Australian Government
Department of Climate Change

MANAGING AUSTRALIAN LANDSCAPES IN A CHANGING CLIMATE

A CLIMATE CHANGE PRIMER FOR REGIONAL NATURAL RESOURCE MANAGEMENT BODIES

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SUMMARY

Australia's climate is changing

The evidence of warming of the Earth's climate system is unequivocal. It is evident from increases in global average air and ocean temperatures, melting of snow and ice, and rising sea levels.

Adaptation to climate change is no longer a question of "if" but rather of "how", "where" and "how fast".

For the regions of Australia in which most people live and most food and fibre is produced — i.e. the eastern seaboard and southern and south-western Australia — the greenhouse effect is leading generally to a hotter, drier climate, marked by more extreme weather events, but less rainfall and even less runoff overall. Climate change is real and long lasting and will have major implications for the way that natural resources are managed at the regional level. From a water perspective alone, the implications of climate change are profound. Changes in water availability will in turn have, for example, major implications for vegetation management.

An extremely variable climate has always been a fundamental driver of ecological processes and land use systems in Australia, shaping adaptations among our unique biota and distinctive farming systems. Australia's inherent climate variability is now being exacerbated by global warming, and underlying climatic parameters are moving.

Climate is a driver for almost every natural resource management issue being tackled by regional NRM bodies*, and climate change will have far-reaching impacts on many ecological, hydrological and resource-degrading processes. Climate change is not just another natural resource management (NRM) issue.

The convergence of climate, water and energy in a carbon-constrained world will likely change the ground rules for managing natural resources in Australia. They will reach deeply into every aspect of our lives and those of our children and their descendants.

We cannot be serious about regional NRM if we put climate change in the too hard basket.

Climate change is core business for regional NRM bodies

Australia's 56 regional NRM bodies are at the front line of tackling sustainability challenges on the ground.

Regional NRM bodies operate at a catchment or landscape scale, across industries, property boundaries and land tenures. They bring diverse stakeholders together to deliver integrated approaches to NRM problems and play an important bridging role between governments and regional communities. They are ideally placed to meld top down strategy and resources with bottom up energy and engagement to deliver effective and lasting responses at a regional scale.

Climate change responses need to be hard-wired into the core business of every regional NRM body in Australia—not as a separate issue but as a core feature of the operating environment.

* The term "regional NRM bodies" is used throughout this document to refer to the 56 regional bodies recognised by the Australian Government. They are called Catchment Management Authorities in Victoria and New South Wales, Regional NRM Boards in South Australia and the Northern Territory, Regional NRM Committees in Tasmania and Regional NRM Groups in Queensland and Western Australia.

Without in any way demeaning the size of the challenge, regional NRM bodies should not be intimidated by climate change adaptation. For many natural resource assets, existing threats such as increasing resource use intensity, poor farming or pastoral practices, invasive species and fire, will remain the main pressures. Those pressures may be exacerbated and compounded by climate change, but they won't be replaced by it. Regional NRM Plans remain appropriate for adapting to and managing climate change impacts, because they provide a framework for integrating a range of responses to a range of pressures across a range of assets, and for managing risk.

Well-managed farms in Australia have always handled climate risk well. Farming profitably in Australia demands sophisticated risk management, and climate change will force us to become even more skilled. Regional NRM bodies must do likewise at a regional scale.

Business as usual NRM planning will not suffice as an adequate climate change response. In most cases, climate change ups the ante and creates a more urgent imperative to find lasting solutions, but in the short to medium term, it does not fundamentally change the game. Many climate change responses are "no regrets" measures with complementary benefits for issues such as biodiversity, soil health or water quantity and quality. The overlap between best practice regional NRM and constructive climate change adaptation measures is significant. This provides lots of scope for regional NRM bodies to make a very useful contribution in the overall response to climate change.

Climate change and specific NRM issues

In the main, on-ground investment undertaken by regional NRM bodies need not look radically different under climate change scenarios. Best practice regional NRM can alleviate existing pressures through actions such as improving land use planning and agricultural practices; restoring landscape connectivity; managing invasive species; targeting provision of environmental water; and improving water quality.

Vegetation

One of the biggest levers that regional NRM bodies can use is their influence over native vegetation management and revegetation activities. Preventing poorly planned clearing and overgrazing of native vegetation and encouraging well planned revegetation works to restore vegetation cover in over-cleared landscapes is a key focus of many Regional NRM Plans. Most Regional NRM Plans already emphasise landscape connectivity, and look to extend defined key habitat areas with buffer zones and corridors to reduce fragmentation and to offer habitat continuity for less mobile species. This strategy will become increasingly important in the face of climate change.

Moreover, climate change underlines the importance of implementing measures to encourage biodiversity conservation outside the formal reserves system of National Parks and other wildlife reserves. Conservation of biodiversity on private and leasehold lands has always been important, but in a changing climate it becomes even more so.

The spatial location and configuration of revegetation projects are among the most critical technical issues in thinking about climate change implications for many Regional NRM Plans. Climate change makes it even more important to get it right: to get the right sorts of vegetation, in the right parts of the landscape, in the right configuration, with the right establishment techniques and the right on-going management regime.

Salinity and water quality

The biggest climate change impact for most regional NRM bodies will be long term reductions in water yield. In many catchments, reduction in water yield will be reflected in increasing stream salt concentrations. Those two factors in turn have significant biodiversity implications across whole landscapes, and obvious impacts on water quality and infrastructure. Climate change will not reduce those impacts, and in some cases will make them worse.

Large scale revegetation is a valuable tool for tackling salinity, especially in catchments with local groundwater flow systems. It can be very valuable to increase or augment wildlife habitat, and it is an important transition tool in offsetting greenhouse gas emissions. But in the context of warming, drying catchments with declining water yields, large scale revegetation has to be planned and sited very carefully if it is not to exacerbate reductions in water yield with consequent knock-on environmental impacts.

Invasive species and fire

Invasive species may be among the more important and least predictable impacts of climate change in Australia. A particular challenge in this area is the potential for “sleeper” weeds and ferals to begin to expand their range suddenly and dramatically in response to even moderate shifts in climate.

Fire is a classic example of how climate change affects other NRM issues and the interactions between them. From an NRM perspective, the biodiversity, water yield and water quality advantages from preventing huge fires and keeping fires as small as possible are considerable.

Summing up

Irrespective of mitigation actions taken now, we need to start now to adapt to climate change for the foreseeable future. Teasing out what this means for regional NRM bodies is the focus of this primer, which points to pathways and resources.

The good news is that there are important synergies between being well positioned for climate change adaptation and best practice regional NRM. Successful regional NRM bodies will incorporate climate change adaptation into their core business at all levels, bringing their communities with them.

That will be a fine and important contribution to tackling the most important challenge of this century.

1. INTRODUCTION

If you are involved in a catchment management organisation — whether as a community leader on the board or as an employee — how do you get your head around something as overwhelming and abstract as climate change? What can you do about it?

This document seeks to help people involved in regional or catchment-based natural resource management (NRM) bodies to think through the issue of climate change, to consider its potential implications for their region, to work out ways of building it into the core business of their organisation, and to identify sources of on-going support. If it can meet this ambitious objective, then it should also be of interest more broadly among regional community and industry leaders and within all levels of government.

Before summarising key findings from climate change science and discussing regional adaptation strategies, the historical context is important.

Over the last half century or so, humans have started to think more seriously about the impacts of our own actions on the world — in particular on our physical environment and its on-going ability to meet our ever-increasing needs.

We have identified particular environmental problems such as weeds and pests, soil erosion, salinity, declining water quality, loss of wildlife habitat and species extinctions, and we have developed responses to try to repair the damage and in some cases to deal with their causes. An innovative Australian response over the last 25 years has been the evolution of participatory approaches (like Landcare, Coastcare, Waterwatch, Saltwatch and so on) that have involved the community directly in developing and implementing measures to tackle such problems at a neighbourhood or district scale.

Over recent decades, environmental concerns have broadened into the sustainability debate, recognising that resource degradation issues are often inter-related, and that cumulatively and in aggregate they are part of a broader question about how humans can continue to meet societal needs from both finite and renewable resources given increasing consumption, depletion and degradation. The need to develop and implement more integrated approaches at a larger geographic scale has seen the Australian natural resource management (NRM) approach evolve to generate a diverse range of 56 regional or catchment-based NRM organisations (regional NRM bodies) — interesting hybrids bringing together community and government interests — that are at the front line of tackling sustainability challenges on the ground.

One of the great strengths in Australia's approach to managing its unique natural resources, with a population thinly spread over a vast ancient continent and concentrated along coastlines, has been its recognition that lasting solutions can only come through getting the relevant community interests, particularly landholders, directly involved. Another complementary strength of the Australian NRM model is that it seeks to integrate responses to a range of sustainability issues (including soil, water and biodiversity) at a landscape scale, across land tenures and industries.

Tackling issues like salinity, invasive species, declining water quality and loss of biodiversity — and involving diverse sectors of the community in doing so — is a complex and challenging business. We have been at it through a range of national programs for about 25 years with ever-increasing levels of public investment (albeit still modest in comparison to the scale of the problems). We have built considerable capacity and developed a much better understanding of the issues. However, success in implementing lasting solutions has been patchy. We clearly have a long way to go.

And then along comes climate change.

Climate change is the ultimate expression of the aggregate and cumulative impact that human actions are having on Earth. The notion that the human environmental footprint has become so heavy that it is changing the very climate of the planet, is profoundly challenging. It makes weeds, feral animals, soil erosion, salinity or tree decline suddenly seem simple. It seems too big, too complex, too uncertain, too abstract, too remote — in short it may at first seem just too hard.

For just a single issue like salinity, we know how difficult it is to get the necessary players together, to develop a shared understanding, to innovate solutions and to get widespread adoption. We know it is even harder to bring a wider range of players together to tackle multiple issues in an integrated way. Extrapolating this to climate change — which seemingly affects everything and everybody on a global scale and which can only be managed effectively through global responses involving all countries and all activities that generate greenhouse gases — is intimidating for any particular region or regional NRM body. Translating such an understanding into practical measures that can be implemented by regional bodies is a huge challenge.

It is a challenge we must meet, and this document suggests some pathways.

We cannot be serious about regional NRM if we put climate change in the too hard basket.

As the next section will show, climate change is real. It won't go away for the next century at least, irrespective of current actions. It has huge implications — for Australia in particular. Climate change cannot be put in a box and treated as a separate NRM issue like soil acidification or a particular endangered species. Climate is a driver for almost every natural resource management issue being tackled by regional NRM bodies, and climate change will have far-reaching impacts on many ecological, hydrological and resource-degrading processes.

Climate change responses need to be hard-wired into the core business of every regional NRM body in Australia — not as a separate issue but as a core feature of the operating environment.

Mitigating greenhouse gas emissions

There are two broad categories of climate change responses: mitigation (avoiding or reducing greenhouse gas emissions and increasing sequestration of greenhouse gases); and adaptation (coping with climate change).

It is not a question of choosing between two options — we have to do both.

Multifaceted mitigation efforts with deep and broad impacts in reducing greenhouse gas emissions are essential and urgent if humans are to avoid runaway climate change.

Like every industry, every business and every household, regional NRM bodies need to understand their own carbon footprint. They have an additional responsibility to understand their wider influence on the mitigation strategies of resource managers within their region. As responsible, professional organisations in the natural resource management sector, it could be argued that regional NRM bodies should practice what they preach in terms of wise and conservative use of energy and water, and the implementation and promotion of best practice conservation measures. Many regional NRM bodies are considering their potential involvement in carbon trading, specifically through facilitating recognition of revegetation work as sinks to offset greenhouse gas emissions.

However, mitigation is not the key focus of this document. The Department of Climate Change[1] is a good starting point to access information and ideas on mitigation options, for example through the Greenhouse Action in Regional Australia program, Greenhouse Challenge Plus and Local Greenhouse Action initiatives.

Note too that the Australian Government has committed to the introduction of an emissions trading scheme in 2010 and a reduction in Australia's total emissions by 60% of 2000 levels by 2050[2]. Campbell (2007) explores carbon trading options for regional NRM bodies in a report commissioned by all Victorian Catchment Management Authorities[3]. This work suggests that regional NRM bodies should be as well informed as possible, but that most should hasten slowly in the carbon market until key aspects about a national carbon trading scheme become clearer.

The unpalatable fact remains that irrespective of mitigation actions taken now, we — in Australia more than most countries — will have to adapt to the unavoidable impacts of climate change for the foreseeable future. Teasing out what this means for catchment management organisations is the focus of this document.

Adapting to climate change

The good news in this story is that there are important synergies between being well positioned for climate change adaptation and best practice regional NRM.

Australia has always had a highly variable climate — much more so than almost all other continents. Table 1, comparing the ratio between the maximum and minimum flows of some of the world's great rivers, bears this out. This table illustrates a key point: we have long been used to a relatively high degree of climate variability — "a land of droughts and flooding rains" — but the amplitude of that variability is being exacerbated by climate change. The range of projected changes is outlined in Chapter 2 Climate change science[4].

Table 1. Flow variability of major world rivers and Australian rivers. The Australian figures in this table do not reflect the current drought, which has seen new record low flows.

COUNTRY	RIVER	RATIO BETWEEN MAXIMUM and MINIMUM ANNUAL FLOWS
Brazil	Amazon	1.3
Switzerland	Rhine	1.9
China	Yangtze	2
Sudan	White Nile	2.4
USA	Potomac	4
South Africa	Orange	17
Australia	Murray	30
Australia	Hunter	54
Australia	Darling	4700

The notion of "average rainfall" has always been dubious for most regions of Australia, both agriculturally and ecologically. The real story is in the variance, not the mean, and how the system (whether farming system or ecosystem) responds to extreme events.

Farmers should be as familiar with the standard deviation of their growing season rainfall, and key thresholds in terms of sowing dates or fruit setting temperatures, as they are with their mean annual rainfall. It is increasingly apparent that conventional wisdom about the average annual rainfall for many regions in Australia was formed during a series of relatively wet decades from the 1950s to 1990s. The timing of rainfall events, or changes in temperature extremes, may be more important impacts of climate change in southern Australia than the net decrease in annual rainfall. For example, a farmer in the Green Triangle region might measure a drop in aggregate annual rainfall of just 10% — from say 600mm to 540mm — but 150mm of the 540mm might occur in one or two January/February storms, whereas well distributed rainfall during the critical growing season might halve. So an aggregate drop in rainfall of just 10% (seemingly manageable) might mask a halving of agriculturally useful rainfall (much more difficult to handle).

