies aim to reduce the decline in biodiversity from current threatening processes and enhance ecosystem resilience and sustainable use of natural resources. The extent to which these policies and programs address the potential effects of climate change varies.

New England National Park, NSW (*Picture: H. Clark*).

A major aspect of this action plan is the need to include the consideration of the impact of climate change as a component of core business for all biodiversity conservation initiatives.

The rationale for this approach is two-fold.

- Integrating climate change considerations into biodiversity programs is the most cost-effective way to deal with climate change, as these programs already have the infrastructure, mandate and encapsulated knowledge to address the issues.
- There is a need to reassess biodiversity program goals, given the potential for climate change to undermine conservation effort (ie by increasing the opportunity for the spread of invasive species).

As a starting point, it may be necessary to review biodiversity programs (and natural resource programs generally) in order to ensure the short-term preservation of species and ecosystems, and to facilitate the long-term adaptation to climate change of biodiversity components.

Over the next three years, all jurisdictions will begin to work with planners and managers to ensure that strategies that minimise the impacts of climate change on biodiversity are incorporated into regional plans, are consistent with sound ecological principles, and take into account more detailed information as it becomes available.

Objective 7: To factor the impacts of climate change on biodiversity into natural resource management and land-use planning

Strategy 7.1		**Incorporating consideration of climate change impacts on biodiversity into NRM/biodiversity policies, strategies and programs, consistent with ecologically sustainable development (ESD) principles.**	
Actions	7.1.1	Review NRM/biodiversity policies, strategies, programs and planning instruments with a view to ensuring that they take into account potential impacts of climate change on biodiversity (all jurisdictions*).	2007
	7.1.2	Incorporate monitoring requirements into the national NRM monitoring and evaluation framework, including the effectiveness of management responses to the impacts of climate change on biodiversity. Linked with 1.3.2 (all jurisdictions*).	
	7.1.3	Incorporate reporting on impacts of climate change into state of environment reporting (all jurisdictions*).	
	7.1.4	Explore the feasibility of incorporating into national and state/territory programs dealing with rural readjustment, opportunities to conserve biodiversity assets threatened by climate change and provide for climate change-driven shifts in the distribution and abundance (all jurisdictions*).	
Strategy 7.2		**Incorporating consideration of climate change impacts on biodiversity into land-use planning and land-use change programs.**	
Action	7.2.1	Review new land-use and reserve planning policies, strategies, programs and planning instruments to take into account current and future impacts of climate change on biodiversity and make provision for adaptation to occur (all jurisdictions*).	2006
Strategy 7.3		**Incorporating consideration of the impacts of climate change when listing threatened species and ecological communities and, in planning for the recovery of these species and ecological communities, ensure prioritisation.**	
Actions	7.3.1	Include consideration of impacts associated with climate change in decision-making processes to list threatened species and ecological communities under national and state/territory legislation (all jurisdictions*).	2007
	7.3.2	Include in recovery plans for species and ecological communities threatened by climate change: • an assessment of adaptation requirements • a list of priority actions appropriate to circumstances which may include ex situ conservation, vegetation linkages, reservation, and to reduce the threat of fire and invasive species management (all jurisdictions*).	

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Implementation

This action plan is the first detailed adaptation strategy to be developed at a national level for one of the key sectors vulnerable to climate change. As such, it is an important step towards putting adaptation to climate change into a national framework. National collaboration on adaptation is also under way in some other sectors, such as agriculture.

Protected areas play an important part in the protection of Australia's biodiversity sector and are the focus of a number of actions in the plan (Actions 3.4.1, 4.5.1, 5.2.1, 5.2.2, 5.2.3, 7.2.1). In Box 5, the responses that can be taken to reduce the impact of climate change on Australia's conservation reserve system are looked at in more detail.

The Australian Government and each state and territory will undertake their own work plan to implement this action plan. The work plans will be informed by the institutional and legislative arrangements that exist in each jurisdiction, as well as this national framework.

It will be important that the actions in this plan are integrated with other natural resource management and allied sectorial activities aimed at managing the impacts of climate change. A working group will be established to oversee the implementation of the plan.

Review of the National Biodiversity and Climate Change Action Plan

The action plan will need to be reviewed periodically. This will ensure that it remains coordinated with research outcomes on climate change adaptation, as well as with core biodiversity conservation strategies and programs.

