Australian Government

AUSTRALIA'S BIODIVERSITY AND CLIMATE CHANGE

A strategic assessment of the vulnerability of Australia's biodiversity to climate change

Summary for policy makers 2009

Summary of a report to the
Natural Resource Management Ministerial Council
commissioned by the Australian Government

thinkchange

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Cover images:

Left – Billybuttons, Australian Alps (Graeme Worboys)
Centre – Boolcoomatta Reserve, South Australia (Wayne Lawler for Bush Heritage Australia)
Right – Rainbow over Brothers Point, Macquarie Island (Mike Preece)

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Preface

This document is a summary of the key issues for policymakers derived from a strategic assessment of the vulnerability of Australia's biodiversity to the impacts of climate change. The assessment was commissioned by the Natural Resource Management Ministerial Council (NRMMC). It was undertaken by an independent Expert Advisory Group, chaired by Professor Will Steffen from the ANU, reporting to the Department of Climate Change.

This is the first such national assessment of the vulnerability of Australia's biodiversity to climate change. The assessment's main focus is on terrestrial biodiversity. This is partly because there has been a recent analysis of the impacts of climate change on marine biodiversity generally[1] (and the Great Barrier Reef in particular[2]); and partly because there is relatively little research to date on the consequences of climate change for freshwater biodiversity. Work is now underway to provide a preliminary assessment of implications for high conservation value freshwater systems.

Three products have come out of the vulnerability assessment: a full report in the form of a book; a Technical Summary; and this short Summary for Policy Makers.

The Expert Advisory Group's assessment does not necessarily represent the views of individual states and territories, or the Australian Government. However, the insights gained through the biodiversity vulnerability assessment should provide a valuable source of guidance and information for biodiversity practitioners in developing climate change adaptation strategies for Australia's biodiversity.

The NRMMC is continuing its effort to confront the challenges of climate change and has identified a broad suite of priorities to be addressed over the period 2009 to 2012. These include a review of the *National Strategy for the Conservation of Australia's Biological Diversity* – Australia's premier biodiversity conservation policy statement – and a review of the *National Action Plan for Biodiversity and Climate Change*, due to be undertaken in 2009.

1 Hobday AJ, Okey TA, Poloczanska ES, Kunz TJ and Richardson AJ (Eds) (2006) *Impacts of climate change on Australian marine life*. Australian Greenhouse Office, Canberra.

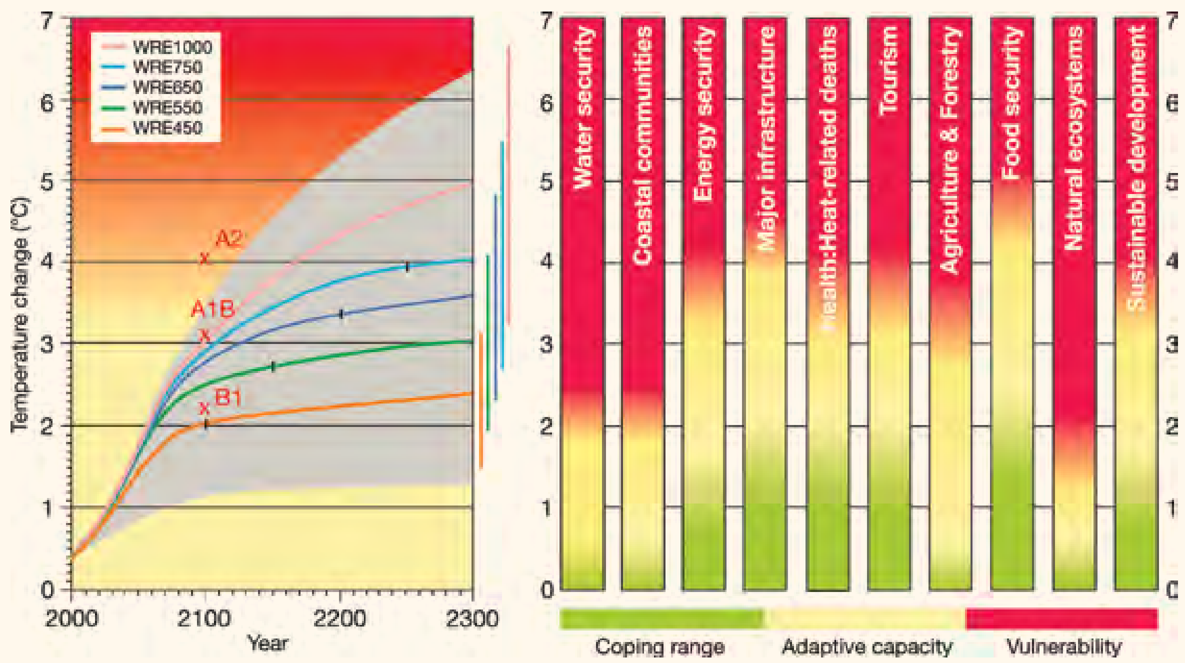
2 Johnson JE and Marshall PA (Eds) (2007) *Climate change and the Great Barrier Reef*. Great Barrier Reef Marine Park Authority and Australian Greenhouse Office, Australia.

Executive summary

Australia's unique biodiversity, already under threat from a wide range of stressors, now faces a further threat from a rapidly changing climate. Effects of climate change are already discernible at the genetic, species and ecosystem levels in many parts of the continent and coastal seas.

Biodiversity is one of the most vulnerable sectors to climate change (Figure 1). Many of Australia's most valued and iconic natural areas, and the rich biodiversity they support, are among the most vulnerable to climate change. They include the Great Barrier Reef, south-western Western Australia, the Australian Alps, the Queensland Wet Tropics and the Kakadu wetlands.

Figure 1 – Vulnerability to climate change for key sectors in the Australia and New Zealand region, allowing for current coping range and adaptive capacity. The right-hand panel assesses relative coping range, adaptive capacity and vulnerability matched against the global temperature changes for various CO_2 stabilisation scenarios shown in the left-hand panel. Biodiversity is represented here as 'natural ecosystems' and is judged the most vulnerable sector. The year of stabilisation of global temperature change is shown as black dots in the left-hand panel (IPCC 2007a).



Much is at stake in dealing effectively with the climate change challenge. Beyond the great richness it lends to our most iconic natural areas, biodiversity underpins our quality of life, our economy and much of our national identity.

The magnitude and rate of climate change pose particularly severe challenges for natural ecosystems. The interaction of climate change with existing stresses – such as land clearing, fire and invasive species – and the different migration rates of species and consequent formation of novel ecosystems, add further levels of complexity. Significant changes are required in policy and management for biodiversity conservation to meet these types of challenges.

First, management objectives for the future aimed at maintaining all species in their present locations and ecosystems in their present composition will no longer be appropriate. A management priority must be to maintain the provision of ecosystem services through a diversity of well-functioning ecosystems, some of which may have no present-day equivalent.

Second, a central strategy is giving ecosystems the best possible chance to adapt by enhancing their resilience. Approaches to building resilience include managing appropriate connectivity of fragmented ecosystems, enhancing the National Reserve System, protecting key refugia, implementing more effective control of invasive species, and developing appropriate fire and other disturbance management regimes. In some instances, ecological engineering will need to be considered.

Third, risk assessments are a key approach to identify especially vulnerable species and ecosystems. Risk-spreading conservation strategies, coupled with active adaptive management approaches, are an effective way to deal with an uncertain climatic future.

Fourth, reorientation of policy and legislative frameworks, and reform of institutional and governance architecture, are essential. These actions can support novel strategies for biodiversity conservation – such as integrated regional approaches tailored for regional differences in environments, climate change impacts and socio-economic trends.

Finally, even with much more effective policy and management strategies, there is a limit to how much we can enhance the adaptive capacity of natural ecosystems (Figure 1). Without rapid and effective mitigation of climate change, there is a high risk of an accelerating wave of extinctions throughout the 21st century and beyond.

The following five key messages comprise an integrated package to support effective policy and management responses to the threat to biodiversity from climate change, and are detailed in section 5.

Reform our management of biodiversity

We need to adapt the way we manage biodiversity to meet existing and new threats – some existing policy and management tools remain effective, others need a major rethink, and new approaches need to be developed in order to enhance the resilience of our ecosystems.

Strengthen the national commitment to conserve Australia's biodiversity

Climate change has radical implications for how we think about conservation. We need wide public discussion to agree on a new national vision for Australia's biodiversity, and on the resources and institutions needed to implement it.