Successful farm managers are generally able to effectively incorporate climate risk in their decision making. That is the essence of a climate change adaptation strategy. It means anticipating climatic extremes and managing for them, not for the illusory average. It means building as much anticipation and opportunism into the system as possible, to enable quick responses ahead of time if possible. It means knowing the critical thresholds and triggers for decisions like whether to sow and what crop to plant, if and when to de-stock or to re-stock, and if and when to buy or sell water. Above all, it means being proactive rather than just crossing fingers and hoping for the best. Farming profitably in Australia has always demanded sophisticated risk management, and climate change will force us to get even better.

The challenges facing regional NRM bodies in adapting to climate change include those facing farm businesses. However they go well beyond the agricultural implications to include the public good aspects of managing natural assets in the wider public interest of this and future generations. The box below is a summary of Australian Government initiatives and contributions that provide some guidance and support to help regional NRM managers adapt to climate change.

The following chapter summarises scientific findings about climate change and those following discuss the broad range of adaptation strategies that regional NRM bodies should consider. As the next section will outline, there remain considerable technical uncertainties around the timing and the magnitude of climate change, especially in trying to predict changes at finer grained scales of analyses down to regional or district scale. These uncertainties will diminish over time, but in the meantime, there is much we can do to better understand and to manage climate risk. This is equally the case whether at farm scale or at catchment or landscape scale.

Australian Government Initiatives and Contributions – Climate Change Impacts and Adaptation: Natural Resource Management

Department of Climate Change

The Australian Government Department of Climate Change provides national climate change adaptation policy leadership and coordination. The Department works with partners (including the CSIRO Climate Adaptation Flagship and states/territories) and stakeholders in vulnerable sectors and regions to assist decision makers to better manage the risks from climate change impacts. The Department of Climate Change delivers a number of key policy, program and research functions to deliver the information that policy and decision-makers need to determine climate change adaptation strategies and actions.

Major contributions of the Australian Government's $170 million commitment towards the implementation of the National Climate Change Adaptation Framework (endorsed by the Council of Australian Governments in April 2007 to guide action by governments over the next five to seven years in vulnerable sectors) include the establishment of a Climate Change Adaptation Research Facility (Griffith University), which will lead Australia's researchers in generating robust biophysical, social and economic information that decision makers need to manage the risk of climate change. This effort is supported by up to $50 million funding for national climate change adaptation research to build understanding and adaptive capacity to reduce sectoral and regional vulnerability to the impacts of climate chance. Further information is available from http://www.climatechange.gov.au/impacts/about.html

CSIRO Flagship on Climate Adaptation

The Australian Government commitment of $170 million mentioned above also includes $44 million to establish a new CSIRO Flagship on climate adaptation which also helps equip Australia with practical and effective adaptation options to respond to climate change and variability. The Flagship will have four themes, including one on "Adaptive Primary Industries, Enterprises and Communities". Further information is available from http://www.csiro.au/org/ClimateAdaptationFlagship.html

Australian Climate Change Science Program

The Australian Climate Change Science Program[5] aims to improve understanding of the causes, nature, timing and consequences of climate change so that industry, community and government decisions can be better informed. The program is administered by the Department of Climate Change and conducted in partnership with leading science agencies, notably the CSIRO and the Bureau of Meteorology. The program addresses six key themes:

- understanding the key drivers of climate change in Australia
- improved climate modelling system
- climate change, climate variability and extreme events
- regional climate change projections
- international research collaboration
- communications.

Key areas of research include improving climate change projection based on probabilities; detecting climate change in Australia, for example, from shifts in mean maximum air or sea surface temperature, or increased frequency and intensity of extreme events such as drought and tropical cyclones; and attributing changes in climate to specific factors such as greenhouse gas emissions, changes in land use, or to natural variability. Further information is available at www.climatechange.gov.au/science/index.html

CSIRO/BOM Centre for Australian Weather and Climate Research

The Centre for Australian Weather and Climate Research, a partnership between CSIRO and the Bureau of Meteorology (BOM) - A new science team is leading Australia's climate change and weather research. The Centre will provide seasonal weather/climate forecasts, support impact and adaptation research, enhance prediction of extreme weather/climate events and provide superior research capability for determining accurate water budgets for different systems (taking into account temperature, precipitation, soil moisture, runoff, evaporation and streamflows).

Australia's Farming Future

In 2007, the Australian Government committed $130 million over four years for the Australia's Farming Future Initiative to address the impacts of climate change on the primary industries sector. This initiative, consisting of three distinct but connected programs will build on the Government's commitment to fast track the National Agriculture Climate Change Action Plan, prepare the sector to adequately respond to climate change and assist with moving farmers towards drought preparedness. This initiative includes the Climate Change Productivity and Research Program ($15 million) and the Climate Change Adaptation Partnership Program ($60 million). Further information is available from www.daff.gov.au

Managing Climate Variability Program

The Managing Climate Variability[6] (MCV) program has been helping Australian farmers to manage climate risk on the ground for over a decade, providing practical tools to incorporate climate variability understanding into farm business decisions. Administered by Land & Water Australia, it aims to enhance adaptation responses to a variable climate. The program's top priority is to provide more accurate and reliable climate information, forecasts and tools to enable farmers and natural resource managers to reduce their exposure to risk from climate.

MCV program has been funded jointly by seven of the rural R&D corporations, the Department of Agriculture, Fisheries and Forestry (DAFF) and the Natural Heritage Trust, with strong support from the National Farmers' Federation. Its Masters of the Climate project has developed a wide range of useful case studies of how innovative individual farmers in many sectors are incorporating climate risk into their business management decisions. The MCV program has contributed to the development of seasonal climate forecasting tools that assist managers to make decisions which maximise climate opportunities and reduce costs in poor seasons. Examples of such tools are: Yield Prophet, WhopperCropper, Australian Rainman and AussieGRASS. Further information on the MCV program and forecasting tools can be found at http://www.managingclimate.com.au/

South-east Australia Climate Initiative

South-east Australia Climate Initiative (SEACI)[7] is seeking to develop much finer-grained projections of likely climate change impacts in south-eastern Australia, with a particular focus on long range water availability and crop yield forecasts. This project, relevant to a number of regional NRM bodies in the Murray Darling Basin, is jointly funded by the Department of Climate Change, the Murray Darling Basin Commission, the Managing Climate Variability program and the Victorian Department of Sustainability and Environment, and it is being delivered by CSIRO and the Bureau of Meteorology. Additional information can be found at http://www.mdbc.gov.au/subs/seaci/index.html

2. CLIMATE CHANGE SCIENCE

The evidence of warming of the Earth's climate system is unequivocal. It is evident from increases in global average air and ocean temperatures, melting of snow and ice, and rising sea levels.

Numerous changes in climate have been observed at the scales of continents or ocean basins, including wind patterns, precipitation, ocean salinity, ocean acidification, sea ice, ice sheets, and aspects of extreme weather.

These are the sober conclusions of the most comprehensive and authoritative analysis of the Earth's climate ever undertaken — the 2007 Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC)[9]. The IPCC concludes that there is a greater than 95% probability that the observed increases in temperatures are mainly driven by the increased concentration of greenhouse gases in the atmosphere due to human activities. The earth is getting warmer and we are causing that to happen. Furthermore, there is a risk that climate change trends may continue to track at the upper end of IPCC projections[9].

We are already having to adapt. Adaptation to climate change is no longer a question of "if" but rather of "how", "where" and "how fast". From a water perspective alone, the implications of climate change are profound. They will reach deeply into every aspect of our lives and those of our children and their descendants.

In 2006, Sir Nicholas Stern, former Chief Economist at the World Bank, in a report commissioned by the British Government, assessed that the economic costs of inaction far outweigh the costs of acting to avert severe climate change.

Let's look briefly at some of the global and Australian evidence that has the world's most eminent climate scientists so concerned.

In its Fourth Assessment Report 2007, the IPCC found that levels of greenhouse gas emissions such as carbon dioxide (CO_2), methane and nitrous oxide in the atmosphere have increased markedly as a result of human activities since 1750[10]. These changes have altered the energy balance in the atmosphere, resulting in a warming effect. For the next two decades, a global warming of about 0.2 degrees per decade is projected for a range of emissions scenarios.

The IPCC report also found that more intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. Changes in sea surface temperatures, wind patterns and decreased snowpack and snow cover have also been linked to droughts.

Figure 1 summarises human influence on the atmosphere since industrialisation. The red line is CO_2, the most ubiquitous greenhouse gas. In the pre-industrial era, CO_2 concentrations were stable for many centuries at about 280 parts per million (ppm) in the earth's atmosphere. The CO_2 concentration has increased markedly since industrialisation and is now at over 380ppm and rising strongly. We know from ice core sampling that temperature and the concentration of CO_2 in the atmosphere have been closely correlated for millions of years.

The other two lines in Figure 1 represent the concentrations of the other key greenhouse gases in the earth's atmosphere: methane (blue line), nitrous oxide (black line), both measured in parts per billion. Note that all the curves are the same shape, and the IPCC concludes that "*Increases since about 1750 are attributed to human activities in the industrial era*".

Global temperatures have tracked the same "hockey stick" curve, trending sharply upwards in the late 20th Century, as outlined in the graph in Figure 2 which looks at average global surface temperatures, global average sea levels and snow cover in the northern hemisphere.

Figure 1. Trends in key global atmospheric parameters (taken from the Fourth Assessment Report (AR4) of the IPCC (FAQ2.1)[11].

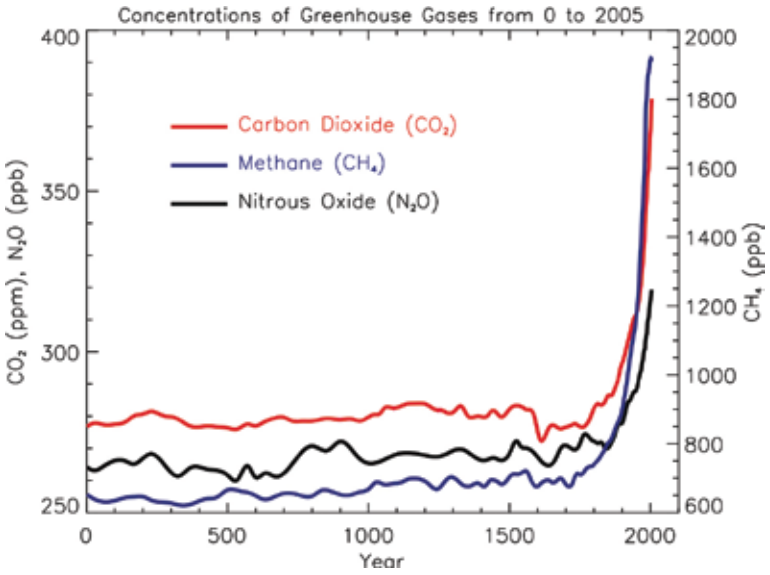
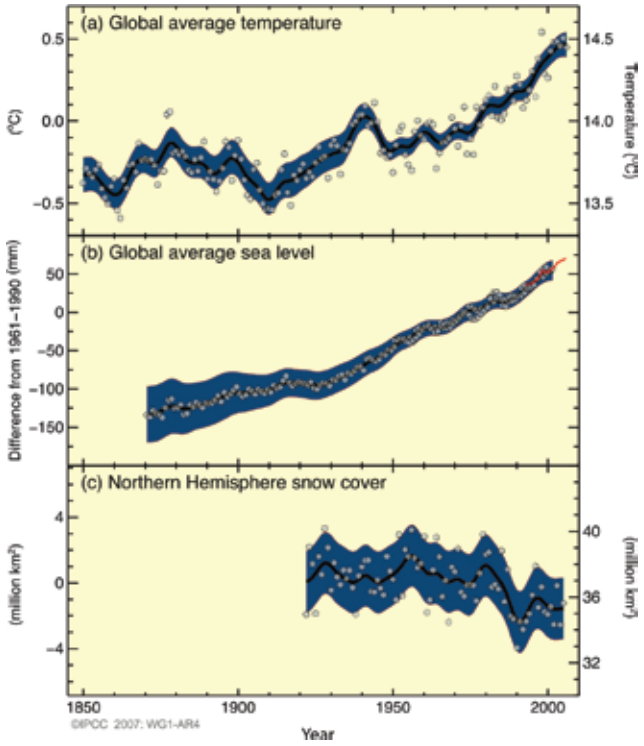


Figure 2. Average global surface temperature, sea levels and northern hemisphere snow cover (from the IPCC AR4)[12]. Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All changes are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal average values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c).

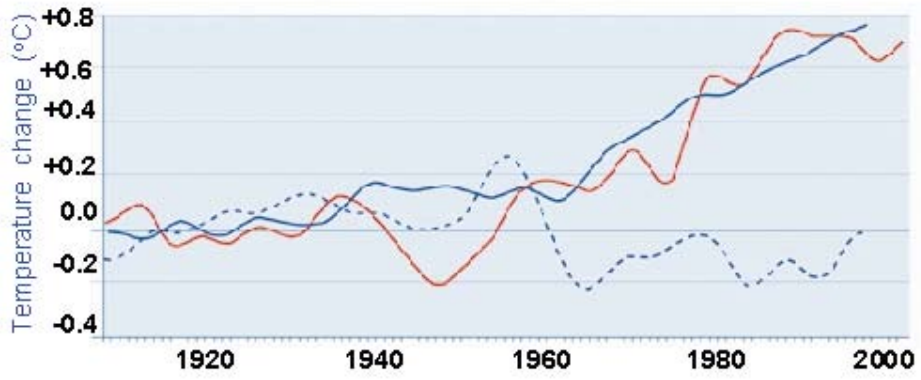


Observed and projected changes in Australia's climate

The global warming trend is very evident in Australia. We are already seeing what the climate models* have been predicting for some time in terms of temperature. There are also suggestions that model projections of changed rainfall distribution, severe weather and so on are being realised.

Figure 3 shows the change in mean annual temperature in Australia since 1910. The red line indicates the measured temperatures, the blue line represents the average predictions of eight climate models with greenhouse gases factored into the models, and the dotted blue line represents the modelled temperature with the effects of greenhouse gases removed from the models. Figure 3 suggests that the climate models*, taking into account the additional greenhouse gases in the atmosphere, are now able to explain and predict temperature fairly well. They have predicted, and we are experiencing, a steady increase in temperature since the 1950s.