The action plan is to be comprehensively reviewed after three years to ensure that the implementation of its actions are on track, and that longer-term actions are integrated into broader adaptation policy. The review timetable also recognises that many of the actions in the initial plan are aimed at improving understanding of climate change impacts on biodiversity and identifying areas of vulnerability. Work on these elements of the plan will provide a base for further development of strategies for managing climate change impacts.

A significant constraint on decision making (and on developing effective actions) in a climate change context is the lack (or uncertainty) of information and science. In order to make appropriate decisions, those engaged in management, planning and policy activities will therefore need accurate and up-to-date information and knowledge (evidence), and improved methods for dealing with inherent uncertainty in strategic planning.

A key initial step in implementing the action plan is a review of the knowledge and information needs of management planning and policy practitioners. This review will provide a useful mechanism to prioritise research and fine-tune targets, based on what is feasible.

Box 5: Active responses to climate change for Australia's conservation reserve system

Protected areas: a flagship of biodiversity conservation

Protected areas are those systems of national parks and other types of conservation areas that are dedicated to the protection and maintenance of biodiversity, and that are formally managed and protected for this purpose. The National Reserve System is one of the most important components in Australia's portfolio of strategies for preserving biodiversity. Across the country, nearly 11% of the land area is currently included in this protected area system.

A priority of the system of protected areas is to: take account of special groups of organisms, eg species with specialised habitat requirements or wide-ranging or migratory species, or species vulnerable to threatening processes that may depend on reservation for their conservation (NRMMC 2004).

Indeed, many areas have been reserved to protect specific species or communities that are geographically restricted. This priority, and most protected area planning, has been based on the implicit assumption that the distribution of species and ecosystems and the composition of communities will not change significantly in the foreseeable future, and protected areas will be generally managed to minimise any such change.

The north-east Tasmanian highlands (*Picture: Australian Heritage Photo Library*).

Climate impacts: how will protected areas be affected?

The distribution of many species and ecosystems is likely to change as the climate changes. Existing communities may dissolve, while new ones may form. Patterns of biodiversity in the landscape may change over timeframes as short as decades, and species that are currently 'protected' in reserves may therefore not be adequately conserved in the future. For example, bioclimatic modelling in South Africa suggests that five national parks may lose more than 40% of their plant species (Rutherford et al 1999). Given the possibility of shifting species and changing ecosystem distributions, the goal of preserving species and ecosystems in their current locations may need to be modified, and management aimed at that goal adjusted to maximise biodiversity conservation in the long term.

Although loss of species from a given reserve, arrival of new species, or a change in ecosystem function may be identified as a negative outcome of climate change and negatively impact on the purpose of the reserve system, in reality, such changes might actually signal successful natural adaptation to climate change.

Adaptation: how might a system of protected areas be modified?

In the future, protected areas will need to take on two distinct roles: preserving species that are particularly vulnerable to climate change in the short-term and facilitating the adaptation of biodiversity to climate change over a longer period. These two goals may require different, sometimes conflicting, management programs. For example, preservation might require maintaining a past disturbance regime, whereas an altered disturbance regime may foster establishment of new species and changes in ecosystems in line with future climates. In some situations, it may be necessary that plans specify which areas need to be actively managed for different outcomes. This presents several challenges to managers. Having two conflicting goals adds an

Box 5: Active responses to climate change for Australia's conservation reserve system *continued*

Great Victoria Desert, Western Australia (*Picture: © CSIRO Land and Water*).

extra dimension of complexity to conservation management that will require new planning tools. Management for each goal will require new and specific information about species and ecosystem responses to climate and carbon dioxide concentration changes.

Current 'rules-of-thumb' and priorities may not apply. For example, it is current best-practice to increase the connectedness of habitat remnants with 'corridors' and 'stepping stones' of habitat. This practice will enhance dispersal and adaptation to climate change for most species. However, for many species, one of the greatest threats from climate change is likely to be establishment of new species of competitors, predators or pathogens, in which case isolation may increase their chance of survival. So, there is a greater imperative to connect areas of habitat, but also a greater risk.

All of the actions currently used to manage protected areas, including active adaptive management, monitoring and evaluation, controlling invasive and problem species, establishing buffer areas, managing disturbance, establishing corridors and acquiring new reserves, will remain critical for protected area management. However, the specific mixture of actions, how they are applied, the information to be managed and the objectives of management are likely to change for many regions.