Invest in our life support system

We are pushing the limits of our natural life support system. Our environment has suffered low levels of capital reinvestment for decades. We must renew public and private investment in this capital.

Build innovative and flexible governance systems

Our current governance arrangements for conserving biodiversity are not designed to deal with the challenges of climate change. We need to build agile and innovative structures and approaches.

Meet the mitigation challenge

Australia's biodiversity has only so much capacity to adapt to climate change, and we are approaching that limit. Therefore, strong emissions mitigation action globally and in Australia is vital – but this must be carried out in ways that deliver both adaptation and mitigation benefits.

1. Climate change impacts: what is happening already?

Australia's unique biodiversity has evolved in a climate of extremes. Our landscapes have been shaped by aridity, high temperatures and fire. The scarcity of fresh water has driven many Australian species to evolve ways to reduce water use and loss, and to survive long periods of drought. Despite their evolutionary adaptiveness, many of Australia's plants, animals and micro-organisms are already being affected by human-induced climate change.

Table 1 provides a few examples of recently observed changes in Australia's biota that are consistent with the emerging climate change 'signal'. What is most remarkable about these observations, and similar observations globally, is that significant impacts are occurring with extremely modest changes in climate when compared with the climatic changes expected over the coming decades.

Table 1 – Examples of observed changes in Australian species and communities consistent with a climate change signal

Type of change	Examples of responses observed
Genetic constitution	Shifts in genetic composition of fruit flies
Geographic ranges	Migration of several bird species to higher altitudes or higher latitudes
Life cycles	Earlier mating and longer pairing of the large skink *Tiliqua rugosa*
Populations	Reduced reproduction in wedge-tailed shearwaters on Great Barrier Reef islands associated with higher sea temperatures
Ecotonal boundaries	Expansion of rainforest at the expense of eucalypt savanna woodland and grassland in the Northern Territory, Queensland and New South Wales (other non-climatic factors have likely contributed to the observed shift)
Ecosystems	Eight mass bleaching events since 1979 on the Great Barrier Reef triggered by unusually high sea surface temperatures
Disturbance regimes	Changing fire regimes in southern Australia, consistent with drier and hotter climate

Even without climate change, Australia's biodiversity is threatened on many fronts. It is under considerable pressure from greatly altered landscapes through vegetation clearing, introduced pests and weeds, highly modified and overcommitted water resources, widespread use of fertiliser and other chemicals, changed fire regimes, urbanisation, mining, and over-harvesting. Most of these stressors have been active over much of the past century and continue to exact a debilitating toll on Australian ecosystems.

The historic drivers have led to profound changes in Australia's biotic fabric at the genetic, species and ecosystem levels. The most prominent of these changes are:

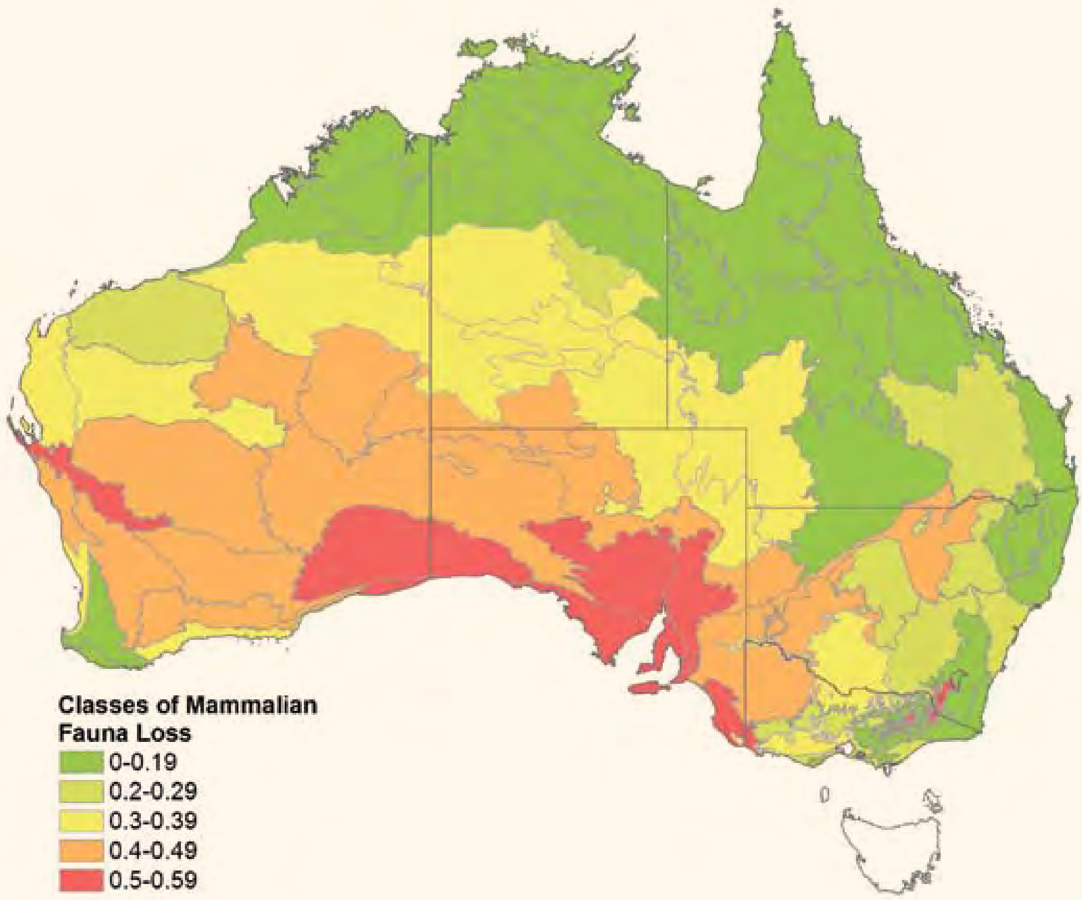
- ***extinction, functional extinction and threatened species*** – in addition to the well-known record of species extinctions and the large lists of threatened species in Australia, many species have reached such low numbers that they no longer play an effective role in the functioning of ecosystems and are thus functionally extinct (Figure 2)

- ***changes in relative abundance and distribution*** – although not yet threatened with extinction, many other species have suffered large reductions in their ranges. For example, many of Australia's mammal species now have distributions covering less than 20% of their original range
- ***introduced species*** – many introduced plants and animals have had deleterious effects on biodiversity. Well-known examples include cats, foxes, rabbits, north Pacific starfish, trout, water hyacinth, cane toads, prickly pear and gamba grass, but there many others.

As a consequence, Australia's biodiversity has experienced massive declines over the past century. Our rate of species extinctions is high in comparison with most other parts of the world, and many more species are on trajectories towards extinction. These changes in species abundance and distribution significantly affect the structure and functioning of ecosystems, the services they provide, and their resilience towards additional stressors like climate change.

Future climate change will thus act on ecosystems that are already under considerable stress and have reduced adaptive capacity. This has profound implications for the types of policy and management strategies required, and the level of investment needed to meet the climate change threat in the 21st century.

Figure 2 – Proportion of loss of mammalian fauna in 76 bioregions of mainland Australia. The Faunal Attrition Index measures the status of a bioregion's fauna along a trajectory, from all species persisting throughout their original range in a region to a point at which all species are extinct. Shown are five classes: 0–0.19, 0.2–0.29, 0.3–0.39, 0.4–0.49 and 0.5–0.66; where 0 = all species persisting, through to 1 = all extinct.



Source: McKenzie et al. (2007).