Figure 3. Modelled and actual changes in mean annual temperature in Australia since 1910[13]

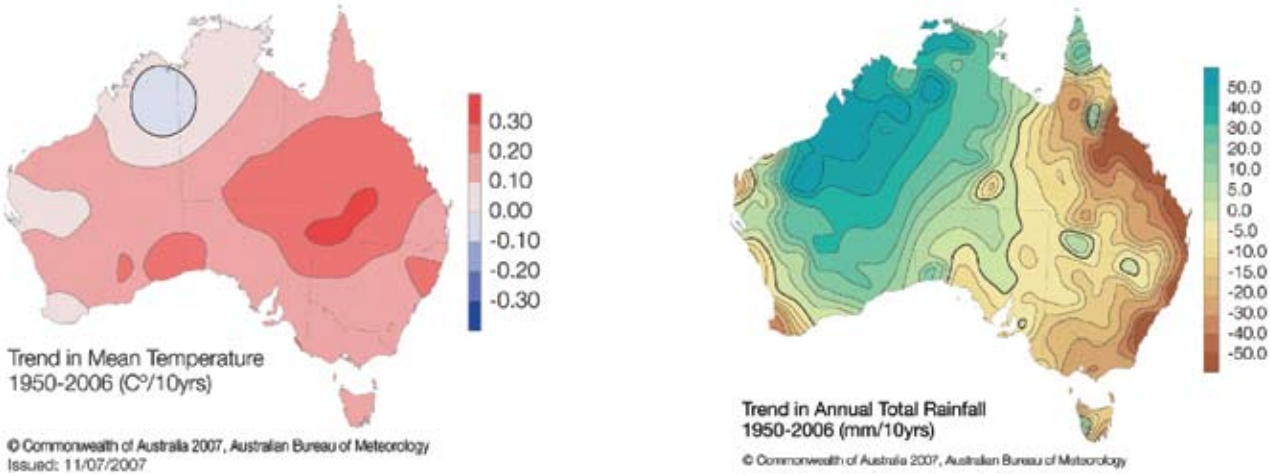


The IPCC Fourth Assessment Report indicates that rainfall patterns are expected to change with northern Australia receiving more rainfall while south and south-eastern Australia will likely receive less. As a result of reduced precipitation and increased evaporation, water security problems will intensify by 2030 in southern and eastern Australia. Annual streamflow in the Murray Darling Basin is likely to fall 10 to 25 per cent by 2050 and 16 to 48 per cent by 2100. Water supply and quality are likely to be affected by higher temperatures, increased evaporation rates and changes in amount and patterns of rainfall.

Recent Australian projections of climate change provide further details to those provided in the IPCC Fourth Assessment report. In its Climate change in Australia: technical report 2007[14], CSIRO and the Bureau of Meteorology reported that average temperatures have increased 0.9ºC since 1950, with significant regional variations (Figure 4). The frequency of hot days and nights has increased and the frequency of cold days and nights has declined. Since 1950, most of eastern and south-western Australia has experienced substantial rainfall declines (Figure 4).

* Climate models are computer programs that simulate the land-ocean-atmosphere processes that govern the Earth's climate. By solving mathematical equations based upon the laws of physics, a GCM (Global Climate Model) attempts to reproduce the way in which climate behaves from day to day, from season to season and over the years.

Figure 4. Trends in annual mean Australian temperature and rainfall since 1950 (CSIRO/BOM 2007).



The CSIRO and the Bureau of Meteorology concluded that by 2030, temperatures will rise by about 1 ºC over Australia – a little less in coastal areas and a little more inland. Later in the century, warming depends on the extent of greenhouse gas emissions. If emissions are low, warming of between 1 ºC and 2.5 ºC is likely by around 2070, with a best estimate of 1.8 ºC. Under a high emission scenario, the best estimate of warming is 3.4 ºC, with a range of 2.2 ºC to 5 ºC.

Annual average rainfall is likely to decrease in southern Australia during winter and spring. Rainfall projections for later in the century are more dependent on greenhouse gas emissions. Under a low emission scenario in 2070, the best estimate of rainfall decrease is 7.5 per cent. Under a high emission scenario the best estimate is a decrease of 10 per cent. While there will be more dry days and other seasonal changes, when it does rain, rainfall is likely to be more intense with consequent increased risk of flooding.

Other findings include:

- droughts are likely to become more frequent, particularly in the south-west
- high fire danger weather is likely to increase in the south-east
- tropical cyclones are likely to become more intense
- sea levels will continue to rise.

Changes in the climate will impact on Australia's natural ecosystems:

- many species are at risk from rapid long-term climate change due to their restricted geographical and climate range
- major changes are expected in all vegetation communities
- significant biodiversity loss will occur by 2020 in ecologically rich sites such as the Great Barrier Reef and the Queensland Wet Tropics
- other areas at risk include Kakadu wetlands, alpine areas, tropical and deep sea coral reefs, coastal and freshwater wetlands and south-western Australian heathlands.

While total annual rainfall in 2006 may be similar in most regions to that experienced in 1900, the intensity of land and water use — and in particular the area under irrigation and the area of land cleared — has increased enormously since the 1950s. Together with the higher average temperatures of recent decades, these compound drought stresses and have a significant influence on the resilience of the system (ecological and agricultural) — its capacity to bounce back after climatic and other shocks. We will return to the concept of resilience later.

One of the most challenging implications of climate change is that analysing historical data will become increasingly less useful as a predictor of future climate. So in developing future climate scenarios, scientists use climate models that make various assumptions about future greenhouse gas emissions.

There remain uncertainties about the timing, magnitude and geographic distribution of climate change impacts in Australia. Scientific consensus, while inherently conservative, has a high level of confidence about the directions of change in temperature, rainfall and sea levels, at a coarse scale of spatial resolution. The science is giving us broad directions, but not with precision about just when, where and by how much, critical climate parameters will change.

Nevertheless, scientific capabilities in this area are improving constantly and rapidly. Analyses of likely climate change impacts at a regional scale are emerging, some of which are discussed later. However, the complexities of the oceanic and atmospheric systems and their interactions are such that for the foreseeable future we are unlikely to have a high degree of predictive precision and it would be most imprudent to wait for it. Uncertainties about the timing, magnitude and distribution of climate change impacts underline the imperative to improve our capacity to anticipate and to adapt to climate change. However, improvements in science are increasing our ability to explore a range of possible scenarios to better understand the range of risks due to climate change.

Before looking in more detail at what that might mean for regional NRM bodies it is worth a short detour to reflect on the business of regional natural resource management.

3. REGIONAL NATURAL RESOURCE MANAGEMENT

In order to discuss what climate change means for regional NRM bodies, it is first necessary to explore why those bodies exist, what they do, and how they might respond to climate change.

At a broad level, it is easy to see why we need regional NRM bodies. The management of Australia's rich and unique endowment of natural resources has never been higher on the national agenda.

Water resources — both surface water and groundwater — are under extreme pressure, as the majority of the Australian population experiences water restrictions and irrigators face severely reduced allocations. Australia is among the most biologically diverse countries, most of our native species exist in no other country, and we have the highest rates of extinction in the industrialised world. The management of vegetation is critical in achieving an appropriate hydrological balance, in managing carbon emissions, in minimising further losses of biodiversity and in sustaining many of our grazing systems. Invasive introduced species, both plants and animals, continue to impose significant costs on agricultural production, and fierce competition and predation pressures on native species. Soils are the engine room of ecological and agricultural productivity. Soil management remains critical — both as a development opportunity for more sustainable production systems and as a key determinant of landscape resilience.

These issues are some of the most pressing challenges facing managers of natural resources. They need tackling at a paddock and property scale, but can rarely be resolved at that scale. The big issues such as conserving and improving the habitats of threatened species, restoring river systems, reversing salinity and managing invasive species, cannot be adequately dealt with just at a local scale.

You cannot fix salinity or clean up a river just by working in a small part of a catchment. You cannot save the habitat of an endangered species unless you influence all of the habitat, and the threats to that habitat. It is extremely frustrating for individual landholders, who may be trying to deal on their own property with pests or weeds, or with a rising watertable problem, only to be swamped by influences from outside their properties and hence their direct control. Putting a lot of effort into revegetation can seem pointless if there is still broadscale clearing occurring in the same district or catchment. Restoring a length of riverbank is of little use unless significant sources of pollutants, both point source and diffuse, are prevented across the catchment.

So a key driver for regional natural resource management (NRM) is to develop effective responses to resource degradation issues at an appropriate scale — the catchment or landscape scale — that crosses property boundaries and even land tenures in planning and implementing on-ground investments to put in place more sustainable management practices.

However, it is not just about scale, it is also about integration. Many NRM issues are interconnected, and trying to fix one of them in isolation can have perverse impacts elsewhere. For example, large scale revegetation to lower watertables as a dryland salinity control measure, can reduce run-off and streamflows, and actually increase in-stream salinity, damaging aquatic biodiversity among other downstream impacts.

Developing real and lasting solutions is also a matter of getting all the necessary players involved, ensuring that the right people are around the table and working together towards more sustainable approaches. Natural resource management occurs through the cumulative and aggregate impact of the countless everyday decisions and actions taken by those with direct responsibility for land and water — including farmers and other resource using industries, indigenous communities, municipalities, water authorities, government agencies, utility companies and so on.

The attitudes, knowledge, skills and capacities of the people taking them inform these decisions and actions. If we are to develop more sustainable land use systems, then people must first of all want that to happen, they must know what to do, and they need the resources and capacity to make it happen. This is why we need to be working with people, at a community level, to support communities "where they are at" — within the context of current attitudes, current awareness and knowledge, and current ways of doing things. As mentioned in the introduction, Australia has a wonderful track record in getting people directly involved at a community level in collaborative efforts to improve the management of natural resources, through Landcare, Coastcare and a wide range of "watch" programs[15].

Australia's 56 regional NRM bodies, supported over the last decade by the Australian Government, build on this work by attempting to:

- scale up to the catchment, landscape or regional scale;
- work across issues, land tenures and industries in an integrated way; and
- bring diverse stakeholders together across both the government and community sectors to develop shared understandings and more collaborative approaches.

In so doing, regional NRM bodies have the great advantage over state and federal government agencies of being better placed to tap into and build on deep local knowledge and connection to place through the involvement of local community leaders and through their engagement with community concerns. State governments have also devolved responsibility (and in some jurisdictions statutory authority and resources) to catchment bodies in response to the challenge of balancing the often competing demands on rural landscapes. So within a few years, these new organisations have emerged at a scale between local government and state government, with a key role in NRM planning and program delivery. They are presiding over the investment of significant public funding, albeit very modest sums in comparison with the scale and systemic nature of the problems being tackled on a continental scale.

Because of their increasingly important role in guiding and delivering public investment, the scale at which they operate, and the diversity of stakeholders they involve and influence, regional NRM bodies are key players in the challenge of mitigating greenhouse gas emissions and adapting to climate change impacts.

4. CLIMATE CHANGE IMPLICATIONS FOR REGIONAL NRM

Climate change is not just another NRM issue.

Adapting and responding to climate change is core business for regional NRM bodies.

It is hard to think of a single NRM issue without significant potential impacts from climate change. For example, in southern Australia a warming, drying, more variable CO_2 enriched climate with more extreme weather, rising sea levels and less predictable seasons is likely to interact with every current NRM issue and will affect the interactions between those issues. Moreover, competition for water resources will increase, as will input costs as oil resources become more scarce. The convergence of climate, water and energy in a carbon-constrained world will change the ground rules for NRM in Australia, causing us to rethink so-called conventional wisdom in many areas.

Climate has always been a fundamental driver of ecological processes in Australia, shaping some exquisite adaptations among our unique biota. Climate and soil largely determine the envelope of production possibilities for Australia's primary producers and water managers.

As mentioned earlier, the Australian climate has long been characterised by extreme variability. Our ecosystems, our farming systems and our NRM policy frameworks have had to adapt accordingly. However, that variability is now being exacerbated by global warming, and underlying climatic parameters are moving. Regional NRM bodies understandably want to know specific likely climate change impacts in their own region, whereas this document has a national scope and necessarily must generalise. Ultimately, every region will need to undertake its own climate change impacts analysis, drawing upon the best available science and expert judgements relevant to that region. Fortunately, that is becoming easier. The Bureau of Meteorology and CSIRO's 2007 regional impact assessments, accessible through an informative website[16], do allow people to click on their region or capital city to look at regional scale impacts. With the outputs from the next generation of global climate models, it should be possible for regions to undertake or to commission expert, rational, subjective analyses focused on their region. Such analyses would complement the modelled projections with some local knowledge and professional judgment to tease out likely impacts in a more nuanced way that lends itself to refining adaptation responses.

One such study has been done by Douglas Bardsley from the South Australian Department of Water, Land and Biodiversity Conservation (DWLBC) in partnership with the Adelaide and Mount Lofty Ranges Natural Resource Management Board, with support from the Australian Government[17]. Bardsley's study is a very readable, comprehensive analysis of what climate change might mean for the Adelaide and Mount Lofty Ranges region, and an example of the considerable intelligence that can be drawn from the existing knowledge base. It would be a good starting point for regional NRM bodies across southern Australia in particular. Given the pervasive impacts of climate change and the imperative for multi-faceted responses, it is desirable that regional NRM bodies undertake their analyses jointly with state agencies and local governments, as was the case for the Adelaide and Mount Lofty Ranges region study. Mark Howden and colleagues have done another regional study of climate change impacts with a stronger focus on agricultural production impacts in the Condamine catchment in southern Queensland[18].

It is important that regional NRM bodies think through the type of climate change impacts analysis that best suits their situation, as it is not necessarily the case that more fine-grained regional analyses of potential future climate scenarios are required in order to make useful progress. A logical sequence would involve:

1. Use the best available climate projections and related information to analyse vulnerability (see below for a discussion of vulnerability).

2. On the basis of this analysis identify:
   i. vulnerabilities that require treatment, where the current information is adequate for determining a course of action to increase resilience;
   ii. vulnerabilities that do not require treatment at the moment, but should be kept under review; and
   iii. potential vulnerabilities that require further study, either because it is not clear how serious they are or the appropriate treatment is unclear.

3. If there are potential vulnerabilities requiring further study, work out what additional information is needed to support such study. This may be more detailed climate projections. Equally, the climate projections already available may be perfectly adequate and the problem resides in the understanding of critical thresholds in the natural resource system being managed.