Climate change significantly increases the threat to Australia's biodiversity, both directly and indirectly by exacerbating many existing pressures. The area, or number of areas, that would be regarded as adequate for protecting a given species under climate change is therefore greater than under the conditions that might have been considered adequate before. Protection could be afforded by off-reserve conservation or additional reserves. Therefore, in addition to changes in the way protected areas are managed, there may be an increased need for protected areas under climate change.

Appendix A: List of actions by crosscutting themes

No	Actions	Page
Actions supporting research (other than in Objective 1)		
3.1.1	Extend existing modelling of catchment hydrology, as information becomes available, to incorporate climate change projections and the potential impacts on biodiversity.	23
4.1.1	Incorporate climate change projections into catchment hydrology models and flood risk assessments in order to better predict impacts on estuarine and other nearshore ecosystems.	25
4.1.2	Using case studies, model impacts of increased frequency and intensity of extreme events (eg storm surges) on estuarine and other nearshore ecosystems.	25
4.3.1	Identify the impacts of erosion on marine, coastal and estuarine ecosystems resulting from storm surges and changes in sea level and surface water flow (and changed nutrient loads) as a consequence of projected climate change.	25
6.1.1	Incorporate current and potential future climate change scenarios into alien invasive species modelling.	29
6.2.1	Analyse potential impacts of native species becoming invasive as a result of climate change and incorporate into relevant management strategies.	29
Actions dealing with terrestrial and marine protected areas (MPAs)		
1.2.1	Improve capacity of models to predict climate change impacts on biodiversity, including regional shifts, at scales relevant to NRM programs, reserve design and management programs, and species management and recovery programs.	19
2.3.1	Develop decision support tools and information networks to assist managers and decision makers in managing uncertainty and risk to improve biodiversity adaptation outcomes.	21
3.4.1	Incorporate assessment of climate change impacts on biodiversity into the guidelines for identifying and selecting reserves to protect aquatic and semi-aquatic species and ecosystems.	23
4.5.1	Incorporate impacts of climate change on biodiversity into the guidelines for identification and selection of MPAs and MPA zoning plans.	25
5.2.1	Review current reserve system plans and guidelines to include consideration of identified priority areas that could be used to assist migration or provide natural refuges for vulnerable terrestrial species under future climate regimes.	27
5.2.2	Incorporate consideration of climate change into programs to voluntarily acquire new land for reserves for conservation purposes.	27
5.2.3	Build on the national programs to retain and restore native vegetation and protect habitat by promoting voluntary partnerships between government and landholders to develop strategic protected area networks at landscape and larger scales to provide linkages and stepping-stones to assist biodiversity adaptations.	27
7.2.1	Review new land-use and reserve planning policies, strategies, programs and planning instruments to take into account current and future impacts of climate change on biodiversity and make provision for adaptation to occur.	31

No	Actions	Page
Actions identifying terrestrial and marine species or ecosystems vulnerable to climate change		
1.2.2	Develop nationally agreed ecological criteria for identifying those species and ecosystems at greatest risk from climate change.	19
1.2.3	Use the criteria developed in 1.2.2, together with existing information and predictive modelling capacity, to map those species and ecosystems at greatest risk from climate change and identify priority habitats that will be important to manage for vulnerable species.	19
4.4.1	Identify and prioritise estuaries and coastal wetlands (for conservation effort) that are vulnerable to changes in surface water flows as a result of changed rainfall patterns.	25
5.3.1	Consider listing species whose status is threatened by climate change as per 7.3.	27
Institutional and ex-situ measures to protect species or ecosystems vulnerable to climate change		
5.1.2	Include in catchment management plans strategies to build ecological resilience to buffer the habitats of vulnerable species and populations against the additional pressure of climate change by putting in place measures (ie zones of complementary management) to reduce the existing impacts of threatening processes such as invasive species, altered fire regimes and over grazing.	27
5.2.3	Build on the national programs to retain and restore native vegetation and protect habitat by promoting voluntary partnerships between government and landholders to develop strategic protected area networks at landscape and larger scales to provide linkages and stepping-stones to assist biodiversity adaptations.	27
5.3.2	Ensure that terrestrial species at highest risk of extinction in the wild as a result of climate change are preserved in zoological and botanical gardens, and germplas/seed banks. Include the consideration of the genetic diversity for each species collected.	27
7.3.1	Include consideration of impacts associated with climate change in decision-making processes to list threatened species and ecological communities under national and state/territory legislation.	31
7.3.2	Include in recovery plans for species and ecological communities threatened by climate change: • an assessment of adaptation requirements • a list of priority actions appropriate to circumstances which may include ex situ conservation, vegetation linkages, reservation, and to reduce the threat of fire and invasive species management.	31
Actions supporting the protection of habitat for terrestrial and marine species or ecosystems vulnerable to climate change[5]		
3.2.2	Stakeholder consultations with water managers and users on the integrated management of prioritised areas that have aquatic and semi-aquatic species, communities and ecosystems that are vulnerable to climate change.	23
3.2.3	Identify and prioritise protection of future habitats that will assist the change in the distribution and abundance of inland aquatic and semi-aquatic species and ecosystems.	23
4.2.1	Identify natural refuges for marine, coastal and estuarine species that are vulnerable to climate change.	25
4.2.2	Identify transition habitats (ecotones) that will provide for shifts in the distribution and abundance of species and ecosystems.	25
5.1.1	Within each Natural Heritage Trust (NHT) and National Action Plan (NAP) for Salinity and Water Quality region, identify natural refuges (priority habitats) and habitat linkages that have the potential to be important in maintaining vulnerable species and increasing the possibility of successful migration of those species whose distribution will change.	27
5.1.4	Identify and implement opportunities to re-establish native vegetation and enhance habitat for vulnerable species on private land through revegetation, vegetation management and land-use-change programs.	27

[5] Other than through formal protected area measures.

Appendix B: International climate activities

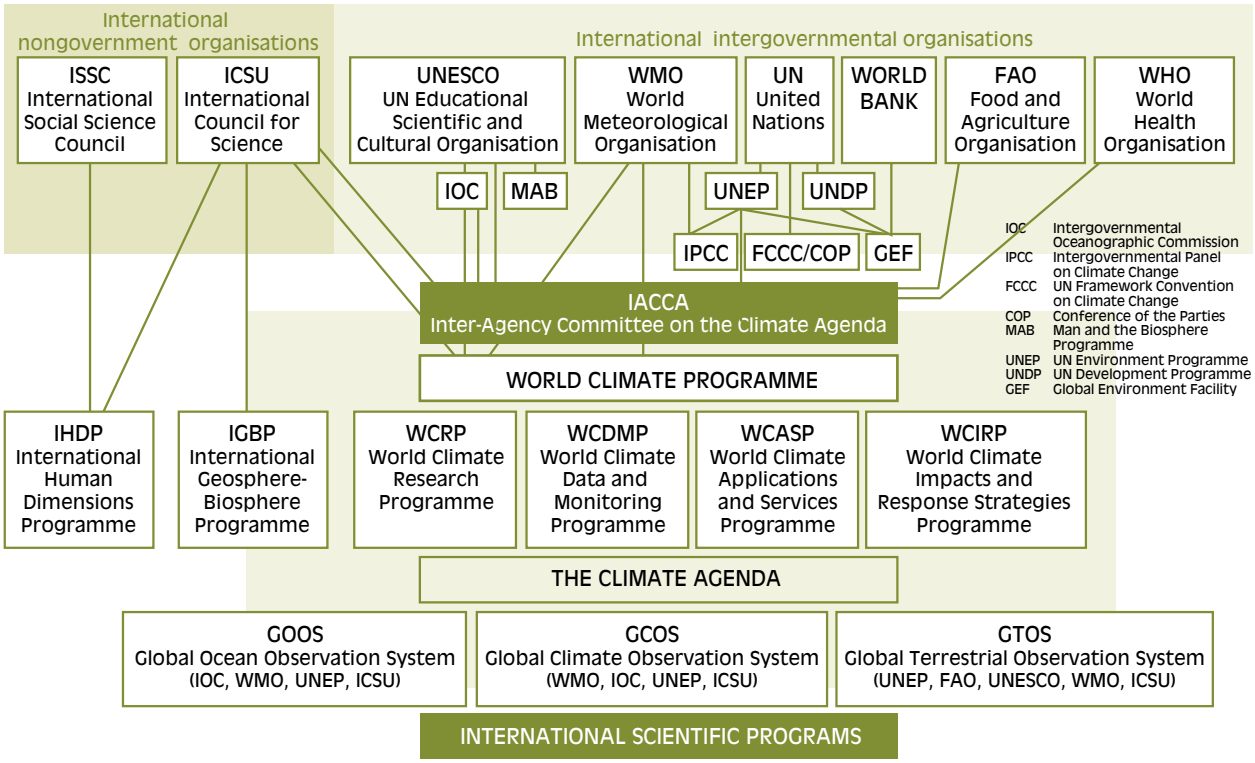
Introduction

To fully appreciate the mechanisms driving regional climate systems and their idiosyncrasies, a comprehensive understanding of the global climate system is required. Such understanding can only be achieved through a coordinated and cooperative international approach (Bureau of Meteorology 2003).

The following overview does not capture the complexity of the many specialist climate and global change-related groups and programs but, in the context of this action plan, provides a summary of the various international climate activities in which Australia participates.

International collaboration

International cooperation to further our knowledge and understanding of climate has existed in some form for more than a century (Bureau of Meteorology 2003). Since the late 1960s, significant changes to the focus and coordination of international efforts have led to the current structure, schematically represented in the figure below (for more detail see *Climate Activities in Australia 2003*, Bureau of Meteorology 2003).



The Climate Agenda embraces the activities of the World Climate Programme (WCP) and its subsidiary programs, the Global Climate Observation System (GCOS) and climate-related elements of the Global Ocean Observation System (GOOS) and Global Terrestrial Observation System (GTOS), as well as elements of the International Council for Science's (ICSU) International Geosphere–Biosphere Programme (IGBP). The intergovernmental and nongovernmental agencies that sponsor the WCP are represented on the currently inactive Inter Agency Committee for the Climate Agenda (IACCA) together with representatives of the Intergovernmental Panel on Climate Change (IPCC) and the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). The GCOS underpins and supports the individual components of the World Climate Programme (WCP) but is not formally part of it. An associated program which is relevant to the Climate Agenda, but not formally part of it, is the International Human Dimensions Programme (IHDP) of ICSU and the International Social Science Council (ISSC) (Australian Greenhouse Office 2003).

Briefly, the activities of the World Climate Research Programme (WCRP) underpin and support the authoritative assessments undertaken by the Inter-governmental Panel on Climate Change (IPCC). The IPCC assessments provide the scientific and technical basis for national and international actions following ratification of the United Nations Framework Convention on Climate Change (UNFCCC), implementation of subsequent decisions by the Conference of Parties (COP) to the UNFCCC, and actions to implement Agenda 21[6] (Bureau of Meteorology 2003).

International climate change science

Of most immediate relevance to this action plan is the IPCC. The IPCC does not carry out research nor does it monitor climate-related data or other relevant parameters. The panel supports the UNFCCC by providing advice, and coordinates and publishes assessments on peer-reviewed scientific and technical literature that cover the magnitude, timing and potential impacts of climate change, possible response strategies for adaptation and mitigation, as well as methodologies for National Greenhouse Gas Inventories (IPCC 2003).

Australia plays an important role in IPCC-associated activities and global science programs and derives substantial benefit from its active participation (Green and MacRae 2002). These benefits include influence on the direction and outcomes of these programs and significant international resources directed at climate change and global change projects in our region (Green and MacRae 2002). Green and MacRae (2002) also note that Australia gains considerable leverage from its investment in international greenhouse science and technology activities — these activities are also closely aligned with the findings of the IPCC Third Assessment Report (TAR) regarding the need for improved understanding of climate change impacts, mitigation and adaptation strategies, and the need for close association between governments and industries (Bureau of Meteorology 2003).

[6] Global agenda and plan of action for the 21st century, crafted during the Earth Summit — the 1992 United Nations' Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil. It is a comprehensive set of programmes of action to promote sustainable development. Although non-binding, Agenda 21 represents an important consensus of the world's governments. See http://www.cadi.ph/glossary_of_terms.htm

Australia's international role

Australian scientists have prominent and influential roles in both the IGBP and the WCRP that are, proportionally, well in excess of other participating countries (AGO 2003, Green and MacRae 2002). This influence is instrumental and ensures that global observing systems have adequate coverage in the southern hemisphere, that Australia gains access to global datasets, and that international programs include a focus on southern hemisphere problems and issues (AGO 2003, Bureau of Meteorology 2003).

While Australia's high profile in international climate change science and research ensures enhanced capacity for Australia to develop regional climate change projections for adaptation planning (Bureau of Meteorology 2003), important gaps exist in our understanding of the links and interactions between climate change and variability, and ecosystem dynamics (Green and MacRae 2002).

United Nations framework

There are a number of other international conventions that, although not directly concerned with climate change science, are relevant to the present discussion. For example, the United Nations Convention on Biological Diversity (UNCBD), ratified at the 1992 Earth Summit in Rio de Janeiro, sets out three main objectives: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. The COP to the UNCBD, supported by the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) and various ad hoc working groups, considers mechanisms and interventions to combat climate change impacts on biodiversity and facilitates interconvention synergies in this area. Examples of other bi- and multilateral international agreements where consideration of climate change impacts is important include the Convention on Wetlands of International Significance (Ramsar), the Japan–Australia Migratory Bird Agreement (JAMBA) and China–Australia Migratory Bird Agreement (CAMBA).

Glossary

Term	Meaning in this action plan
Adaptations	Responses that decrease the negative effects of climate change and capitalise on positive opportunities associated with impacts. Adaptations can be split into 'autonomous' (internal, automatic system adjustments such as evolutionary responses in natural systems) and 'planned' (where a deliberate intervention is made in an attempt to achieve a specific goal, recognising the change in environment). Howden et al (2003).
Biodiversity	Defined in the 1992 Convention on Biological Diversity as: The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems (United Nations (1992) Convention on Biological Diversity, Secretariat to the Convention on Biological Diversity, Montreal).
Buffer zone	In a reserve, an area of moderately utilised land that provides a transition into the unmodified natural habitat in the core reserve where no human disturbance is allowed. Buffer zones are essential for all conservation areas and provide a degree of protection from threatening processes and impacts. They are especially important for those areas where the small size of the reserve is already compromising conservation objectives. Buffer zones should be implemented outside reserve boundaries to prevent part of the reserve being sacrificed from its primary conservation purposes.
Climate	Climate, in a narrow sense, is usually defined as the 'average weather' or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time, ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (modified from IPCC 2001).
Climate change	The United Nations Framework Convention on Climate Change (UNFCCC) definition (in its Article 1) has been used in this action plan. It defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is *in addition to* natural climate variability observed over comparable time periods'. The IPCC definition of climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). It may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (modified from IPCC 2001).
Connectivity	A term derived to establish the 'ecological opportunities for movement' rather than viewed in the traditional sense of 'corridors' (ie narrow continuous links between entities). For instance, connections may be enlarged 'islands' of habitat between major natural areas. When these islands are restored to current or recent past vegetation, preferably through natural regrowth, they can create 'connectivity' between larger habitat areas.

Term	Meaning in this action plan
Ecosystem	A community of organisms, interacting with one another, plus the environment in which they live and with which they also interact (eg a lake, a forest, a grassland, tundra). Such a system includes all abiotic components such as mineral ions, organic compounds, and the climatic regime (temperature, rainfall and other physical factors). The biotic components generally include representatives from several trophic levels; primary producers (autotrophs, mainly green plants), macroconsumers (heterotrophs, mainly animals) which ingest other organisms or particulate organic matter, microconsumers (saprotrophs, again heterotrophic, mainly bacteria and fungi) which break down complex organic compounds upon death of the above organisms, releasing nutrients to the environment for use again by the primary producers (Abercrombie et al 1992).
Ecosystem resilience	A measure of the ability of an ecosystem to withstand and recover from environmental stresses and perturbations. The healthier an ecosystem is (eg absence of exotic grazers, weeds), the greater its resilient capacity — it is dynamic in time but frequently refers to a spatially static environment. With shifting distributions induced by climate change, resilience may also refer to the capacity to shift to other localities. In this action plan the term 'ecosystem resilience' is used in both ways.
Refuges	A place where many species have survived past environmental changes. Species may remain restricted to the vicinity of a refuge or disperse from a refuge thus (re)colonising wider areas following further environmental changes. Past refuges might include places where species have survived past glacial periods, eg protected valleys within rainforests, or drought, eg permanent water holes. In the context of climate change, a refuge is a place where species may survive the immediate impacts of climate change and from which they may disperse to colonise new locations as environmental conditions allow.
Weather	The fluctuating state of the atmosphere around us, characterised by the temperature, wind, precipitation, clouds and other weather elements (Baede et al 2001).

Abbreviations and acronyms

CAMBA	China–Australia Migratory Bird Agreement
COP	Conference of Parties
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ESD	Ecologically Sustainable Development
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
IGBP	International Geosphere–Biosphere Program
IPCC	Intergovernmental Panel on Climate Change
JAMBA	Japan–Australia Migratory Bird Agreement
NAP	National Action Plan (for Salinity and Water Quality)
NHT	Natural Heritage Trust
NRM	natural resource management
Ramsar	Convention on Wetlands of International Significance
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
TAR	Third Assessment Report (IPCC)
UNCBD	United Nations Convention on Biological Diversity
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WONS	Weeds of National Significance

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