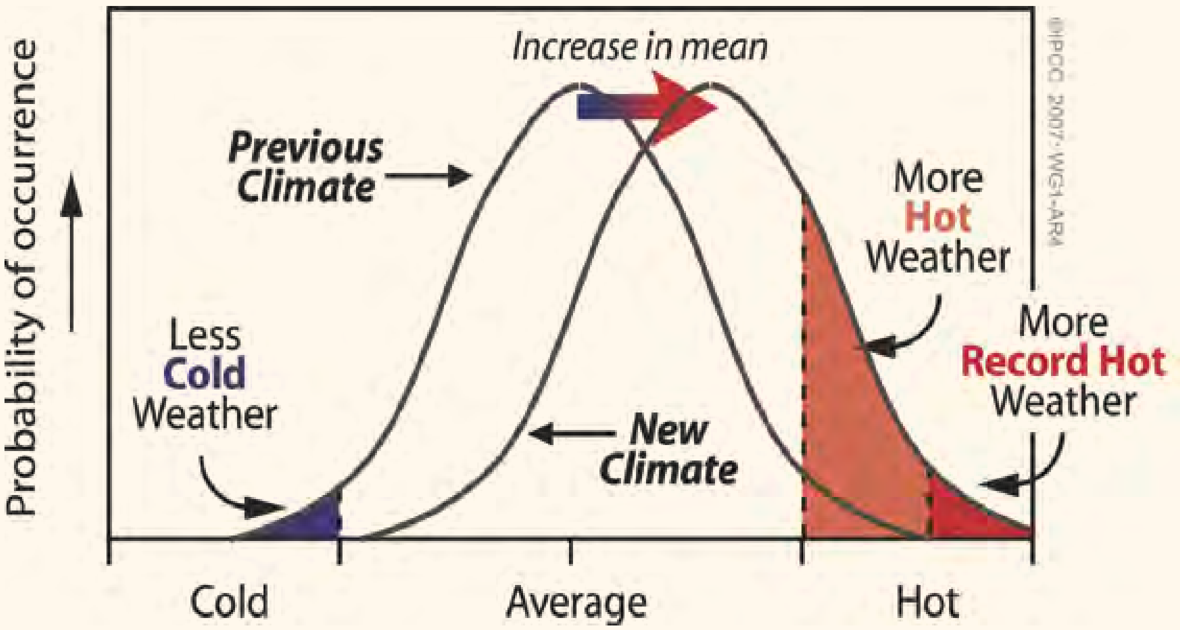
2. Climate change impacts: what does the future hold?

Australia's biodiversity is not distributed evenly over the continent but is clustered in a small number of hotspots with exceptionally rich biodiversity. Most of these areas, as well as many of Australia's most valued and iconic natural areas, are among the most vulnerable to future climate change. They include the Great Barrier Reef, south-west Western Australia, the Australian Alps, the Queensland Wet Tropics and the Kakadu wetlands.

Predicting the future effects of climate change on Australia's biodiversity in these iconic areas and elsewhere is challenging for a variety of reasons:

- Climate change will interact with other stressors that are currently affecting biodiversity.
- Responses to the physical and chemical changes associated with climate change are individualistic – that is, they occur at the level of the individual.
- Properties of ecological systems – communities of interacting species and their abiotic environment – are often non-linear, and can be difficult to understand and predict. A change in the average value of a variable, such as temperature, may not be as important ecologically as a change in the variability or extremes of that variable (Figure 3).
- Basic knowledge is generally lacking about limiting factors, genetics, dispersal rates, and interactions among species that comprise Australian communities and ecosystems.

Figure 3 – Relationship between means and extremes. Graph shows the relationship between a shifting mean and the proportion of extreme events when extreme events are defined as some fixed physiological or life history threshold.



Source: (IPCC 2007b).

Furthermore, many of the most important impacts of climate change on biodiversity will be the indirect ones at the community and ecosystem levels, together with the interactive effects with existing stressors. For example, for the Kakadu wetlands, the major threats of climate change are not the direct impacts on vulnerable species but rather an intersection of effects due to changing fire regimes, rising sea level and the resulting saltwater intrusion into freshwater wetlands, as well as the consequences of climate change for a suite of invasive weed and feral animal species. Such indirect effects highlight the difficult but important issues that biodiversity managers face in responding to climate change – severe uncertainties, non-linearities, time lags, thresholds, feedbacks, rapid transformations, synergistic interactions and surprises.

The situation, however, is not hopeless. Going back to fundamental ecological principles provides the basis for developing robust rules-of-thumb that support effective responses to climate change, despite the severe scientific uncertainties and lack of predictive capability. Principles relating to ecosystem structure and functioning that are important for dealing with the climate change threat cluster into four groups:

- relationships between characteristics of individual species and the surrounding environment
- role of individual species in communities and ecosystems
- ecosystem and landscape structure and functioning
- phenomena associated with environmental change at all levels – genetic to biome.

An example of how application of these principles can provide useful information at the species level is shown in Figure 4. The suite of traits that make a species vulnerable to disturbance generally will also predispose that species to risk from rapid climate change. Conversely, species with traits that assist in invading or colonising disturbed areas may also have an advantage in a rapidly changing climate. Indeed, many species – both native and exotic – that are not currently considered to be invasive may expand their range and increase in abundance to such an extent that they have a transforming – and often negative – impact on other species and ecosystems.

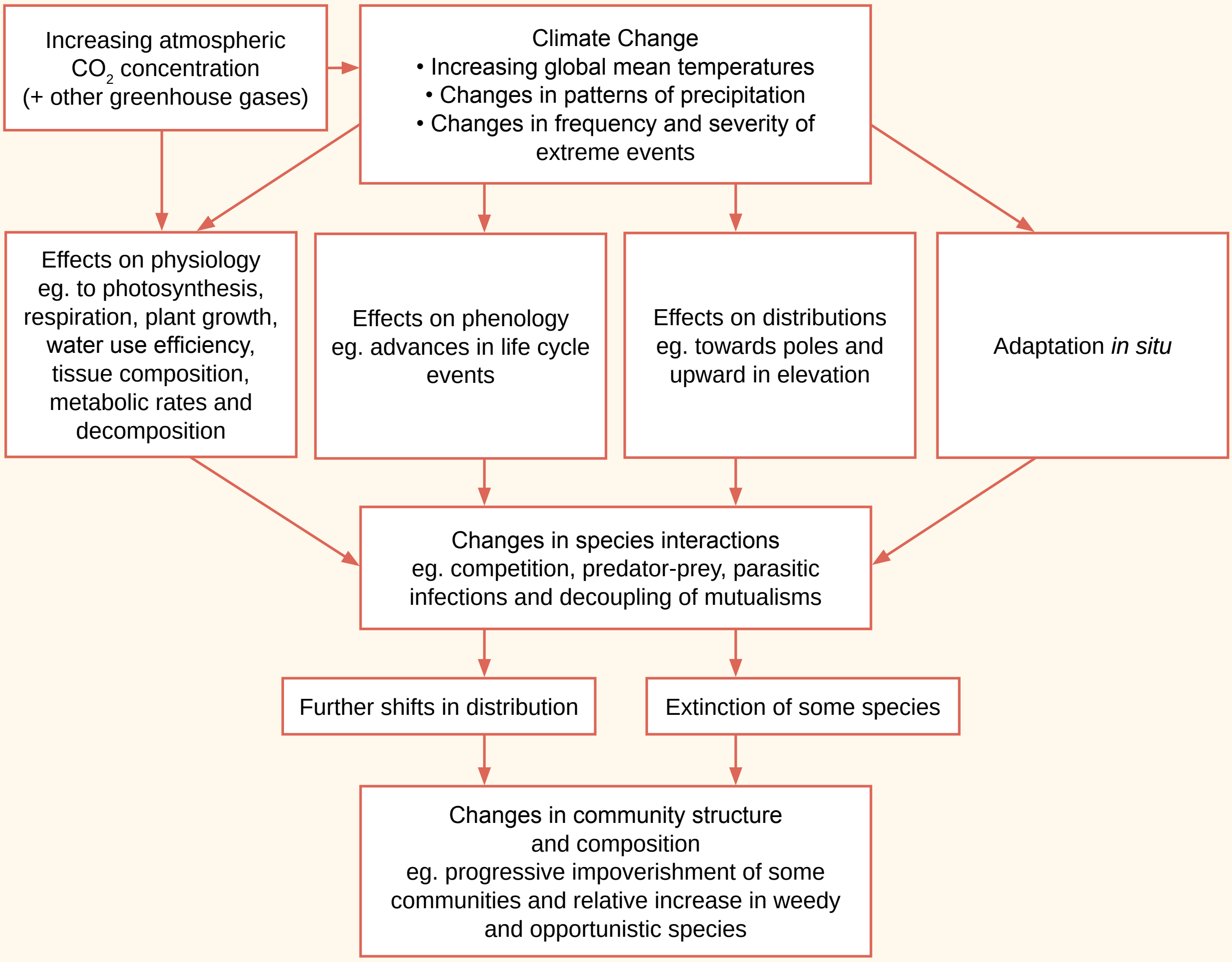
Figure 4 – Physiological and life history traits of species that influence vulnerability or resilience in response to climate-related disturbance

SPECIES LEAST AT RISK	SPECIES MOST AT RISK
• Physiological tolerance to broad range of factors such as temperatures, water availability and fire • High degree phenotypic plasticity • High degree of genetic variability • Short generation times (rapid life cycles) and short time to sexual maturity • High fecundity • 'Generalist' requirements for food, nesting sites, etc. • Good dispersal capability • Broad geographic ranges	• Narrow range of physiological tolerance to factors such as temperature, water availability and fire • Low genetic variability • Long generation times and long time to sexual maturity • Specialised requirements for other species (e.g. for a disperser, prey species, pollinator or photosynthetic symbiont) or for a particular habitat that may itself be restricted (e.g. a particular soil type) • Poor dispersers • Narrow geographic ranges

Based on the physiological characteristics of some taxa, some more specific predictions of the impacts of future climate change can be made. For example, warming temperatures may alter sex ratios of reptiles such as crocodiles and turtles. Also, freshwater fish species are vulnerable to reductions in water flows and water quality and, in addition, have a limited capacity to migrate to new waterways.

Although it is much more difficult to predict future climate impacts at the community, ecosystem and biome levels, some general trends can nevertheless be anticipated (Figure 5). For example, for tropical rainforests, higher temperatures and changes in rainfall patterns – longer dry periods between intense rainfall events – will increase the probability that fires penetrate into rainforest vegetation. In arid and semi-arid regions, shifts in the seasonality or intensity of rainfall events could change the proportions of woody and grassy vegetation in somewhat predictable directions.

Figure 5 – Example of the potential pathways of community change flowing on from individual responses to climate change. Increased CO_2 concentration will act on species directly (via physiology) and indirectly (via climate changes) (first tier). Individual species might respond in four ways (second tier), resulting in changes in species interactions (third tier). These changes might then lead either to extinctions or to further shifts in ranges (fourth tier), ultimately leading to changes in the structure and composition of communities.



Source: Redrawn from Hughes (2000).

The ways in which climate change will unfold over the rest of this century add another level of uncertainty to assessing future impacts on biodiversity. Novel climates will almost surely emerge in the future; that is, combinations of temperatures, precipitation and seasonality that have no current equivalents in those regions. Indeed, novel climates may have already emerged in some regions, such as south-west Western Australia.

Biological systems, from individuals to ecosystems, will often respond to climate change in rapid transformations after a long period of little change. Such rapid transformations usually occur when 'tipping points' or 'critical thresholds' are crossed. Increasing frequency and intensity of extreme climate events have the potential to more readily breach tipping points and thresholds. Most current projections of future climatic conditions are couched in terms of average temperature and rainfall, while researchers assessing impacts on particular systems and species are more likely to be interested in information on the extreme events.

Finally, the rate of climate change will likely become its most important feature in terms of consequences for biodiversity. Change at too fast a rate may simply overwhelm the capacity of current ecosystems to adapt – whether assisted by human interventions or not – leading to escalating extinctions and widespread reorganisation of ecosystems.

3. Implications of accelerating climate change

The assessment used three stylised scenarios of climate change (Figure 6) to explore the consequences for biodiversity and to inform strategies for biodiversity conservation.

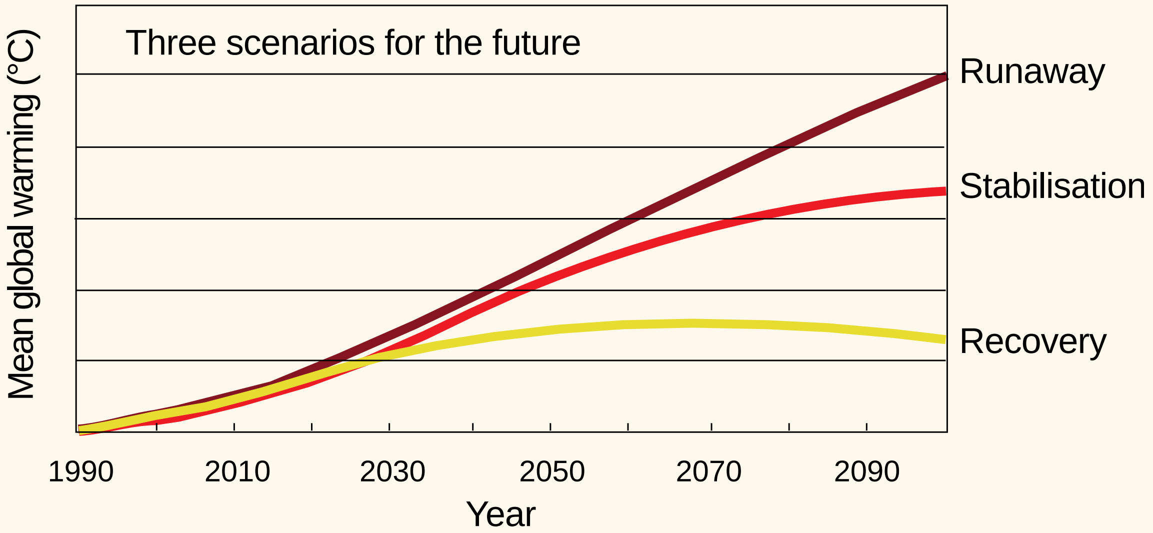
Under a runaway climate scenario there are no promising and cost-effective approaches for conserving our vulnerable natural ecosystems. If such a scenario were to play out, it is likely that many extinctions and massive ecosystem change will result.

A ***stabilisation scenario*** provides a focus for management actions to assist natural ecosystems to adapt to some altered future climate. However, the higher the level at which atmospheric greenhouse gas concentrations stabilise, the greater the change will be.

A ***recovery scenario*** will require adaptation approaches that might be able to 'nurse' vulnerable systems through a period of increasing climate change, anticipating the prospect of better conditions at some future date, albeit centuries away.

Planning for decisions with long-term implications needs to accommodate these possible futures until there is increasing certainty about future emission levels and about the degree of climate change that will result.

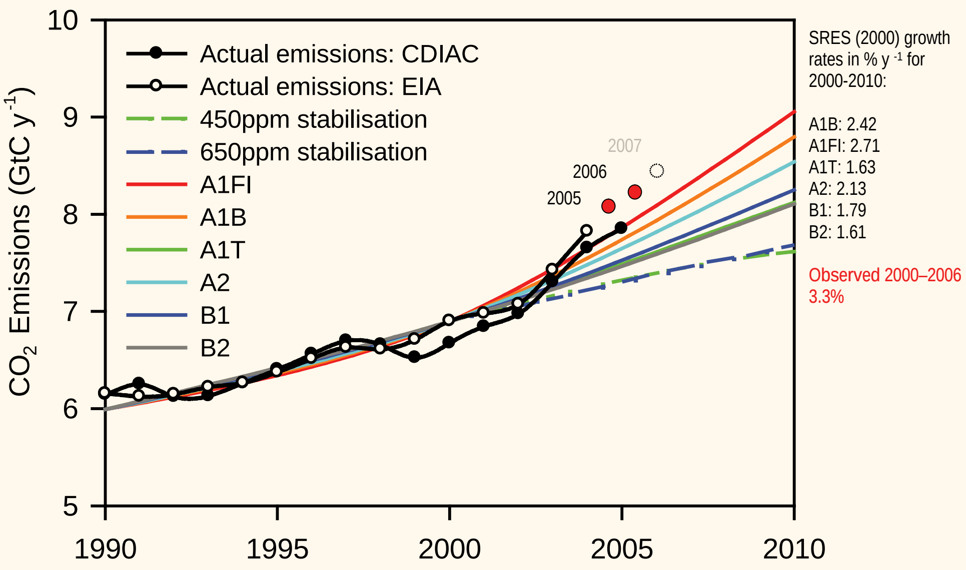
Figure 6 – Three scenarios of future climate: recovery, stabilisation and runaway. Scenarios are based on the IPCC suite of scenarios (IPCC 2007b) and driven by different assumptions about humanity's response to mitigating CO_2 emissions over the coming century.



The runaway scenario deserves further analysis. Although the three scenarios in Figure 6 cannot be distinguished until 2030, a more detailed analysis shows that we are currently tracking on the runaway scenario. Carbon dioxide concentrations are rising even faster than previous projections, including those published by the Intergovernmental Panel on Climate Change (IPCC) in 2007 (Figure 7a). The observed rate of temperature increase (Figure 7b) lies within the range of IPCC projections, while sea level rise (Figure 7c) is tracking at the upper limit of the IPCC scenario set.

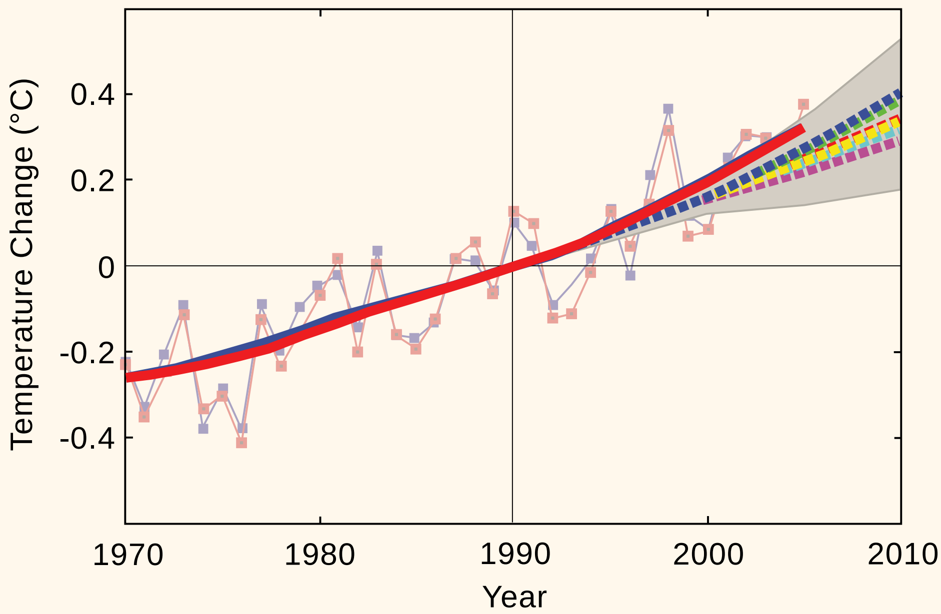
What are the implications of the current trajectories for biodiversity? Even under the most modest climate change scenario, the potential impacts on biodiversity will increase through most of this century. Formation of novel ecosystems, abrupt changes in ecosystem structure and functioning, and surprising, counterintuitive outcomes will become more common. If the current trajectories continue, though, we are headed for even more significant changes – a mass extinction event equivalent to those of the distant past; in fact, the sixth great extinction event in the Earth's history. It took millions of years for biodiversity to recover from these past massive extinction events.

Figure 7a – Observed CO_2 emissions compared to IPCC projections.



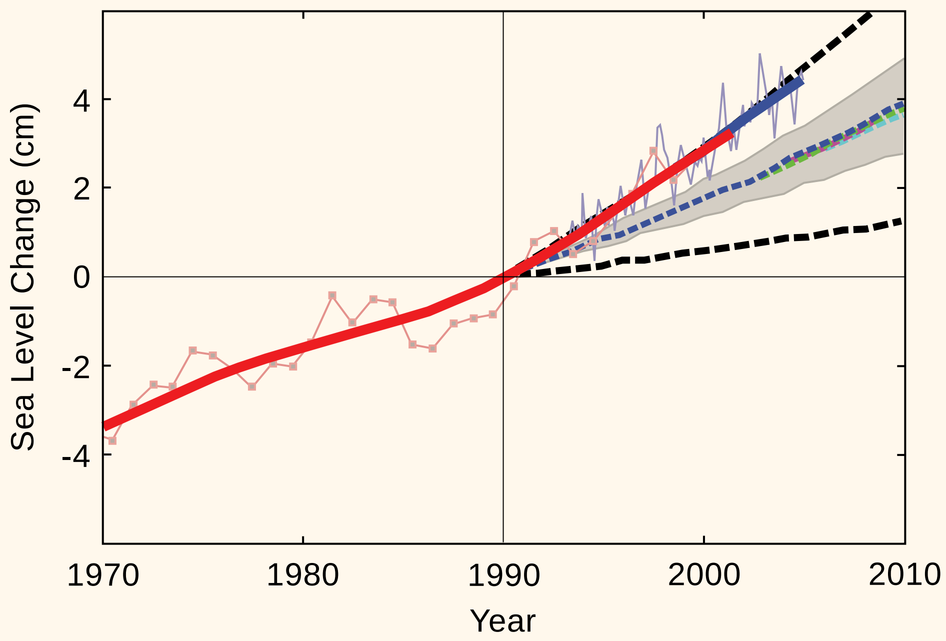
Source: Raupach *et al*. (2007) with additional data points from Canadell et al (2007).

Figure 7b – Change in global average surface air temperature (smoothed over 11 years), relative to 1990. The solid blue line represents data from Hadley Center; the solid red line is GISS data. Broken lines are model projections.



Source: Rahmstorf *et al*. 2007 with data for 2007 and 2008 from S Rahmstorf.

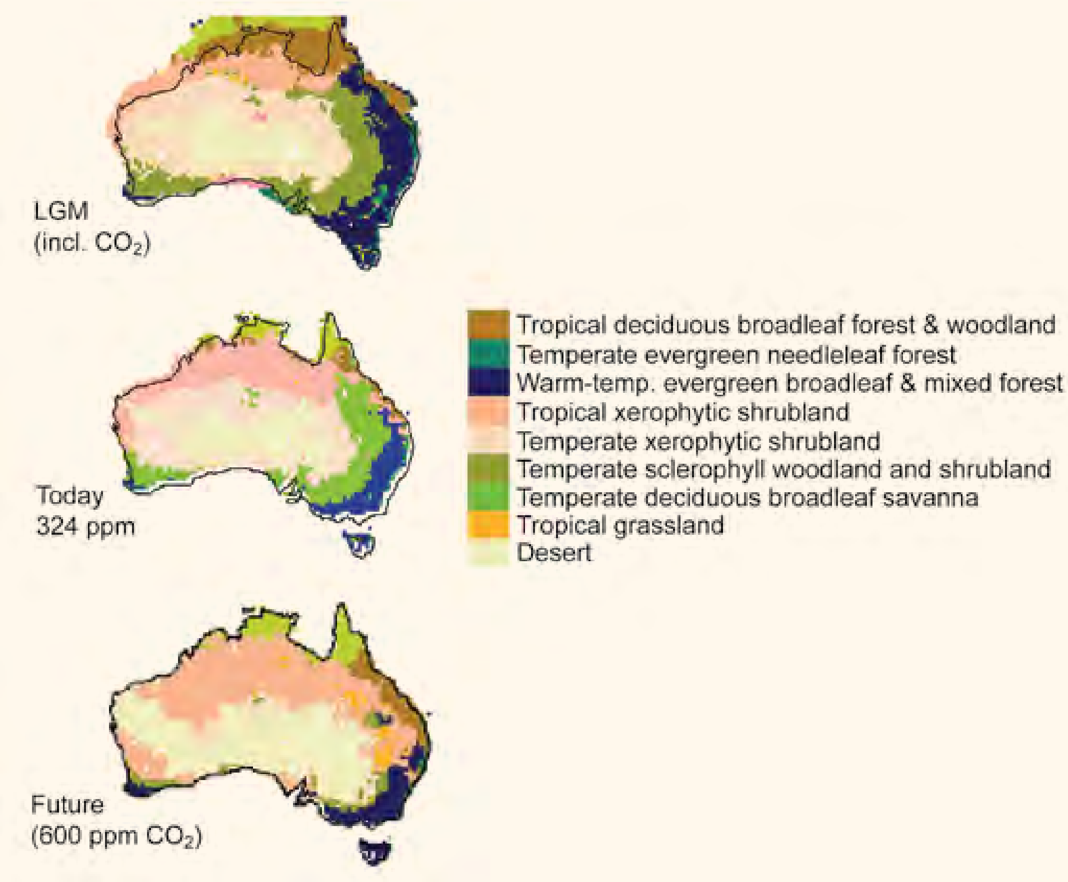
Figure 7c – Sea level change from 1970 to 2008, relative to the 1990 level. The envelope of IPCC projections are shown for comparison. Solid red lines are data from tide gauges; solid blue lines are data from satellite altimetry. Broken lines are model projections.



Source: Rahmstorf *et al*. (2007). Based on data from Cazenave and Narem (2004); Cazenave (2006) and A Cazenave for 2006–2008 data..

A long-term, continental-scale perspective on the relationship between biota and climate provides a more direct view of the potentially profound changes that await Australia's biodiversity. Figure 8 compares the equilibrium distribution of biomes at the Last Glacial Maximum to the present, and then simulates biome distribution for a 2100 climate with a CO_2 concentration of 600 ppm. Over the next 100 years Australia could well experience changes in ecosystem type and distribution at least as great as those associated with the transition from the Last Glacial Maximum to the present – a period of at least 5000 years. The rate of climate change – a similar transition in only 100 years – is almost surely unprecedented for the past several million years. Maintaining well-functioning biodiversity systems in the face of such a rapid rate and relatively large change in climate will be difficult.

Figure 8 – Australian biome distribution at Last Glacial Maximum, present, and 2100 (600ppm CO_2 scenario) using BIOME 4.0.



Source: Sandy Harrison, University of Bristol, UK.

Natural ecosystems and the biodiversity they support have the lowest adaptive capacity of any sector (Figure 1). If Australian society wishes to minimise the risk of an unprecedented wave of extinctions over the next 100–200 years, mitigation of climate change must be undertaken vigorously, rapidly and globally. Figure 1 illustrates that a mean temperature rise of 1.5-2.0°C relative to pre-industrial levels will lead to increasing loss of biodiversity. If climate change continues on the current trajectory, opportunities for adaptation will become increasingly difficult as species and ecosystems become further stressed.

4. Biodiversity conservation in a changing climate

Even with a rapid and vigorous level of global action to reduce greenhouse gas emissions, we are committed to continuing climate change for the rest of this century and beyond, and to a global average temperature of nearly 2°C or higher above pre-industrial levels. To avoid an escalating loss of biodiversity and the consequent disruption to the ecosystem services on which our society depends, Australian managers and policy makers must undertake a vastly enhanced conservation effort

Biodiversity conservation in a changing climate requires a re-evaluation of what we are managing for. The rate of change within natural systems could be very swift compared to the past and the magnitude of change could be large. Management approaches that seek to maintain current spatial arrangements of species will be very difficult to implement under a changing climate – and could well become counterproductive. Management objectives will need to be reoriented from preserving all species in their current locations to maintaining the provision of ecosystem services through a diversity of well-functioning ecosystems.

Concepts such as resilience and transformation provide positive, proactive avenues for reducing the vulnerability of biodiversity to climate change. The emphasis is on making space and opportunities for ecosystems to self-adapt and reorganise, and on maintaining fundamental ecosystem processes that underpin vital ecosystem services.

Progress in biodiversity conservation over the past several decades provides a solid base on which to tackle the climate change threat. A blend of existing and new policy and management strategies and tools is required. They can be grouped into three areas: (i) building resilience; (ii) proactive interventions; and (iii) flexible policy and management approaches.

Building resilience

Maintain well-functioning ecosystems

With decades or centuries of projected climate change that is significant in magnitude but uncertain in detail, the single most important adaptation strategy is the maintenance of well-functioning ecosystems. However, a key question is when, under climate change, does maintenance of resilience of existing ecosystems become counterproductive and facilitation of transformation into new ecosystems become more appropriate? Better regional and local monitoring is required to inform such decisions.

Protect a representative array of ecosystems

The principle of representativeness – representing all biodiversity in appropriately managed systems – remains essential. However, under a rapidly changing climate, the purpose may change – to represent as many different combinations of underlying environments and drivers, rather than specific arrays of current species. Nevertheless, the National Reserve System remains the pillar of biodiversity conservation in the 21st century, and needs to be strengthened with ambitious conservation targets and the means to achieve them.

Remove or minimise existing stressors

Climate change exacerbates the effects of many existing stressors, which continue to be the biggest threat to Australia's biodiversity. Accelerating the control or elimination of existing stressors offers an extremely low-risk, high-payback starting point in building resilience of natural systems to climate change.

Build appropriate connectivity

With increasing pressure on species to migrate in response to a changing climate, and for ecosystems to disassemble and reassemble, there needs to be a greater focus on achieving appropriate types of landscape and seascape connectivity to 'give space for nature to self-adapt'. A key strategy is to integrate all types of protected areas into a single national system, and to facilitate better integration of off-reserve conservation with protected areas.

Identify and protect refugia

There is a need to ensure that key sites likely to provide refugia in the face of climate change are identified and included in reserves or otherwise managed to protect their values.

Proactive interventions

Implement eco-engineering

Although costly and not always successful, eco-engineering may nevertheless constitute a necessary response in a few specific cases. For example, re-establishing keystone, long-lived or structuring species may allow ecological systems to self-organise around critical elements, or the use of provenances and species for the anticipated climatic conditions may help forests regenerate after successive fires.

Preserve genetic stock

As a last resort, species may need to be preserved outside an ecosystem context; for example, in zoos and seedbanks. However, such last-resort, ex situ methods should be seen in no way as substitutes for conserving species in well-functioning ecosystems.

Flexible policy and management approaches

Reconsider management objectives

A changing climate is driving change in species distributions, and in the composition and functioning of communities and ecosystems. These dynamics must be recognised in conservation management. For example, there may be a need to reconsider what is 'native' versus 'invasive' as species increasingly move around the landscape. Groups such as migratory species may require different strategic approaches.

Uncertainty about future climate projections is no excuse for delay

There is high confidence in climate projections (especially temperature) to 2030 or 2040 (Figure 6); actions taken now will be valuable out to mid-century at least. For the more distant future, spreading risk by adopting a range of conservation strategies, coupled with active adaptive management, is an effective way to deal with the uncertainty of climate projections in that time frame.

Focus more on risk assessments

Climate change presents new and bigger risks for biodiversity conservation at species, ecosystem and process levels. For example, risk assessment at a species level can identify vulnerabilities and help shape appropriate management options; risk assessment at the taxonomic group level (e.g. through Action Plans) can identify individual species or groups of species on which to focus attention. Risk assessment at the landscape scale will allow identification of management options that improve resilience and maintain ecosystem function.

Implement active adaptive management

The linear approach of research–policy–management–outcome needs to be replaced by an iterative, cyclical approach in which biodiversity outcomes are appraised – leading to new research, and adjusted policy and management (Figure 9). Such an adaptive, cyclical approach needs high quality information, based on monitoring and experimentation.

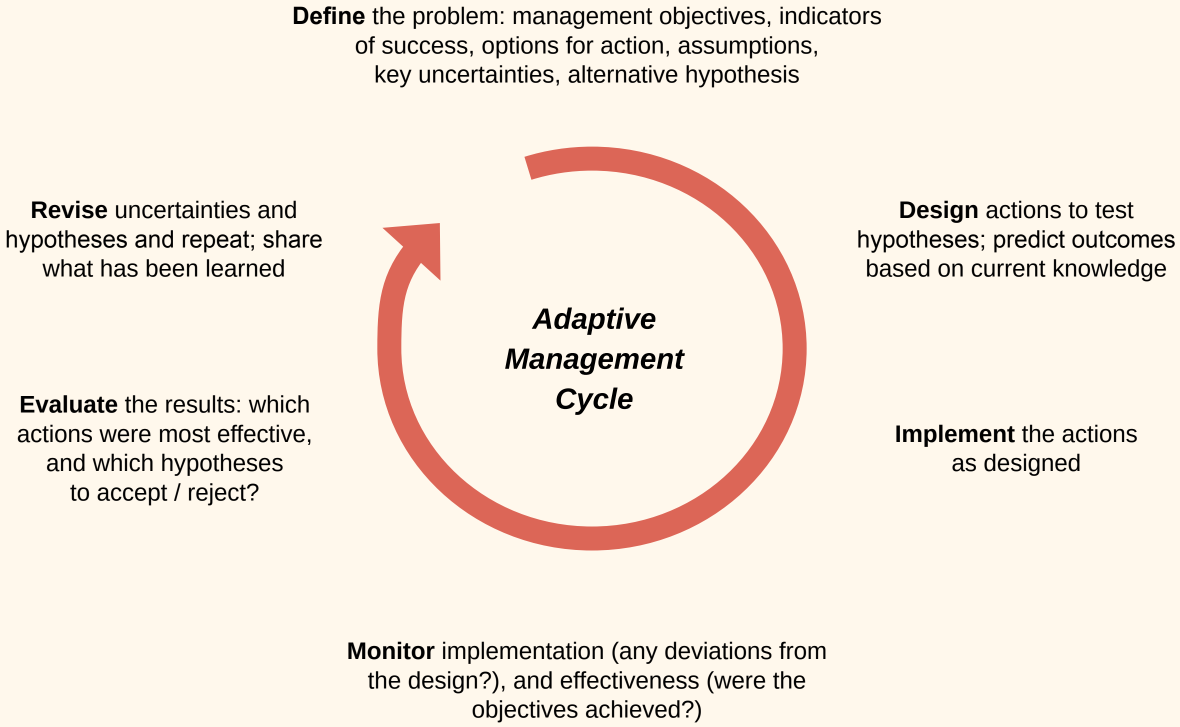
Build consensus

To achieve widespread, effective implementation of an enhanced conservation effort, we need to transform the way that societies think about and value the biotic world around them. The increasing urbanisation of the Australian population means that most of the public know less and less about the significance of biodiversity in providing services to their everyday lives. Strengthening their support for maintaining biodiversity is critical for dealing with the climate change threat, and ultimately for their own long-term well-being.

Seize opportunities from mitigation

Carbon trading and offset schemes, probably the most common climate mitigation approach in landscapes, offer an opportunity to promote sequestration in biomass while simultaneously benefiting biodiversity. For example, revegetating degraded landscapes with complex forest ecosystems, rather than with fast-growing plantations, creates good biodiversity outcomes while eventually storing more carbon.

Figure 9 – A visual representation of active adaptive management, an iterative approach built around explicit, experimentally based development of plausible management options.



Source: Murray and Marmorek (2004).

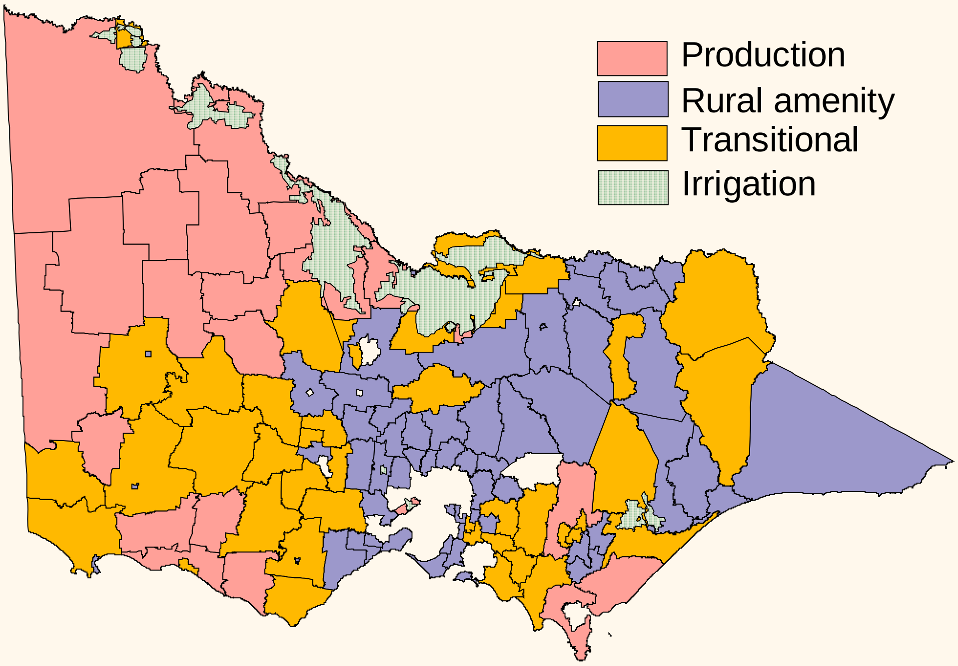
The current policy and institutional landscape is changing rapidly, with simultaneous trends towards both centralisation and decentralisation. This state of flux provides opportunities to explore alternative institutional architectures and modes of policy delivery that can provide the flexibility needed to deal with a changing climate. Such reforms could include a regionally differentiated and integrated system with enhanced local rights and responsibilities, together with greater coherence at the national level and across jurisdictions. Such changes to our biodiversity management policies, legislative frameworks and institutional structures will provide the agility required to respond to rapid change and to align with a changed emphasis in management objectives.

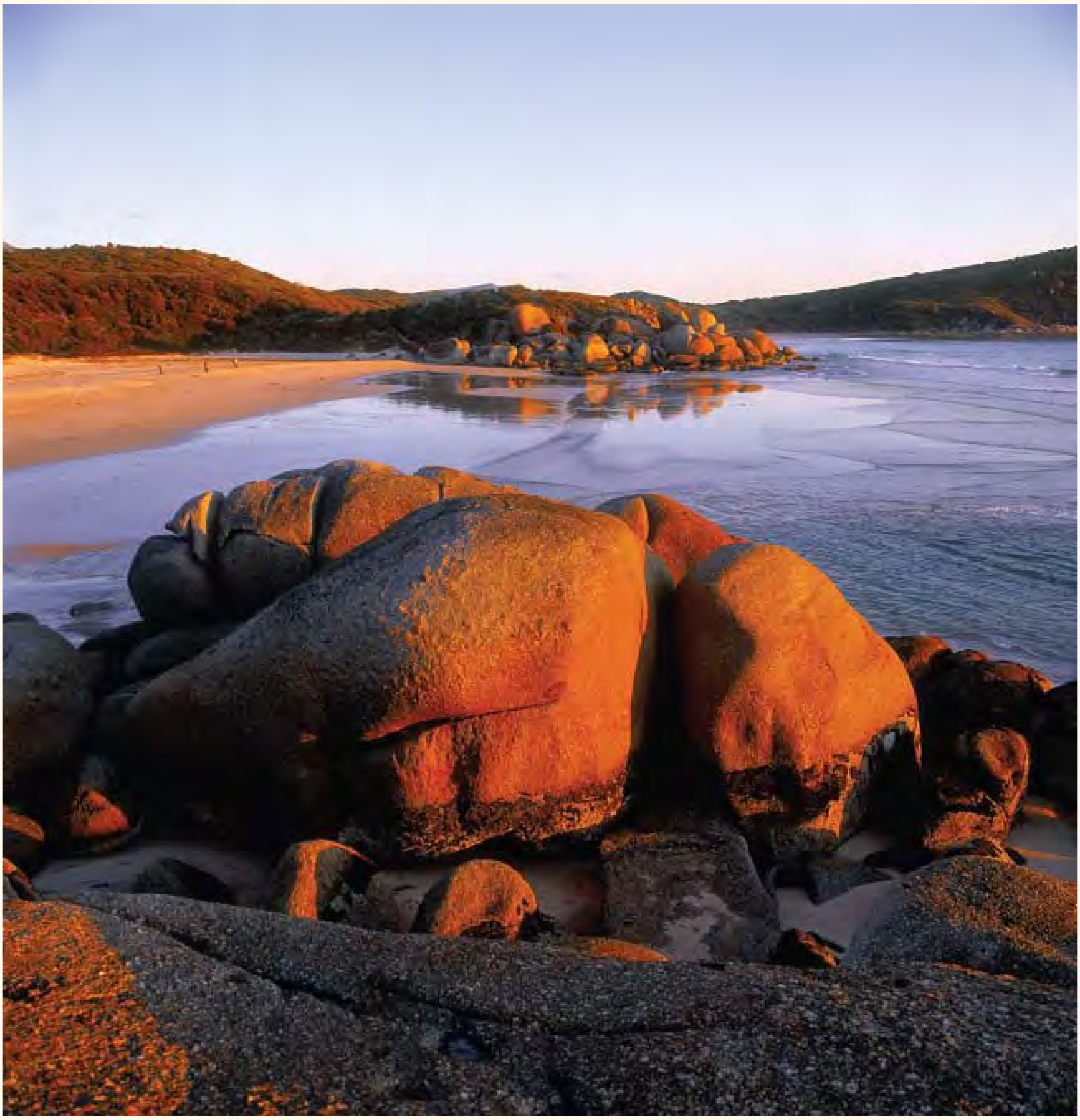
Community recognition of the threat of climate change to biodiversity is growing rapidly, providing an opportunity for Australian society to re-examine its level of commitment to, and resourcing of, the conservation of the continent's unique biotic heritage. By any measure, Australia's natural capital has suffered from depletion and under-investment over the past two centuries. Significant new funding strongly focused towards on-ground biodiversity conservation work – carried out within an active adaptive management framework – is essential to enhance our adaptive capacity to deal with the climate change threat as well as existing stressors.

Innovative regional approaches to build adaptive capacity for more effective biodiversity conservation can make use of some of the major socio-economic trends sweeping across Australia (Figure 10). For example, in the south-east, the abandonment of marginal agricultural areas, and an influx of retirees and escapees from urban areas, provide new opportunities for integrating biodiversity values into these changing landscapes. More generally, integrated response packages – in terms of governance, education, investment sources and action plans for biodiversity conservation – can be tailored to the demographic, land use, climatic and socio-economic trajectories of specific regions around the country.

Climate change is a daunting challenge for biodiversity policy makers, managers and researchers. However, it also provides opportunities. Preparing for climate change might catalyse a transformation that is required to achieve a turnaround in the ongoing decline of Australia's biodiversity. Conservation of biodiversity is increasingly becoming a mainstream activity of governments, businesses, landowners, Indigenous Australians and community groups, and there have been some notable conservation successes over the past couple of decades. Recognition in the community of the threat of climate change to biodiversity is growing rapidly, providing an opportunity for Australian society to re-examine its level of commitment to, and resourcing of, the conservation of the continent's unique biotic heritage in a rapidly changing world.

Figure 10 – Stylised social landscapes of rural Victoria based on analysis of 2001 data for nine indicators grouped by Statistical Local Areas from Barr (2005). The study suggests transformation of farming areas to the north and east of Melbourne from production to rural amenity with high levels of non-resident land ownership.





5. Key messages and policy directions

The impacts of climate change on Australia's biodiversity are now discernible at the genetic, species, community and ecosystem levels across the continent and in our coastal seas. The threat to our biodiversity is increasing sharply through the 21st century and beyond due to growing impacts of climate change, the range of existing stressors on our biodiversity, and the complex interactions between them.

A business-as-usual approach to biodiversity conservation under a changing climate will fall short of meeting the challenge. A transformation is required in the way Australians think about biodiversity, its importance in the contemporary world, the threat presented by climate change, the strategies and tools needed to implement biodiversity conservation, the institutional arrangements that support these efforts, and the level of investment required to secure the biotic heritage of the continent.

The key messages coming out of the assessment, presented below, comprise an integrated set of actions. The order is arbitrary; they are highly interdependent and of similar priority. Taken together, they define a powerful way forward towards effective policy and management responses to the threat to biodiversity from climate change.

Reform our management of biodiversity

We need to adapt the way we manage biodiversity to meet existing and new threats – some existing policy and management tools remain effective, others need a major rethink, and new approaches need to be developed in order to enhance the resilience of our ecosystems.

As we are rapidly moving into an unprecedented state for our biodiversity and ecosystems, there is a need to transform our policy and management approaches to deal with this enormous challenge. Climate change presents a 'double whammy' – affecting species, ecosystems and ecosystem processes directly, as well as exacerbating the impacts of other stressors. Many effective management approaches already exist; the challenge is to accelerate, reorient and refine them to deal with climate change as a new and interacting complex stressor. The National Reserve System, the pillar of current biodiversity conservation efforts, needs to be enhanced substantially and integrated with more effective off-reserve conservation. Acceleration of actions to control and reduce existing stressors on Australian ecosystems and species is essential to increase resilience. However, there is a limit to how far enhancing resilience will be effective. Novel ecosystems will emerge and a wide range of unforeseen and surprising phenomena and interactions will appear. A more robust, long-term approach is to facilitate the self-adaptation of ecosystems across multiple pathways of adaptation that spread risk across alternative possible climatic and socio-economic futures. Active adaptive management – backed by research, monitoring, and evaluation – can be an effective tool to support self-adaptation of ecosystems. An especially promising approach is to develop integrated regional biodiversity response strategies, tailored for regional differences in environments, climate change impacts and socio-economic trends.

Strengthen the national commitment to conserve Australia's biodiversity

Climate change has radical implications for how we think about conservation. We need wide public discussion to agree on a new national vision for Australia's biodiversity, and on the resources and institutions needed to implement it.

If the high rate of species loss and ecosystem degradation in Australia is to be slowed and eventually reversed, a more innovative and significantly strengthened approach to biodiversity conservation is needed. To meet this challenge – particularly under a rapidly changing climate – perceptions of the importance of biodiversity conservation and its implementation, in both the public and private sectors, must fundamentally change. A national discourse is therefore required on the nature, goals and importance of biodiversity conservation, leading to a major rethink of conservation policy, governance frameworks, resources for conservation activities and implementation strategies. The discourse should build a much broader and deeper base of support across Australian society for biodiversity conservation, and for goals that are appropriate in a changing climate. In particular, biodiversity education, policy and management should be reoriented from maintaining historical species distributions and abundances towards: (i) maintaining well-functioning ecosystems of sometimes novel composition that continue to deliver ecosystem services; and (ii) maximising native species' and ecosystem diversity.

Invest in our life support system

We are pushing the limits of our natural life support system. Our environment has suffered low levels of capital reinvestment for decades. We must renew public and private investment in this capital.

There is as yet no widely accepted method – be it changes in natural capital, adjusted net savings or other indicators – to account for the impact of changes in Australia's biotic heritage due to human use. However, by any measure, Australia's natural capital has suffered from depletion and under-investment over the past two centuries. Climate change intensifies the need for an urgent and sustained increase in investment in the environment – in effect, in our own life support system. The challenge is to establish an enhanced, sustained and long-term resource base – from both public and private investment – for biodiversity conservation. In particular, significant new funding strongly focused towards on-ground biodiversity conservation work – carried out within an active adaptive management framework – is essential to enhance our adaptive capacity during a time of climate change. Monitoring the status of biodiversity is especially important as without reliable, timely and rigorous information on changes in species and ecosystems, it is not possible to respond effectively to growing threats. An effective monitoring network would be best achieved via a national collaborative program with a commitment to ongoing, adequate resourcing.

Build innovative and flexible governance systems

Our current governance arrangements for conserving biodiversity are not designed to deal with the challenges of climate change. We need to build agile and innovative structures and approaches.

While primary responsibility for biodiversity conservation resides with each state and territory, over the past two decades many biodiversity conservation policies and approaches have been developed nationally through Commonwealth–state processes. There has also been a recent trend towards devolution of the delivery of natural resource management programs to the level of regional catchment management authorities and local Landcare groups. Dealing with the climate change threat will place further demands on our governance system, with a need to move towards strengthening and reforming governance at the regional level, and towards more flexibility and coherence nationally. Building on the strengths of current arrangements, a next step is to explore the potential for innovation based on the principles of: (i) strengthening national leadership to underpin the reform agenda required; (ii) devolving responsibilities and resources to the most local, competent level, and building capacity at that level; (iii) facilitating a mix of interacting regional governance arrangements sensitive to local conditions; and (iv) facilitating new partnerships with other groups and organisations, for example, with Indigenous and business entities. In addition, improved policy integration across climate change, environment protection and commercial natural resource use is required nationally, including across jurisdictional boundaries.

Meet the mitigation challenge

Australia's biodiversity has only so much capacity to adapt to climate change, and we are approaching that limit. Therefore, strong emissions mitigation action globally and in Australia is vital – but this must be carried out in ways that deliver both adaptation and mitigation benefits.

There is a limit above which biodiversity will become increasingly vulnerable to climate change even with the most effective adaptation measures possible. Global average temperature increases of 1.5 or 2.0°C above pre-industrial levels will likely lead to a massive loss of biodiversity worldwide. Thus, the mitigation issue is central to biodiversity conservation under climate change. To avoid an inevitable wave of extinctions in the second half of the century, deep cuts in global greenhouse gas emissions are required by 2020 at the latest. The more effectively the rate of climate change can be slowed and the sooner climate can be stabilised, the better are the prospects that biodiversity loss will be lessened. Societal responses to the mitigation challenge, however, could have significant negative consequences for biodiversity, over and above the effects of climate change itself. Examples include planting monocultures of fast-growing trees rather than establishing more complex ecosystems that both support more biodiversity and store more carbon, and inappropriate development of Australia's north in response to deteriorating climatic conditions in the south. However, with flexible, integrated approaches to mitigation and adaptation, many opportunities will arise for solutions that both deliver positive mitigation/adaptation outcomes and enhance biodiversity values.

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