Following a sequence such as this will help ensure that effort and resources are directed to analyses that can provide useful directions for adaptation. As teased out in the following sections, in most cases, climate change ups the ante, makes the stakes higher and creates a more urgent imperative to find lasting solutions to existing NRM problems, but it does not fundamentally change the game. In such contexts, better climate projections usually are not essential in making useful short-term progress.

Nevertheless, in the medium term refined projections of climate change impacts will become increasingly important. The Australian Climate Change Science Program is working to improve climate change projections for decision makers.

4.1 Conceptualising climate change adaptation strategies

This section attempts to illustrate at a generic level how a richer picture of climate change impacts can be built up, using examples from some regions.

Two useful ways of thinking about adaptation are as risk management and reducing vulnerability and/or increasing resilience. The latter approach is often more helpful at regional, catchment or sectoral scales. A risk management approach is likely to be more helpful at the enterprise level (including government as well as business operations).

Managing Risk

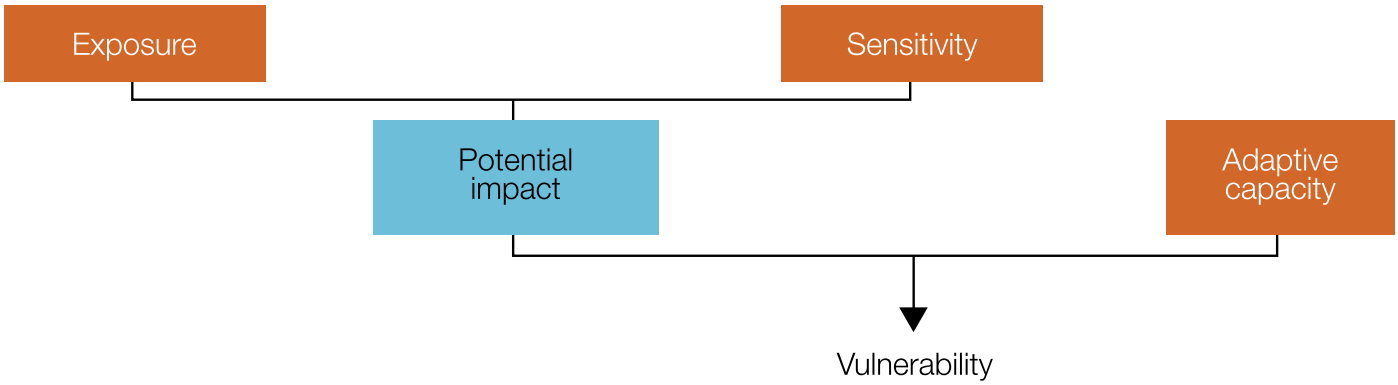
Climate change amplifies what is already a high level of climate risk in many regions of Australia. The Australian Government has developed specific resources to assist organisations to apply a risk management approach to climate change[19] and the Prime Minister's Science, Engineering and Innovation Council produced an informative overview of climate change[20] risks for regional Australia.

Reducing Vulnerability/Increasing Resilience

Vulnerability is a product of the potential impact of climate change and the capacity to adapt to climate change.

A 2005 report by The Allen Consulting Group, commissioned by the Australian Government, suggests a basic framework for initially assessing the vulnerability of a region or sector to climate change, outlined in Figure 5.

Figure 5. Factors determining vulnerability[21] (adapted from a European vulnerability assessment published by the Potsdam Institute for Climate Impact Research).



Exposure is influenced by a combination of the probability and magnitude of climate change. Sensitivity reflects the responsiveness of systems to climatic influences, the threshold points at which effects will be exhibited, whether changes will occur in trends or steps and whether they will be reversible. The combination of exposure and sensitivity determines the likely potential impact, positive or negative. The adaptive capacity of the system, region or sector refers to its capacity to respond in a way that makes it better equipped to deal with external influences via either autonomous or planned adaptation[22].

Regional NRM bodies have little influence over the exposure or sensitivity of their region to climate change, although it could be argued that reducing habitat fragmentation may reduce the sensitivity of some species to climate change impacts and increase their resilience in the face of climate change. Moreover, regional NRM bodies should pull their weight in mitigating greenhouse gas emissions and in encouraging others to do so. The factor in the above equation that is most within the influence of regional NRM bodies however, is adaptive capacity — improving the ability of regions to anticipate, adapt and respond to a changing climate.

Notwithstanding the on-ground environmental influence of regional NRM bodies, it must be acknowledged that many policy instruments will need to be applied to improve the resilience to climate change of Australian regions, including education, trade, transport, taxation, energy, welfare and so on. Ideally, regional NRM bodies should integrate their activities with those of industries and other levels of government, leading where appropriate.

Unpacking climate change impacts on regional NRM

In many regions, climate change creates a more urgent imperative to get it right, but it does not fundamentally alter NRM priorities. Many climate change responses can be “no regrets” measures with complementary benefits for issues such as biodiversity, soil health or water quantity and quality.

There is much that regional NRM bodies can do within their existing operating frameworks that will be beneficial in adapting to climate change. The overlap between best practice regional NRM and constructive climate change adaptation measures is very large. This provides lots of scope for regional NRM bodies to make a very useful contribution in the overall response to climate change.

However let’s not be too glib. Some potential ramifications of climate change go way beyond what can be tackled with best practice NRM based on current knowledge. It would be foolish to pretend otherwise. More radical responses will be needed, and in some cases activities that we currently undertake will simply no longer be tenable — at least in their current locations.

For regional NRM bodies, while it is important to be aware of such big picture threshold issues, it is more likely that responses to them will need to be led from state or Federal governments.

The trick is how to unpack potential climate change impacts in such a way as to be able to put to one side the things over which you have little or no influence, and to focus on the things that regional NRM bodies can do in ways that help meet other objectives in the Regional NRM Plan including soil, water, biodiversity and landscape amenity.

Two examples of how a NRM regional body approached exploring the implications of climate change in their region are provided in this section; the North Central Catchment Management Authority in Victoria; and the Adelaide and Mount Lofty Ranges Region in South Australia.

North Central Catchment Management Authority, Victoria

In 2005, the Australian Government funded workshops with a number of regional NRM bodies to explore the local implications of climate change with stakeholders in those regions. The workshops were facilitated by Sinclair Knight Merz Pty Ltd (SKM). The material below draws largely on the workshop undertaken with the North Central Catchment Management Authority (CMA) in Victoria[23]. The process undertaken in these workshops illustrated three key points:

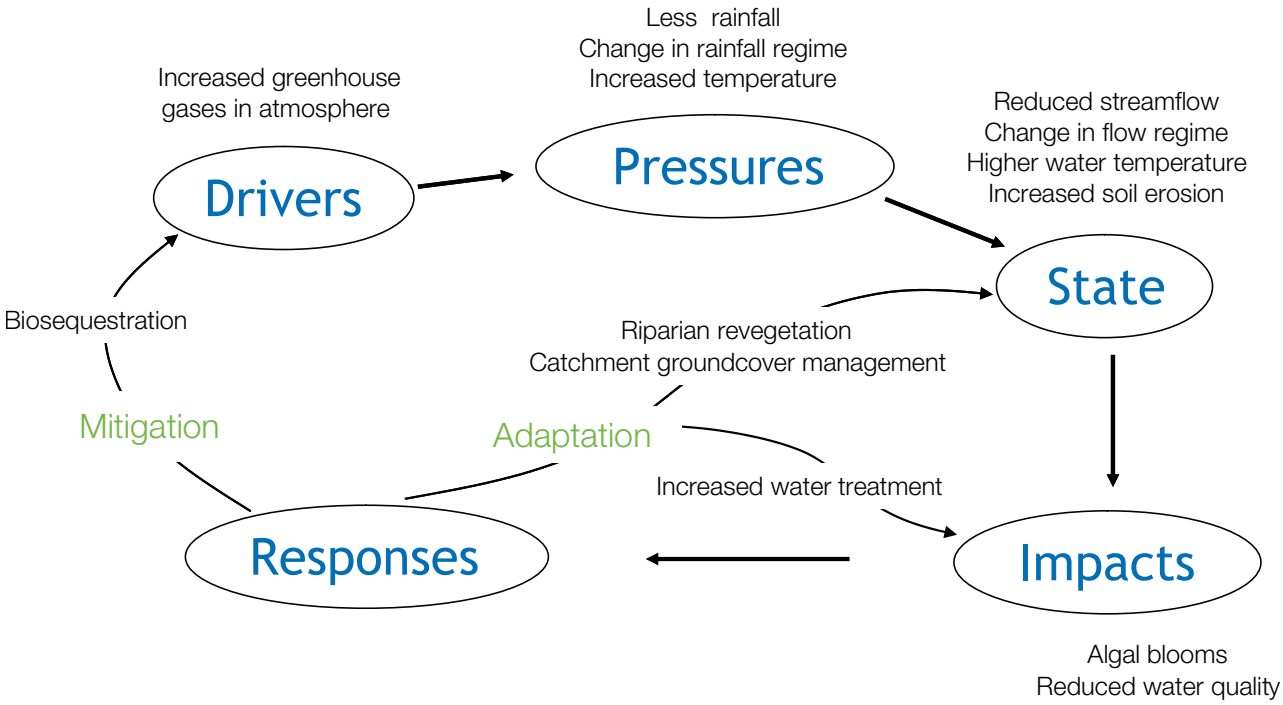
1. Climate change affects just about everything in NRM, it will change some critical ecological relationships and it will lead to many feedback loops, not all of them predictable or even expected. At first glance, it is intimidating in its complexity and scary in just how profoundly it threatens our landscapes, lifestyles and livelihoods.

2. On the other hand, when you unpack the broader phenomenon and start to look at it more systematically, climate change impacts can be teased out, mapped and sorted in ways that enable analysis in the context of existing NRM issues and responses.

3. When these responses are worked through, many of them are just an extension of existing "best practice NRM" in terms of planning, developing and implementing, in an integrated way at a catchment or landscape scale, more sustainable land use systems and management practices. For most natural resource assets in most regions, the most urgent threat to long term sustainability is not climate change, but the usual mix of poor farming practices (over-grazing, over-clearing, over-irrigating, over-cultivating etc), invasive species, fire, increasing water and energy use and inappropriate residential and commercial development.

The workshop process with the North Central CMA that generated the diagrams in Figures 6, 7 and 8 is one way of doing just that. It enables regions to build up a richer picture of climate change impacts and responses at a regional level. The SKM project team used the Drivers-Pressures-State-Impacts – Response (DPSIR) model developed by the European Environmental Agency[24] to work through a framework for linking climate change signals (the *pressures* or threats; e.g. change in rainfall, increased temperature), with consequential changes in resource condition (or *state*) and the *impacts* of those changes. It helps to place climate change in the context of other *drivers* of resource condition change and helps with the identification of adaptive *responses*.

Figure 6. The DPSIR model in a climate change and water example[25]

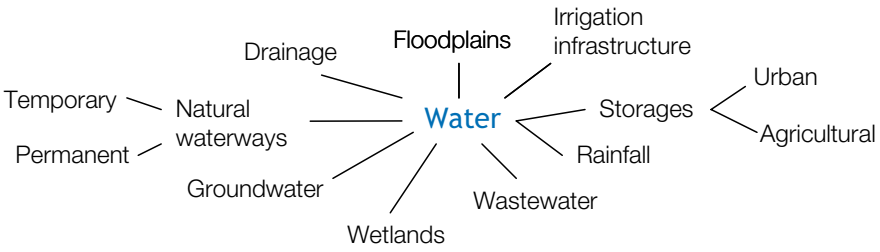


The value of the DPSIR model from a regional NRM perspective is that it translates well into the regional NRM framework of planning management actions to meet resource condition targets for natural resource assets. In the model above, State equates to resource condition targets and Responses equates to management actions. Drivers, Pressures and Impacts are useful in understanding the relationship between management actions and resource condition targets, and hence where best to target effort and investment.

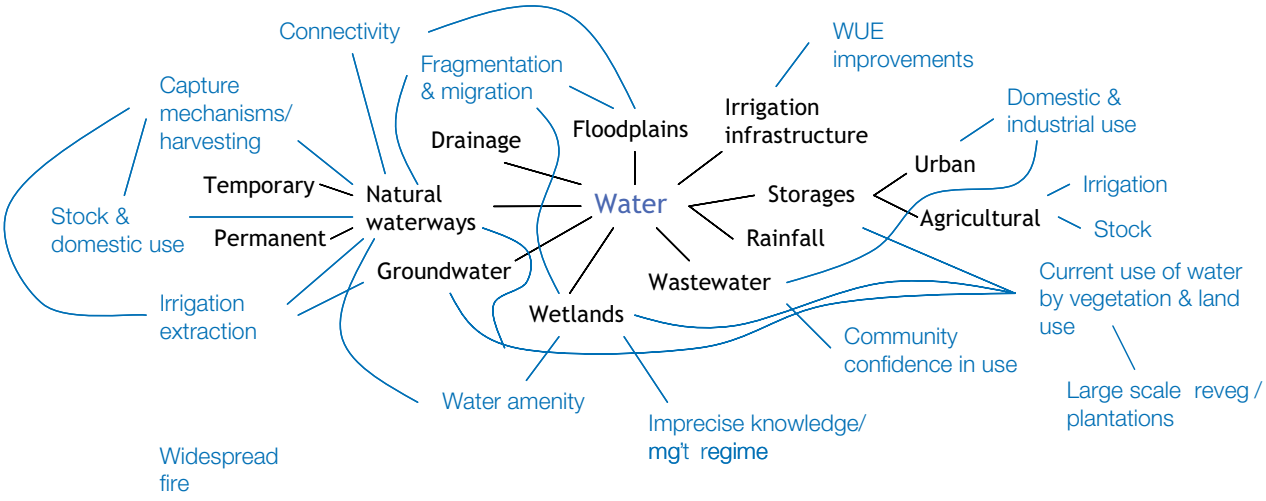
Referring back to the North Central CMA case study, the next step in the workshop process was to define the natural resource asset, before examining pressures and drivers and how climate change affects them. The diagrams in Figure 7 illustrate how the picture was built up for water in the North Central CMA region in Victoria.

Figure 7. Building a mind map of climate change pressures on water resources[26]

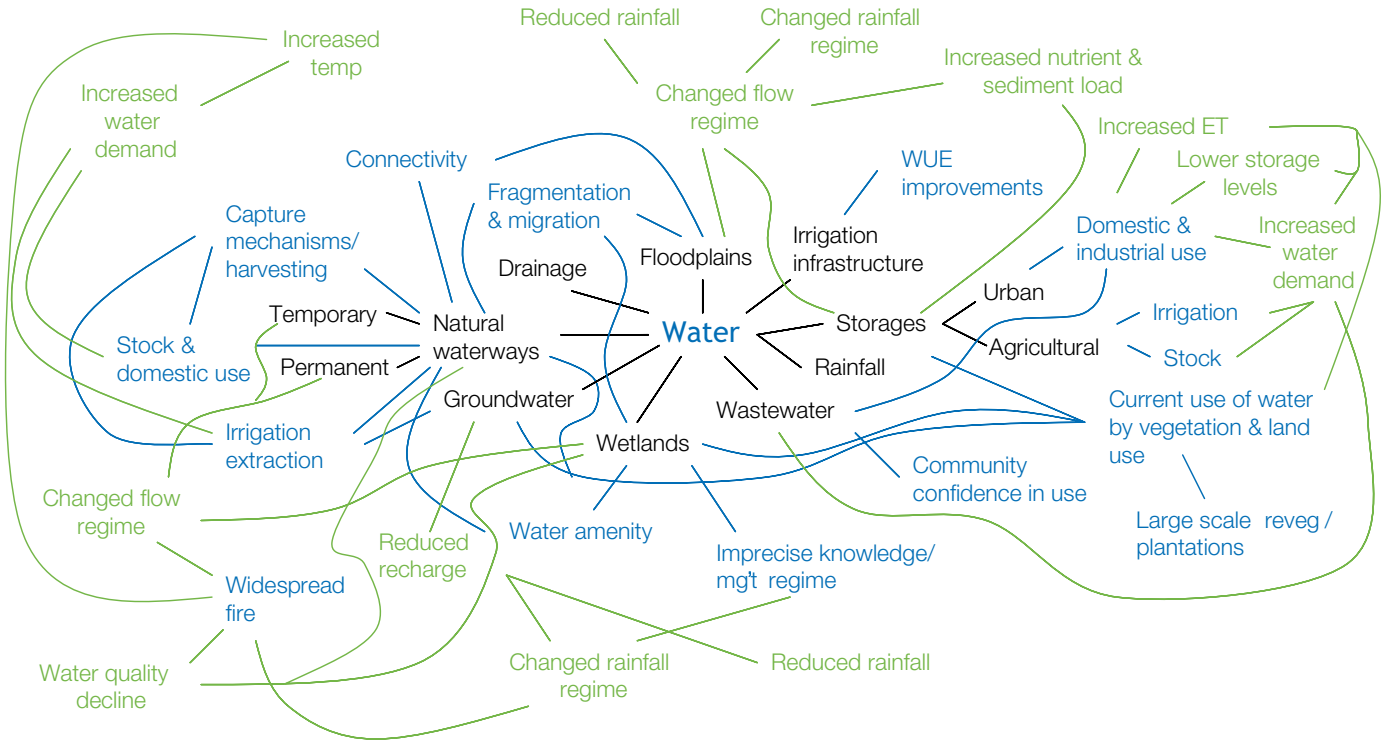
a *Defining the asset*



b *The influence of pressures and drivers (blue layer)*



c *The influence of climate change pressures (green layer)*

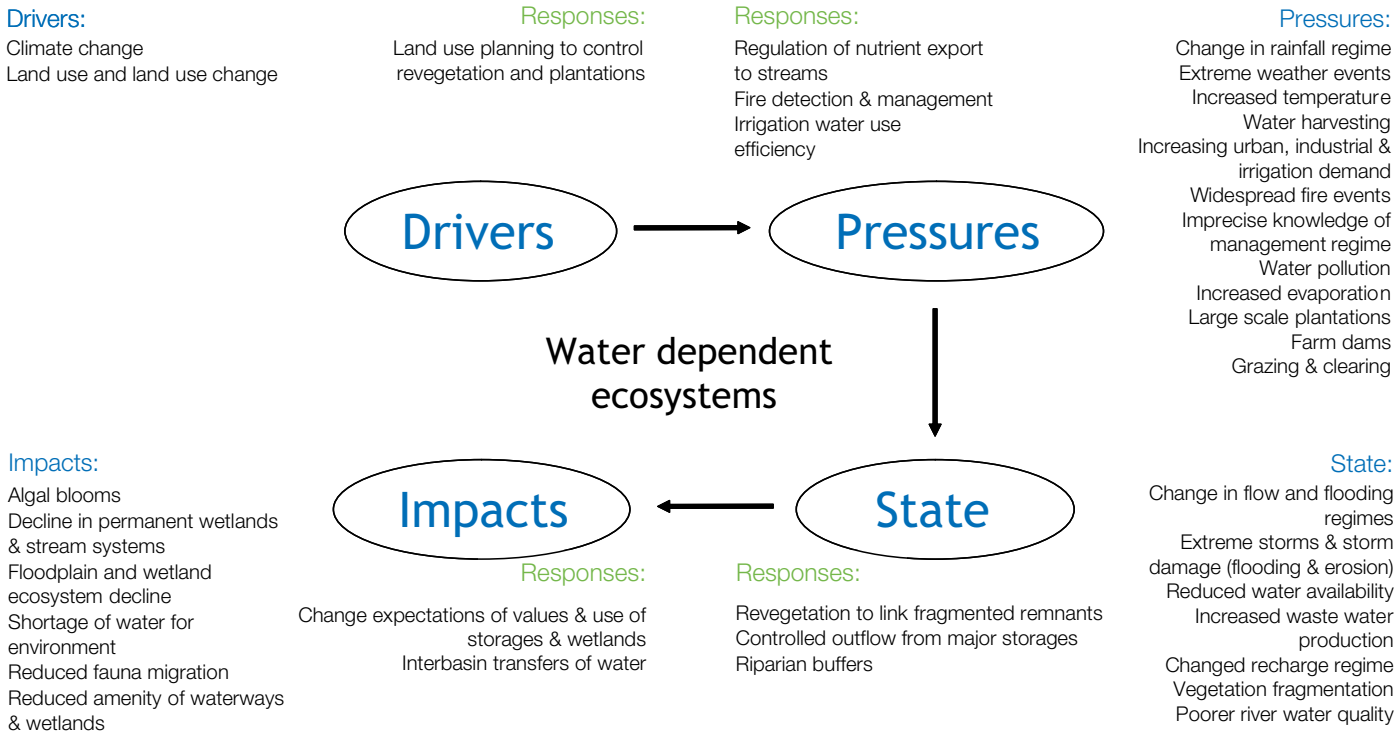


Having disaggregated climate change pressures from other pressures on the particular natural resource asset — in this case water — the next focus was on responses to climate change pressures, using the DPSIR model again. For the North Central CMA, the main assets examined were water, ecosystems and land, with water generally divided into water resources and water for ecosystems. Staying with water, it is interesting to look at the workshop outputs that mapped responses to climate change impacts on water for ecosystems in North Central Victoria.

In this case, climate change along with land use and land use change are identified as the major pressures on environmental water. Changes in rainfall will lead to reduced average flow and periodic extreme flow events. Wetlands and river systems are likely to change due to the increased intermittency in flow and flooding regime. Water quality may decline due to fire, extreme flow and erosion events and reduced dilution flows under typical conditions.

Taking the case study as a whole, the North Central analysis revealed that the most vulnerable assets to climate change impacts in that region are water for consumptive and environmental uses, lowland wetlands, and northern plains grassy woodland ecosystems[28]. In each case, these resources are already under threat from other pressures, which are being exacerbated by climate change.

Figure 8. Interactions between climate change and water for ecosystems in north-central Victoria[27]



Adelaide and Mount Lofty Ranges Region, South Australia

Many natural resource assets however, are not acutely vulnerable to climate change. Their major sustainability issues can be managed to a large extent through the application of best practice regional NRM. Douglas Bardsley's analysis of the Adelaide and Mount Lofty Ranges (AMLR) region[29] developed a climate change adaptation vulnerability matrix, applying the Potsdam vulnerability model (refer Figure 5) to a range of assets and issues across the region, summarised in Table 2. This analysis suggests that freshwater biodiversity and coastal flooding are the most vulnerable issues to climate change impacts in the AMLR region. Bardsley's analysis suggests that the overall exposure and sensitivity to climate change in the AMLR region is generally high, consistent with other regions of the world with a Mediterranean climate — characterised by cool wet winters, a winter-spring growing season and hot dry summers:

> *"Mediterranean systems from western North America, Southern Europe, the Cape region in South Africa, Chile and south-west Western Australia have already shown substantial warming and drying trends since the 1970s*[30]*"*

The Adelaide Hills and Mount Lofty Ranges are in effect an island of cool, moist conditions in an extensive sea of hot, arid landscapes. As such the region is crucial in supplying 60% or more of Adelaide's water in a "good" year and in supporting regionally distinctive ecosystems. But such islands are highly vulnerable to rapid environmental change[31], which emphasises the need for timely anticipation and responses (Table 2). It follows that if exposure and sensitivity are generally high, then so will be the potential impact. However, Bardsley's assessment of the AMLR region is that adaptive capacity is generally medium or significant, moderating the overall vulnerability accordingly. The fertile ground for the AMLR Regional NRM Board to explore, in concert with other stakeholders, is how best to realise this adaptive capacity across this range of assets and issues.

Table 2. Summary of climate change vulnerability analyses for NRM in the Adelaide and Mount Lofty Ranges region[32]

	EXPOSURE	SENSITIVITY	POTENTIAL IMPACT	ADAPTIVE CAPACITY	VULNERABILITY
Riparian flood management					
Surface water					
Groundwater					
Coasts: flooding					
Coasts: beaches					
Biodiversity: terrestrial					
Biodiversity: freshwater					
Invasive species					
Parks and Gardens					
Revegetation					
Agriculture: annual crops					
Agriculture: horticulture					
Agriculture: livestock					
Land management					
Bushfires					
Air quality					

Colour Key Exposure, Sensitivity, Potential impact and Vulnerability (not Adaptive capacity)				
Low	Low-Medium	Medium	Medium-High	High
Colour Key for Adaptive Capacity				
Significant		Medium		Limited

In summary

It is equally possible to apply an analysis such as the DPSIR approach to a specific ecosystem, such as a high priority asset identified in a Regional NRM Plan. Some ecological assets particularly vulnerable to climate change impacts include the Australian Alps, the Great Barrier Reef, many estuaries and wetlands lower in catchments, and the moister "islands" within the landscapes of southern Australia that have traditionally enjoyed a Mediterranean climate. In the high country example, we are already seeing rising temperatures, a marked decline in snow cover, more frequent, larger and more intense bushfires, and the penetration of invasive species into areas that were formerly too cold for them. The habitat niches for many alpine species are shrinking, their adaptive capacity appears to be very limited and hence their vulnerability is acute.

In such cases, best practice regional NRM can alleviate existing pressures through actions such as improving land use planning and agricultural practices; restoring landscape connectivity; managing invasive species; better prevention, detection and suppression of bushfires; targeting provision of environmental water and improving water quality. Through such actions we may be able to reduce their sensitivity to climate change and hence buy some time for the most vulnerable ecosystems. But the longer term outlook for these ecosystems is critically dependent on getting climate change under control and averting run away climate change, which means mitigating global greenhouse gas emissions.

New insights about how NRM regional bodies can explore and understand more about the implications of climate change will emerge from national projects currently underway. The Victorian Department of Sustainability and Environment, under the auspices of the Natural Resources Management Ministerial Council, is leading the implementation of a project that will develop and trial in a number of NRM regions various methodologies for assessing regional climate change vulnerability. The methodologies will involve the gathering, synthesising and disseminating of information products on climate change vulnerability. The project, due for completion in early 2009, will then pilot in a few NRM regions a risk assessment and management planning approach for addressing climate change.

The second project, funded by the Australian Government, is a national scoping study of all NRM regions to systematically identify areas and NRM priorities that are at risk from climate change impacts, including a review of:

- available information from NRM regions of the potential vulnerability of key NRM assets to climate change;
- the likely implications of projected climate change for regional NRM priorities;
- what regions have done to date to understand regional vulnerability to climate change in relation to NRM priorities; and
- the adequacy of current information and tools to assist NRM decision makers manage climate change risk.

This project, due for completion in 2009, will involve both a literature review and a series of state based regional workshops to review available information from NRM regions and to highlight the potential vulnerabilities of key NRM assets to the impacts of climate change.

4.2 Climate change impacts on specific NRM issues and management implications

The preceding section discussed how regional NRM bodies can identify climate change impacts and assess climate change vulnerability systematically for specific natural resource assets. There is much that regional NRM bodies with similar issues can do to alleviate these existing pressures, which in turn will increase adaptive capacity and thus reduce vulnerability to climate change.

This section looks at some specific NRM issues and how they may intersect with climate change. Again, the effects discussed here are generalised and not specific to any particular region, and are based on the limited existing studies. But they may assist regional NRM bodies in thinking about how current approaches may need to be modified to better consider the potential impacts of climate change.

Invasive Species

Invasive species are those that are either introduced or Australian plants, animals, invertebrates and pathogens that become problems outside of their home ranges. Invasive species may be among the more important and least predictable impacts of climate change in Australia.

Invasive species tend to be colonisers — adaptable opportunists among the first to occupy new or expanding environmental niches after disturbance or within stressed ecosystems.

One challenge in this area is the potential for “sleeper” weeds and ferals to begin to expand their range suddenly and dramatically in response to even moderate shifts in climate or to changes in the frequency of extreme events, such as fires or cyclones. For example, *Mimosa pigra*, now a major problem on floodplains in the Top End, was deliberately introduced and existed quietly in one small patch for about 90 years before it took off, presumably in response to one or more favourable seasons. The potential for cane toads (*Bufo marinus*) to spread further south in a drying climate is already well known, but there are likely to be many other potential sleeper weeds and ferals. Further, as many weeds are characterised by C4 photosynthetic pathways, the “CO_2 fertilisation” effect of rising concentrations of CO_2 in the atmosphere may be significant and consequently may give C4 weeds a competitive advantage[33].

This issue lends itself to a comprehensive risk assessment at a number of levels from the national level down through major agro-ecological zones to the individual region. Such risk assessments should not just look at the potential for existing problem species to spread, but at the potential for biological control agents to become more or less effective[34], and for new invasives, including invertebrates and diseases, to become problems.

One of the major factors exacerbating the risk associated with many invasive species, especially weeds, is fire.

Fire

Fire management is not generally regarded as core business for regional NRM bodies, but climate change may change that.

Fire is a classic example of how climate change affects other NRM issues and the interactions between them.

Fire size, frequency and intensity have a big influence on species composition and structure for both flora and associated fauna. Increasing fire frequency and intensity will favour some species over others, including weeds. Many rainforest species can only complete their life cycle in the absence of fire. More frequent and more intense fires favour fire-adapted species like the introduced invasive aquatic Para grass *(Urochloa mutica)* in the Top End, which generates a huge biomass and continuous fuel layer from ground level to the tree canopy in wetlands, leading in turn to even hotter fires, earlier in the dry season. Many native species (plants and animals) are displaced by Para grass[35] and are struggling to cope in this vicious circle of increasing fire frequency and intensity.

Large bushfires in the key forested water catchments of south-western and south-eastern Australia have big impacts on biodiversity. They also have significant implications for water resources, both in terms of quantity and quality. Large, hot fires can have a devastating impact on water quality. In the Cotter catchment in the Upper Murrumbidgee after the fires that hit Canberra in January 2003, many streams filled with sediment (equivalent to 27 years of average sediment yield) in the rains that followed the fires. Three water supply reservoirs had to be closed for many months. The catchment is still far from recovery, and bushfire regrowth will now impact on water yields for decades to come[36].

The NRM implications of currently common fire prevention and suppression measures are rarely considered or reported in the heat of the moment. For example, in combating large bushfires, it is common for large control lines to be bulldozed in understandable haste, often during the night, whether for back-burning or to protect key assets. Such control lines are naturally sited for fire suppression reasons, not for erosion control or biodiversity conservation. They often generate significant erosion risk as well as destroying habitat, they can facilitate weed incursions deep into previously undisturbed areas, and their rehabilitation post-fire tends to be patchy at best[37].

Calls for more frequent and larger scale fuel reduction burning is a predictable response to worsening bushfire risk in drought and a drying, warming climate. However this also has major NRM implications. As mentioned earlier, in addition to affecting water quality and quantity, increasing fire frequency changes species composition and floristic structure, favouring species that like fire including weeds — many of which are highly flammable, thus increasing fire risk and hazards over the long term. Further, a warming, drying climate makes it much more difficult to undertake so-called “cool” burns safely. The windows of optimum weather will be shorter and rarer, and more likely to be followed by periods of higher fire danger, thus leading to even more wildfires originating from prior fuel reduction burns. Spring burns risk many nesting bird species and breeding mammals with young that are unable to move quickly, and are highly problematic from a biodiversity perspective.

In recent years, governments have invested hundreds of millions of dollars in trying to put out large bushfires, and insurance companies have paid out even more in claims. From a greenhouse perspective, it would be highly desirable for Australia to shift a bigger proportion of this expenditure into early fire detection and rapid response suppression. Similarly from an NRM perspective, the biodiversity, water yield and water quality advantages from keeping fires as small as possible are considerable.

When fires do become large, then the fire suppression techniques of fire management agencies need to take water quality, water yields and biodiversity into greater account than is currently the case.

Whether in the rangelands or the wet forests, fire management will become an ever-bigger NRM issue, exacerbated by climate change. It has very significant implications for water resources and biodiversity in particular. Regional NRM bodies will need to map out these intersections, and participate in the inevitable debates about fire management strategies over coming years.

Vegetation

Mansergh and Cheal (2007)[38] assess that increases in atmospheric CO_2 concentration and changes in the spatial distribution of temperature and rainfall are likely to induce changes to a range of biological and ecological processes in the terrestrial biota including:

- the structure and function of ecosystems;
- the physiological, genetic and/or behavioural make up of species;
- phenology (flowering, breeding etc.);
- growth rates, nutritional value and community structure;
- fire and water regimes; and
- the spatial distribution of species/communities.

Many of these changes such as phenology[39] and gene frequency[40] have already been observed from the warming over recent decades.

Individual species can exhibit various combinations of two broad responses to climate change: they can adapt to new conditions within their existing range; or they can migrate. The capacity of individual species to adopt either of these strategies will vary. Mansergh and Cheal[41] suggest that a two-tiered risk management approach is required to buffer nature against climate change:

> *"Firstly, to make current habitats including reserves as healthy as possible to reduce the effect of unnatural perturbations and protect source populations and refugia. Secondly, to ensure connectivity and permeability between habitats."*

One of the biggest levers that regional NRM bodies can use to achieve both these ends is their influence over native vegetation management and revegetation activities.

Revegetation and vegetation management is a critical tool:

- **hydrologically**, for filtering and managing run off and groundwater recharge;
- **ecologically**, for maintaining and improving wildlife habitat and landscape connectivity;
- **agriculturally**, for assisting in soil management, integrated pest management, improving microclimate and diversifying farm incomes through farm forestry; and
- from a **greenhouse** perspective in reducing emissions from land clearing and in establishing vegetation "sinks" to sequester carbon dioxide.

For all of these reasons, preventing poorly planned clearing and overgrazing of remnant vegetation and encouraging well planned revegetation works to restore vegetation cover in over-cleared landscapes is a key focus of many Regional NRM Plans.

This section examines two key issues. What are some of the potential impacts of climate change on remnant vegetation and on species selection, establishment and survival in revegetation projects? And what is the potential for regional NRM bodies to play a role in establishing vegetation sinks to offset greenhouse emissions, in particular as a national emissions trading scheme emerges? The relationship between vegetation, dryland salinity and water management, and how that may be affected by climate change is dealt with later.

Climate change impacts on remnant vegetation

Remnant vegetation in the agricultural landscapes of southern Australia is already under pressure from the aggregate and cumulative impacts of clearing, grazing, firewood harvesting, insects and disease, invasive species and fire. Those impacts have much more serious implications for remnant native vegetation than climate change per se, although as discussed above, a warming, drying climate will favour some invasive species, will lead to varying adaptation and migration responses among native species and will lead to increased fire frequency and intensity.

Nevertheless, in the main, the issues that regional NRM bodies are already grappling with in terms of maintaining and increasing remnant vegetation cover, remain the big issues. Again, "best practice regional NRM" will remain the best strategy for remnant native vegetation for the foreseeable future.

However as climate change starts to cause geographic shifts in the preferred niches for many species, we will need to amend our concept of best practice regional NRM. Most Regional NRM Plans already emphasise landscape connectivity, and look to extend defined key habitat areas with buffer zones and corridors to reduce fragmentation and to offer habitat continuity for less mobile species. This strategy will become increasingly important in the face of climate change.

Moreover, climate change underlines the importance of implementing measures to encourage biodiversity conservation outside the formal reserves system of National Parks and other wildlife reserves. Conservation of biodiversity on freehold and leasehold lands has always been important, but in a changing climate it becomes even more so.

Climate change impacts on species selection, establishment and survival

The situation with remnant vegetation is echoed with revegetation. In the main, existing best practice revegetation work remains the best strategy in the face of climate change.

Increasing drought frequency and intensity may lead to some changes in species selection at the margins, to reduce the proportion of drought-intolerant species in plantings. However such considerations are indeed marginal compared with the traditional issues of ensuring appropriate site preparation, choosing good seedlings or seedstock, planting at the right time of year when there is moisture in the root zone, achieving effective weed control for at least the first two years, mulching if necessary, protecting seedlings from browsing, and ensuring sufficient width in the fenced-off area. Well planned and well implemented revegetation projects have performed very well even in the current extreme drought wherever they have got the above basics right. Provided the basics are done well, revegetation projects on cleared farmland often do well in drought years, as competition from weeds (including pasture species) is less ferocious.

In regions where climate change is leading to hotter, drier conditions, attention to issues such as site design, deep ripping, mulching, weed control and protection from browsing will have a much bigger impact on survival rates than species selection, assuming local species are used. No case can yet be made for leaving native species out of a planting or seeding mix for a given site because their preferred climate may be shifting south or inland or wherever. Getting the basics right will have far greater influence on survival rates for the foreseeable future. In fact it could be argued that there is a conservation case for replanting more of those species that appear more vulnerable to climate change, paying particular attention to the micro-climate of planting sites and designs.

The situation for commercial plantings is somewhat different, in that growth rates are important as well as survival rates. Projected reductions in rainfall and increasing drought frequency and intensity are likely to reduce the growth rates and hence commercial viability of some species. This issue has been examined in a useful report commissioned by the Australian Government which looked at a number of commercial and semi-commercial species under two climate change scenarios for each of 2030 and 2070[42]. This CSIRO analysis found that changes in the preferred range of most species by 2030 for both climate change scenarios were minor, but that the medium-high climate change scenario saw some range restrictions in some species by 2070, which is within the planning timeframe for some forestry plantings. It also suggested that climate change may extend the range of species such as Spotted Gum (*Corymbia maculata*) through reduced frost frequency and intensity.

For environmental plantings, a more critical issue than the actual species mix may be the genetic diversity within the species planted or seeded. The issue of in-breeding depression caused by using local seed with too narrow a genetic base has already been found to be a problem in some revegetation projects for some genera[43]. It would be prudent in regions where climate change impacts are likely to be significant, to ensure that the provenances used in revegetation work are gathered from a wider range of sites, and preferably micro-climates.

In more difficult conditions, survival rates will tend to be lower in any case, and edge effects more serious, which makes planting design even more important. In difficult planting or direct seeding conditions (poor rocky soils on hill tops, northern aspects or steep slopes etc), skinny, linear plantings are always likely to struggle. A hotter, drier climate with more weeds and more fires will exacerbate the vulnerability of narrow (less than 50m wide), linear revegetation projects. We have tended to see shelterbelts, wildlife corridors and riparian plantings become more generous in width over the last twenty years — which also has the benefit of reducing fencing costs per hectare of vegetation established. Climate change underlines the need for this trend to continue and to accelerate.

Greening Australia's Exchange project[44] provides an informative first stop shop for technical advice about revegetation and managing remnant native vegetation. There is a very active scientific debate about the best ways to achieve biodiversity objectives through conservation and augmentation of remnants and through revegetation, and the validity of tools such as the focal species approach and landscape function analysis[45].

From a climate change perspective, the key revegetation messages are:

- Maximise landscape connectivity through riparian plantings (especially on the north and west sides of streams) and through joining up and buffering significant remnants with revegetation;
- Make new plantings or buffers for remnants as wide as practicable and try to minimise the edge:area ratio (and consequently fencing costs per hectare);
- Use local species for habitat plantings, including understorey species, but broaden the genetic base within species as much as possible; and above all
- Get the basics right in site preparation, establishment (especially weed control) and protection from browsing.

Further information about the implications of climate change on Australia's biodiversity can be found in a recent report released by the Australian Government, *Implications of Climate Change for Australia's National Reserve System: a preliminary assessment*[46]. While focussing on the possible future impacts of climate change on Australia's system of formally protected conservation areas, the report explores a number of issues relevant to managing the impacts of climate change on biodiversity at the landscape scale.

A broader, *Strategic Assessment of the Vulnerability of Australia's Biodiversity to Climate Change* is also being undertaken and will be of interest to regional NRM managers. The assessment will consider the potential impacts of climate change on Australia's biodiversity and discuss the management responses that might be required. It will highlight our current state of knowledge, identify future directions for biodiversity adaptation response, and discuss knowledge gaps in research and management. It will cover biodiversity conservation in terrestrial, freshwater and marine ecosystems. The report is being guided by a panel of experts and is due to report towards the end of 2008.

Potential roles for regional NRM bodies in carbon trading

The Australian Government has commenced work to develop a national emissions trading scheme, to commence operation in 2010. The options for regional NRM bodies in biosequestration projects in any national emissions trading scheme were canvassed in more detail in a recent review commissioned by the Victorian Catchment Management Authorities[47]. That review concluded that there is considerable interest from greenhouse gas emitters (large and small) in vegetation offsets projects (biosequestration), that projects meeting specific criteria will likely be recognised in any national emissions trading scheme and that they will be part of the eligible mix of greenhouse responses for the foreseeable future. There are many firms offering vegetation offsets, most in the voluntary market and several in the mandatory market, which at this stage in Australia is confined to the NSW Greenhouse Gas Reduction Scheme.

The review noted that there is growing scope for regional NRM bodies to promote carbon sinks projects that also deliver biodiversity benefits and are consistent with the objectives of Regional NRM Plans, and that such projects are more viable in the voluntary market. However the review cautioned that actual net returns to landholders from the carbon market, especially for environmental mixed species plantings (as distinct from commercial forestry plantations), are likely to be modest at current carbon prices. The carbon returns alone are insufficient to justify widespread plantings, but they could be a useful bonus for environmental revegetation where the measurement and transaction costs of negotiating long term contracts with landholders to deliver secure carbon rights can be managed efficiently.

The review set out and analysed eight options for regional NRM bodies in the carbon market, from reasoned inaction, through measurement and quality assurance roles, to becoming a direct player in the market by "bulking up" revegetation projects and managing and marketing a carbon pool. Overall, it concluded that regional NRM bodies should hasten carefully if not slowly in the carbon market, especially while the design of Australia's emission trading scheme is not yet finalised. Regional NRM bodies who see big opportunities in the future carbon market would be wise to build in-house skills and expertise, and to partner (and share risks) with firms that specialise in greenhouse offsets — either individually or in concert with other regional NRM bodies.

Salinity and water

The recent (still current in many places) drought across southern Australia has had one apparent environmental benefit. Groundwater tables have dropped in many regions, shrinking saline discharge areas and in some cases drying them up completely.

So could climate change "fix" the salinity problem in southern Australia?

In short, no. At least not as an environmental issue, and not in terms of impacts on infrastructure and water resources for irrigation, town water supplies and biodiversity. However it is likely that a warming, drying climate across southern Australia will reduce the symptoms of secondary salinisation and their impacts on dryland agriculture.

In effect though, the most important impacts of dryland salinity have always been off-farm. Certainly a small proportion of valuable productive land has been lost to salt scalds (although saltland agronomy is now providing productive options for those areas), but by far the major impacts of dryland salinity in economic and environmental terms have been through downstream impacts on water quality, infrastructure and biodiversity. Climate change will not reduce those impacts, and in some cases will likely make them worse.

Percentage changes in rainfall will be amplified in runoff, as has been seen already in south-west Western Australia, where a 10-15% decline in average annual rainfall since 1970 has seen inflows to Perth's water storages drop by around half[48]. While projected decreases in rainfall and bigger declines in runoff will lead to reduced salt yields in most regions of southern Australia, they will lead to even greater reductions in streamflow. As a consequence, the concentration of salt in streams will tend to increase, even as water tables continue to drop.

However the processes that determine salt export behaviour vary according to the hydrogeology, in particular the groundwater flow systems (GFS) of different types of catchments. There are three broad types of GFS: local, intermediate and regional. Catchments characterised by local GFS have relatively confined aquifers, and changes to groundwater recharge can show up relatively quickly (years to decades) in response to changes in climate and/or vegetation cover. Whereas in catchments with large areas of intermediate and regional GFS, it can take many decades to centuries for changes in rainfall or plant water use to be fully expressed in the surface water balance. A comprehensive knowledge base on dryland salinity causes and solutions for catchment managers, including the influence of groundwater flow systems, is the Managing Dryland Salinity in Australia Toolkit comprising three manuals and an interactive CD-ROM[49] available from Land & Water Australia.

A detailed analysis of climate change impacts on salinity and water yields in the Murray Darling Basin undertaken by Austin and colleagues from CSIRO[50] predicted that under the selected scenarios:

- Water yields could decline by up to 64% and salt yields by up to 49% in the drier western and northern catchments of the MDB by 2070;
- Water yields could decline by up to 45% and salt yields by up to 34% in the wetter southern catchments by 2070;
- For the Border Rivers catchment, the water yield reduction is 54% and salt yield reduction is 33%, but EOV stream salinity increases by 10% by 2070;
- For the Goulburn, the water yield reduction is 43% and salt yield reduction is 30%, but EOV stream salinity increases by 8%; and
- For the Murrumbidgee, water yields are estimated to drop by up to 48% by 2070, and salt yields by 30%, but end-of-valley (EOV) stream salinity concentrations are predicted to increase by 11%.

Naturally, such reductions in water yield will have significant impacts on in-flows to water storages. Some of the regional impacts that have been predicted by different studies include: streamflow reductions of 0–15% by 2030 and 0–35% by 2070 in the Macquarie River, leading to decreases in the storage of Burrendong Dam by up to 30% and 55% respectively[51]; worst-case stream flow reductions of 20% in eastern and 40% in western Victoria by 2030, and potential reductions in excess of 50% for all of the Victorian part of the Basin by 2070[52]; and a 23% reduction of flows into the main reservoirs in the Murrumbidgee (Burrinjuck and Blowering Dams) and 36% of tributary inflows below the reservoirs. This would cause flow reductions of 52% in the lower Murrumbidgee below the major irrigation areas[53].

From the depths of the current drought these projected streamflow reductions seem conservative.

Regional NRM bodies within the Murray Darling Basin (MDB) should keep a watching brief on the CSIRO Murray-Darling Basin Sustainable Yields project[54], commissioned by the Australian Government. The project is providing a robust, Basin-wide estimate of water availability on an individual catchment and aquifer basis, taking into account climate change and other risks, using four different scenarios:

1. historic climate (1895-2006) and current development;

2. recent climate (1997-2006) and current development;

3. 2030 climate change and current development; and

4. 2030 climate change and 2030 development of farm dams, plantations and groundwater.

The project is:

- modelling the surface runoff and groundwater recharge patterns for each defined catchment under each defined scenario;
- using the river system and groundwater models used by state agencies for water resource planning (and other models where necessary), assessing the implications of the changes in runoff, recharge and water resource development, on water availability in each defined catchment under each defined scenario;
- assessing the implications of potential changes in water availability on diversion volumes (and their reliability), environmental flows and on the likely ability to meet the stated aims of current water sharing plans, assuming current water sharing arrangements; and
- reporting on results progressively — catchment by catchment, and finally for the entire Basin.

Many of the central and southwest catchments of the MDB have large areas of regional and intermediate groundwater flow systems, which mean they have very long lag times. Eventually, after several centuries, the decrease in rainfall and consequent gradual lowering of watertables will lead to a corresponding decrease in groundwater discharge and salt export. However in the meantime, the decrease in rainfall shows up immediately in a reduction in the dilution effect of surface flows, and consequently an increase in stream salinity even as salt yields decline[55].

In areas with local groundwater flows systems, the system responds more quickly, and measures such as revegetation can reduce stream salinity within decades, even under climate change scenarios. The Austin study (2006) suggested that there are areas within the Border Rivers, Goulburn and Murrumbidgee catchments, and in other catchments including the Darling, Benanee, Namoi, Lachlan, Ovens and Upper Murray, where carefully targeted revegetation could control stream salt concentration *"with appropriate consideration of water yield and other environmental outcomes"*[56].

Vegetation, salinity and water interactions

That last caveat from Austin and her CSIRO colleagues is critical.

It should be clear by now that for the regions of Australia in which most people live and most food and fibre is produced — i.e. the eastern seaboard and southern and south-western Australia — the greenhouse effect is leading to a hotter, drier climate on average, with less rainfall and even less runoff.

So the biggest climate change impact likely for most regional NRM bodies will be long term reductions in water yield. In many catchments, that same reduction in water yield will be reflected in increasing stream salt concentrations. Those two factors in turn have significant biodiversity implications across whole landscapes, not just for in-stream biota.

Large scale revegetation is a valuable tool for tackling salinity, especially in catchments with local groundwater flow systems, it can be very valuable to increase or augment wildlife habitat, and it is an important transition tool in offsetting greenhouse gas emissions.

But in the context of warming, drying catchments with declining water yields, large scale revegetation has to be planned and sited very carefully if it is not to exacerbate reductions in water yield with consequent knock-on environmental impacts. As a rule of thumb, the lower in the landscape and the closer to the stream, the more influence that revegetation has on streamflow, especially in drier catchments with less lateral flow[57]. *Trees, Water and Salt*, edited by Richard Stirzaker, Rob Vertessy and Alastair Sarre provides an overview of the interactions between vegetation, salinity and water[58].

One of the biggest opportunities to improve landscape condition across a range of biodiversity, water and carbon objectives is protection and revegetation of riparian areas. From both a biodiversity and a water quality perspective, riparian vegetation performs a crucial role, stabilising stream banks, filtering runoff, shading streams and thus keeping water temperatures within their natural range, and contributing to the food web for in-stream biota. When older trees drop limbs or topple over, they provide large woody debris (snags) that is valuable habitat for many creatures, fish in particular. Siwan Lovett and Phil Price have edited a comprehensive overview of riparian land management including vegetation issues[59].

Riparian vegetation is in effect often the “thin green line” protecting the arteries of the landscape. Its benefits in improving water quality and in-stream habitat far outweigh any disbenefits in reducing water quantity. However the points above about the disproportionate influence on streamflow of revegetation closer to streams remain valid, especially in salt-affected catchments. So from a water yield, water quality and in-stream habitat perspective, riparian revegetation should ideally be targeted to the northern and western sides of streams (to maximise shading benefits) and in the zones most vulnerable to erosion. It should be sufficiently wide to be ecologically viable and to offer useful terrestrial habitat corridors. However in salt-affected catchments, care should be taken that riparian plantings are not so wide as to constitute plantations covering valley floors that may substantially reduce streamflow.

The spatial location and configuration of revegetation projects is among the most critical technical issues in thinking about climate change implications for many Regional NRM Plans. In salt-affected catchments, especially those with local groundwater flow systems, large scale broadacre revegetation should be targeted higher in the landscape to preferential recharge zones such as “break of slope” plantings. Fortunately, there are now a range of tools to assist regional NRM bodies to prioritise revegetation works to optimise their value for multiple objectives, available through CSIRO Land and Water and Greening Australia’s Exchange program.

Climate change makes large scale revegetation an even more important and valuable measure in the regional NRM toolkit. Equally, climate change makes it even more important to get it right: to get the right sorts of vegetation, in the right parts of the landscape, in the right configuration, with the right establishment techniques and the right on-going management regime. Inattention to any of these details could lead not just to wasted money, but to damaging unintended environmental impacts at a catchment scale.

5. BUILDING CLIMATE CHANGE INTO THE BUSINESS OF REGIONAL NRM BODIES

By now it should be clear that climate change has to be hard-wired into every aspect of regional NRM bodies' business.

The following section looks at the key roles common to regional NRM bodies and discusses how climate change considerations can be incorporated into their core business functions.

5.1 Roles of regional NRM bodies

As is traditionally the case across the Australian federation, each State and Territory has taken a different approach to the development of regional NRM bodies. The regional NRM investment model has evolved in different ways across the country. Just as with local governments, there are also significant differences between regional NRM bodies within jurisdictions as they have responded to their individual local circumstances and community leadership in diverse ways.

However for the purposes of this document, the differences in governance frameworks and administrative arrangements among regional NRM bodies across and within different jurisdictions are not critical. All regional NRM bodies perform the generic roles outlined below to a greater or lesser degree and climate change is a big issue for all of them.

Bridge between Government and community

As we have seen above, regional NRM bodies have emerged through a combination of "bottom up" and "top down" forces. As a result, they are an interesting hybrid between government and community interests. They exist, survive and prosper because of the large overlap between those interests.

The bridging role that regional NRM bodies play between governments and regional communities is critical. They are in touch with governments, familiar with government processes, have access to public funding and have a mandate to act in the public interest. However they are generally led at board level by well known people from regional communities with relevant expertise and a strong local track record. Accordingly, regional NRM bodies are well placed to moderate between governments and local communities — with the interests of the catchment foremost.

Climate change is the ultimate challenge demanding collaboration and integration across human activities and geographic scales — right up to the global scale. But, just as greenhouse gases have accumulated in the atmosphere through the aggregate impacts of innumerable human actions, some big and many small, so will the responses to climate change need to be expressed at all levels from the individual to the household, firm, neighbourhood, district, catchment, town, industry, region, city and so on. This means that any effective response to climate change will need to bring the whole community along, reaching into every sector.

In that mix, bodies like regional NRM bodies that can straddle the community-government divide have a crucial role to play. They are ideally placed to meld top down strategy and resources with bottom up energy and engagement to deliver much more effective and lasting responses.

Planning

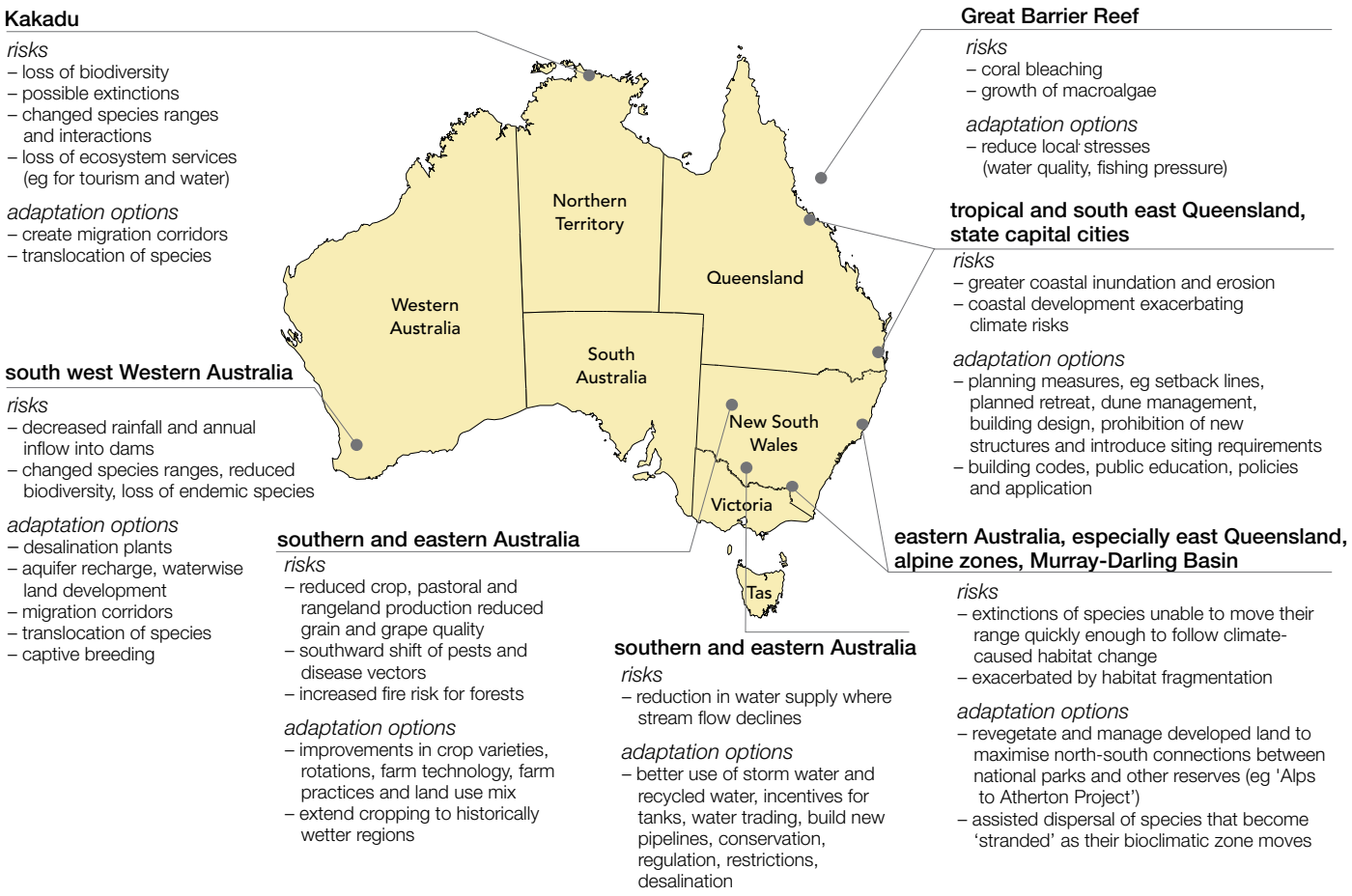
The development and implementation of Regional NRM Plans that identify key natural resource assets, set and prioritise resource condition targets, and outline the management actions that need to be implemented to meet those targets, is at the heart of core business for regional NRM bodies.

The impact of climate change on planning processes in Australia at all levels is a huge issue that could fill several books. It is an issue that goes well beyond Regional NRM Plans and the roles of regional NRM bodies and should be front of mind for all levels of government. For example, projected sea level rises have huge implications for coastal developments and infrastructure, and consequently for planning and zoning schemes and development approval processes. If we are to make the necessary cuts in national greenhouse gas emissions while maintaining landscapes, lifestyles and livelihoods in a warming, drying climate, then Australia's major infrastructure assets around water, energy, transport and construction will need a complete rethink. These issues will need to be handled in a much more integrated way than has hitherto been customary.

Regional NRM bodies would be wise to assume that broader statutory planning frameworks in Australia will be overhauled in the foreseeable future. Anticipating and responding to climate change will be one of the drivers for that to happen. Regional NRM bodies should in theory be well positioned in such a reform process, with a good understanding of potential climate change impacts and prudent responses at a catchment scale, but in practice it pays to be proactive. Regional NRM bodies may need to play a more active role in outlining climate change implications for regional statutory planning and development control processes. Such positioning need not be about trying to enshrine the Regional NRM Plan in statutory frameworks (although many regions may see that as a desirable outcome), but it does offer opportunities to get a better fit between the Regional NRM Plan and other plans and to extend the influence of the Regional NRM Plan into government at all levels. It behoves regions to ensure that local governments and others administering the statutory frameworks are acutely aware of the implications that climate change places upon ecosystems and natural resources and the services they provide. Equally, it behoves regional NRM bodies to be aware of some of the wider implications of climate change and what that means for regional planning processes.

Figure 9 is taken from a 2007 report prepared by an independent working group of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) that looked at regional climate change impacts and adaptation options. It illustrates just some of the many climate change risks identified in that report and the adaptation options available to address them.

Figure 9. Examples of different risks and adaptation options[60]



But what does climate change mean for the Regional NRM Plan itself?

In essence, it boils down to developing a good understanding of the vulnerability of key natural resource assets to climate change, and trying to improve the adaptive capacity of NRM managers and resilience of the region in coping with and responding to climate change impacts. Regions or clusters of adjoining regions should look at the relevant regional studies that have been done already, and think about undertaking work to analyse what those potential impacts might mean for key assets. The vulnerability analysis undertaken by Bardsley for the Mt Lofty Ranges is one example, and the workshop process led by SKM is another.

When key natural resource assets or processes identified in the Regional NRM Plan are assessed as being highly vulnerable to climate change, then regional NRM bodies need to develop appropriate responses. However such responses should not be developed in an ad hoc way for each individual "problem". Such an approach would increase the risk of using resources inefficiently and causing unintended consequences.

While it is important to be able to zoom in on particular assets and explore climate change risks for them in detail, it is equally important to be able to stand back and look at the Regional NRM Plan as a whole. Take some of the worst case scenarios from the climate models as outlined earlier in terms of reductions in water yield, increasing salt concentrations, rising temperatures and increasing drought frequency and intensity and so on. Make some assumptions based on current trends in water use, land clearing, irrigated area, invasive species and so on. Then have a fresh look at the Regional NRM Plan and see how well its implementation would prepare the region to respond to the range of scenarios and manage the associated risks.

All aspects of Regional NRM Plans will need to be re-examined, from the setting of priorities to the identification of management actions, to evaluate how robust they are against climate change scenarios. Do they remain valid in the face of worst-case scenarios, are they consistent with either decreasing sensitivity or increasing adaptive capacity of particular assets to climate change impacts?

As has already been outlined, in many cases for many assets, existing threats such as increasing resource use intensity, poor farming or pastoral practices, invasive species and fire, will remain the main cause of pressures on key natural resource assets. Those pressures may be exacerbated and compounded by climate change, but they won't be replaced by it. The Regional NRM Plan remains appropriate for adapting to and managing climate change impacts, because it provides a framework for integrating a range of responses to a range of pressures across a range of assets, and for managing risk.

This is not to suggest that "business as usual" NRM planning will suffice as an adequate climate change response. As mentioned earlier, and as the scenario planning approach would probably reveal, climate change increases the stakes. It makes it even more important to deliver best-practice NRM, and it renders the system less able to cope with or recover from poor land use and management practices, or over-consumption. Ecosystems or species that are already stressed may become much more so, and less able to recover from drought or fire or disease and so on.

One of the areas where most Regional NRM Plans will need considerable work is in developing the "early warning system" for closely anticipating and monitoring climate change impacts, and for identifying trigger points or thresholds that would stimulate a quick response. An example would be undertaking risk analyses for "sleeper" invasive species and having response plans ready, should particular problem species start to expand their range. Another example would be in keeping a close eye on catchment water yields in relation to water use, particularly when major water-using developments are proposed.

Climate change responses will also present opportunities for regional NRM bodies. There is a significant and growing demand for vegetation offsets, and there is likely to be increasing investment in large scale revegetation activities, as introduced earlier. These have the potential to contribute to many Regional NRM Plan goals, but only if revegetation projects are very carefully planned in terms of spatial location within the catchment and site-level configuration, and only if they are well implemented on the ground. Most Regional NRM Plans will need a finer-grained analysis to identify with precision the optimum location of biosequestration projects to meet multiple Regional NRM Plan objectives as well as absorbing CO_2 and storing carbon.

All of the above anticipation and response measures demand a good information base to underpin detailed planning. This is particularly the case at the catchment, landscape and regional scales. At the farm scale, farmers' intimate local knowledge and experience can compensate to a degree for holes in formal data sets. But at the catchment scale, it is virtually impossible for planners, even with deep local knowledge, to compensate for a lack of base data. If you don't have good basic datasets about the natural resources you are trying to plan for, and you don't have good data about current land uses and management practices, and you don't have the capacity to do decent trend analysis, then you are starting from a fundamentally weak position in planning more sustainable NRM approaches. Moreover, if you don't have good data on who is living in the catchment, how they are making a living and their lifestyle aspirations, the planning process is unlikely to get much traction with the locals. This is particularly the case along the eastern seaboard of Australia which has seen significant demographic change over the last decade[61]. Districts previously (and often still) thought of as "agricultural" now need to be reconsidered, with new planning approaches.

David Brunckhorst and colleagues at the University of New England argue that the watershed boundary is often a very poor match for the "social catchment", and that the two key considerations in working out the most appropriate planning units (especially if you want to get people involved, which will be critical in developing effective climate change responses) are the geographic match with "the community" and the broad homogeneity of the landscape units[62]. In other words, people are more interested in getting involved in planning (and presumably in implementation) for country that is meaningful to them, and of which they feel a part. Indicators like where people shop, where the kids go to school, which football and netball teams they follow, the name of the district or community they identify with, are as important in working out the boundaries of planning units as soil types and drainage basins. This means that point source data, able to be aggregated or disaggregated into any set of polygons according to circumstances, are preferable to data that lose their meaning outside a particular set of boundaries.

It should not be assumed that regional NRM bodies have to undertake all the measures suggested here themselves. Many climate change responses — for example ensuring that appropriate data is being collected and monitored in appropriate ways, or commissioning research, or fixing the planning system — are rightly the responsibility of state or federal government agencies. But regional NRM bodies individually and collectively can create a demand and a market for such responses, and they should think through systematically what they need.

Implementation (on ground investment)

As outlined above, on-ground investment undertaken by regional NRM bodies need not look radically different under climate change scenarios from what we currently regard to be best practice, because the amplitude of current climate variability is already generally greater than the long term shift in the underlying climate signal.

Regions may wish to develop a simple checklist for on-ground works that would help to manage climate-driven risks. Items on the checklist would vary across regions but would essentially revolve around the extent to which on-ground projects improve the resilience of their target ecosystem(s) — i.e. the capacity to withstand and to recover from a severe weather event or a series of very bad seasons — and also the extent to which the on-ground works themselves would withstand an extreme climatic event.

Regional NRM bodies should also practice what they preach by understanding their own carbon footprint and by taking active steps to reduce their own emissions and to offset those that cannot be avoided.

Community education and building capacity for change

Australia enjoys a high level of community awareness of and interest in climate change. However that interest is yet to translate into widespread understanding of and agreement about causes and solutions — which in part reflects the real and considerable uncertainties about the magnitude and timing of climate change impacts.

One of the most valuable things that regional NRM bodies can do in building the adaptive capacity within their regions to handle climate change impacts is to work at a community level, across industries, sectors and communities within their region, to start the essential discussions and debates about this sustainability challenge and what it means. Regional NRM bodies are well placed to bring the community along, to build climate change literacy within their communities. Regional NRM bodies can demystify this large, abstract, complex concept, breaking it down into manageable chunks and doable actions at local level. This may require a reworking of communication strategies and key messages within some regions.

In many ways the situation with climate change now is analogous to the situation with salinity 20-25 years ago. Climate change presents a much more serious and pervasive challenge, but like salinity, it needs to be demystified and translated into responses that are able to be implemented at a local scale. Accordingly, we might do well to look at some of the very successful community education approaches used in the early days of salinity and landcare, like Saltwatch, Waterwatch and Landcare for Schools, and to think about how they could be freshened up and applied to climate change.

Within every region there are scientists, individuals and businesses who are ahead of the game on climate change issues, with a deeper understanding of the challenge and the measures necessary to tackle it. Such people or firms are not necessarily involved in or have even heard of NRM — they might be involved in manufacturing, or the energy sector, or in sustainable transport. That matters little. Regional NRM bodies should seek out local champions and learn from them about what can be done at a local level, building them into their own strategies as appropriate.

Extension

A particular type of community education in which regional NRM bodies are playing an increasingly important role is extension — the deliberate application of non-coercive measures to promote desired changes in practices among farmers and other landholders.

Regional NRM bodies have emerged during an era of rationalisation and out-sourcing of many government services and a broader trend towards a smaller role for government in service delivery. Agricultural extension has changed significantly, in particular the provision of technical advice direct to farmers, with the private sector now providing most technical production advice. However private service providers still have only a modest and patchy presence in provision of conservation advice or development and implementation of sustainable farming practices, reaching only a small proportion of the farming community.

Farming practices like grazing, cropping, clearing and irrigation represent the biggest ecological disturbance on the Australian landscape, with profound impacts on wildlife habitat, water quality and quantity, vegetation cover and soil condition. Accordingly, because they can be modified, they are very powerful ecological levers and represent a huge ecological opportunity. Consequently, encouraging more sustainable farming practices is a high priority for most regional NRM bodies and they have become significant players in extension, filling some of the gaps between the private sector and state agencies.

Climate change creates an even stronger imperative for regional NRM bodies to influence farming systems and practices. As the habitat niches for many species shrink and/or shift, the formal reserves system may become less comprehensive, adequate and representative than it is now, and off-reserve conservation measures will become even more important. Because climate change is still a new and emerging issue for many agencies and companies in both the public and private sectors, it is not being handled well by the agricultural extension system. This represents both an imperative and an opportunity for regional NRM bodies seeking to improve landscape resilience in the face of climate change.

From both a mitigation and an adaptation perspective, regional NRM bodies have a potentially important role in working with industries and governments to promote the development and adoption of measures (farming systems and practices) that avoid, reduce or sequester greenhouse gas emissions; and that are able to anticipate, adapt and respond to climate change in ways that complement broader catchment goals such as biodiversity, river health, water quality and landscape amenity.

In some cases however, mere tweaking of existing farming systems that are already marginally profitable at best and highly vulnerable to poor seasons, will not be an adequate response to the threat posed by climate change — especially in the context of current distorted world agricultural markets that do not reward producers for farming sustainably. Regional NRM bodies will be closer to local social and environmental impacts than state governments, and more technically skilled in the issues than local governments, so there is an important advocacy role in drawing areas of particular climate change vulnerability and risk to the attention of state and federal governments and the wider Australian community.

Further, it is possible in some regions that climate change responses may promote significant land use change. Several state governments are considering mandatory targets for biofuels and ethanol, for example, and some companies have taken out options on land and water to produce ethanol. Regional NRM bodies have a strong legitimate interest in ensuring that emerging land use changes are sustainable across the broad spectrum of NRM issues.

5.2 Climate Change and high performing regional NRM bodies

In analysing how regional NRM bodies can build climate change into their core business, the previous section worked through their generic roles. This section looks through a slightly different lens. It examines the characteristics of high-performing catchment bodies[63] against four key performance indicators: Understanding; Relationships; Positioning; and Governance.

Understanding

Leading regional NRM bodies have a very good understanding of who their clients are, of the demographic trends within their catchment, and of how different stakeholders perceive different NRM issues. They also are tapped in to the best available knowledge — scientific, organisational and local — relevant to the objectives of their regional catchment strategy. They understand sustainable land use options and the detail of best practice measures and factors affecting their adoption. They also understand the full sustainability toolkit including extension, incentives, planning, markets, tenure allocation and regulation. They "mix and match" from this palette according to the objective and the context.

This performance indicator seems to be equally applicable from a climate change perspective. Leading regional NRM bodies will quickly develop a comprehensive understanding of potential climate change implications for their region, drawing on the best available science (and continually updating that understanding) but also drawing on a close feel for the hopes, fears, perceptions and values of their local community as it grapples with this big issue.

In addition to the comprehensive information available through the Department of Climate Change website[64], regions should keep a close eye on Land & Water Australia's Knowledge for Regional NRM project, which is developing an integrated suite of tools designed to help regions find the knowledge they need[65].

Relationships

Leading regional NRM bodies have very good relationships with their key stakeholders — they are understood and valued by key client groups including grassroots community volunteers, landholders and consumers of resources (e.g. tourists), resource-using industries, all tiers of government, and other relevant non-government organisations. Leading regional NRM bodies are seen as adding value by these groups, not as a competitor or a drain on public resources. As a consequence of these good relationships, leading regional NRM bodies are well placed to influence the behaviour of these key stakeholders consistent with implementing the regional catchment strategy.

This also holds equally well in a climate change context. Regional NRM bodies are likely to become significantly more "climate literate" than many of the stakeholders they deal with. Where they have good relationships in place, then other stakeholders are likely to see regional NRM bodies as credible sources of information and advice about responding to climate change.

Positioning

Positioning is closely linked with relationships, in that it is difficult to get one right if the other is askew. Successful regional NRM bodies define and clearly articulate their own role very well. They also do a good job in explaining how those roles relate to the functions of each tier of Government, especially local governments and state government agencies.

Clearly articulating the roles of regional NRM bodies is easier in some states than others, because in several jurisdictions it is formally set out in a specific Act of Parliament. Nevertheless, in ambiguity lies opportunity for the nimble. In jurisdictions with more flexible frameworks, regional NRM bodies have more scope to define their own roles in their own words. This is important, because it is all too easy for regional NRM bodies to be seen as just another layer of bureaucracy, or to become jammed between the planning, zoning, rating, on-ground works and development approval processes of local government; and the policy initiatives, larger scale planning and regulatory approaches of state government.

One of the most effective positioning strategies for regional NRM bodies lies not in how they articulate their roles, but how they perform them. Actions do speak louder than words, and many stakeholders judge regional NRM bodies by how well they invest and manage public funds and community effort. