Summary for policy makers 2009

Table of Contents

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.

K L V D W L@D W O Q H V O V T@ W L V E L O Q D L V E Q O D L R

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 LQWHUDFWLRQ RI FOLPDWH FKDQJH ZLWK H[LVWLQJ VWUHVVHV the different migration rates of species and consequent formation of novel ecosystems, add further levels RI FRPSOH[LW\ 6LJQL¿FDQW FKDQJHV DUH UHTXLUHG LQ SROLF 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 FRQWURO RI LQYDVLYH VSHFLHV DQG GHYHORSLQJ DSSURSULD
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.

7KH IROORZLQJ ¿YH NH\ PHVVDJHV FRPSULVHWDQHLQWHJUDWHG
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.

Strengthe301.5147ent ol841.8MC Cnvo ad the3 0lifees for bi0.341 /TT3 1 Tf 11 0 0 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.

1. Climate change impacts: what is happening already?

Australia's unique biodiversity has evolved in a climate of extremes. Our landscapes have been shaped E\ DULGLW\ KLJK WHPSHUDWXUHV DQG ¿UH 7KH VFDUFLW\ RI I 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 abourcA with

‡ 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

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:

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 YXOQHUDEOH VSHFLHV EXW UDWKHU DQ LQWHUVHFWLRQ RI HIIH the resulting saltwater intrusion into freshwater wetlands, as well as the consequences of climate change IRU D VXLWH RI LQYDVLYH ZHHG DQGHHFWDVOKDQQLPDJKWSWKHGVL 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

)LJXUH ± 3K\VLRORJLFDO DQG OLIH KLVWRU\ WUDLWV RI VSHFL response to climate-related disturbance

SPECIES LEAST AT RISK	SPECIES MOST AT RISK
Å Physiological tolerance to broad range of factors such as temperatures, water availability and ýre Å High degree phenotypic plasticity Å High degree of genetic variability Å Short generation times (rapid life cycles) and short time to sexual maturity Å High fecundity Å ôGeneralistõ requirements for food, nesting sites, etc. Å Good dispersal capability Å Broad geographic ranges	Å Narrow range of physiological tolerance to factors such as temperature, water availability and ýre Å Low genetic variability Å Long generation times and long time to sexual maturity Å 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) Å Poor dispersers Å Narrow geographic ranges

%DVHG RQ WKH SK\VLRORJLFDO FKDUDFWHULVWLFV RI VRPH WD future climate change can be made. For example, warming temperatures may alter sex ratios of reptiles VXFK DV FURFRGLOHV DQG WXUWOHV $OVR UHGHFWLRQHULQ¿VKDW and water quality and, in addition, have a limited capacity to migrate to new waterways.

$OWKRXJK LW LV PXFK PRUH GLI¿FXOW WR SUHGLFWVWKHUHQGO 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 UDLQIDOO HYHQWV ± ZLOO LQFUHDVH WKH SUREDELOLW\ WKDW 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.

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.

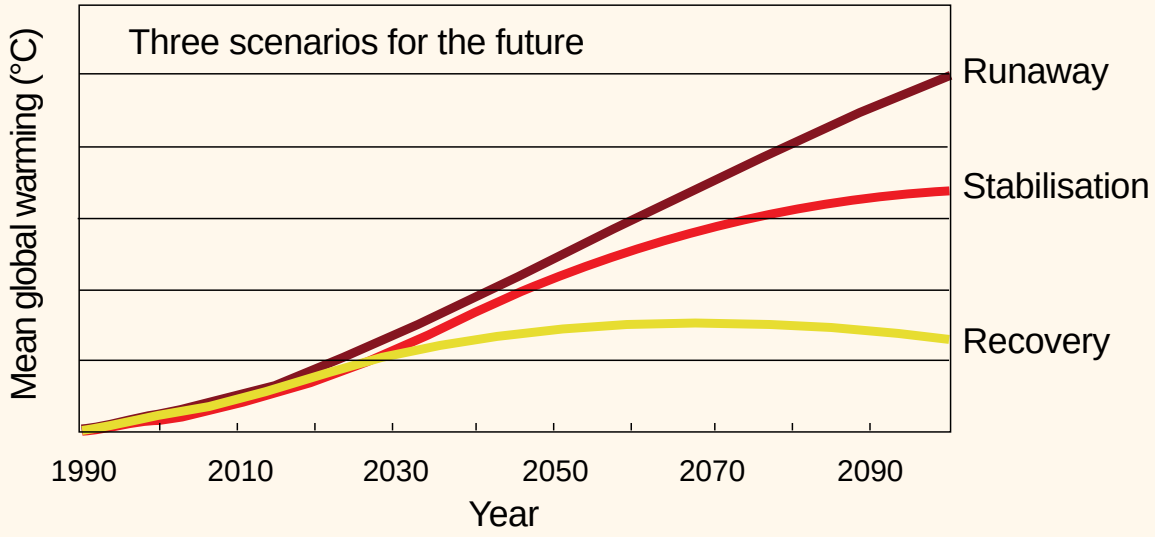
Under a runaway climate scenario there are no promising and cost-effective approaches for conserving our vulnerable natural ecosystems. If such a scenario were to play out, it is likely that many extinctions and massive ecosystem change will result.

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.

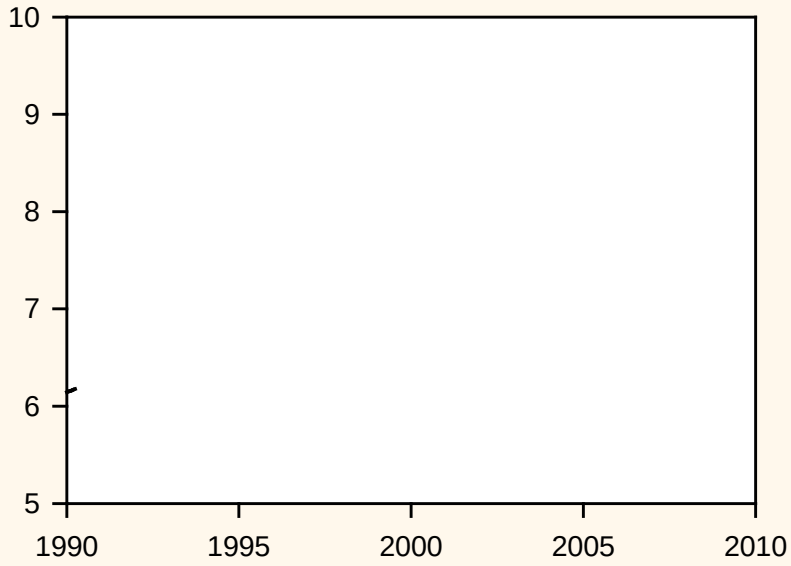
)LJXUH ± 7KUHH VFHQDULRV RI IXWXUH FOLPDWH UHFRYHU\ V
based on the IPCC suite of scenarios (IPCC 2007b) and driven by different assumptions about humanity's response to mitigating CO_2 emissions over the coming century.



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 KHDGHG IRU HYHQ PRUH VLJQL¿FDQW FKDQJHV ± D PDVV H[WLQ 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 WR 7KH VROLG EOXH OLQH UHSUHVHQWV GDWD IURP +DGOH 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 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..

Figure 8 – Australian biome distribution at Last Glacial Maximum, present, and 2100 (600ppm CO_2
VFHQDULR XVLQJ %,20(

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
IRU DGDSWDWLRQ ZLOO EHFRPH LQFUHDVLQJO\ GLI¿FXOW DV VS

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 RI VSHFLHV ZLOO EH YHU\ GLI¿FXOW WR LPSOHPHQW XQGHU D F 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

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 L G H Q W L ¿ H G D Q G L Q F O X G H G L Q U H V H U Y H V R U R W K H U Z L V H P D Q D

Proactive interventions

Implement eco-engineering

Although costly and not always successful, eco-engineering may nevertheless constitute a necessary U H V S R Q V H L Q D I H Z V S H F L ¿ F F D V H V) R U H [D P S O H U H H V W D E O may allow ecological systems to self-organise around critical elements, or the use of provenances and V S H F L H V I R U W K H D Q W L F L S D W H G F O L P D W L F F R Q G L W L R Q V P D \ K

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 to mid-century, so decisions and 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 adaptation of management of 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 W 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 vegetation with co-benefits for 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 E R W K F H Q W U D O L V D W L R Q D Q G G H F H Q W U D O L V D W L R Q 7 K L V V W D W L Q V W L W X W L R Q D O D U F K L W H F W X U H V D Q G P R G H V R I S R O L F \ G H O L 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 V X I I H U H G I U R P G H S O H W L R Q D Q G X Q G H U L Q Y H V W P H Q W R Y H U W K 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.

Innoh policy e00300470n in adaptv8dy chdy ch803001ud and integratctures will provi an3 inaptiveservation work – carr

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

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 RYHU WKH SDVW WZR FHQWXULHV &OLPDWH DFKDQJH QHFHVVLWDWHV LQ 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 ELRGLYHUVLW\ FRQVHUYDWLRQ ,Q SDUWLFXODU VLJQL¿FDQW 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.

%XLOG LQQRYDWLYH DQG ÀH[LEOH JRYHUQDQFH V

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 WKH UHJLRQDO OHYHO DQG WRZDUGV P%RXLOGLQJ RQ ÀH[LEOH LQQRYDWLYH F 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.

References

Barr NR (2005) *The changing social landscape of rural Victoria*. Department of Primary Industries, Melbourne.

Canadell JG, Le Qu®r® C, Raupach MR, Field CB, Buitenhuis ET, Ciais P, Conway TJ, Gillett NP, Houghton RA and Marland G (2007) Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity, and efýciency of natural sinks. *Proceedings of the National Academy*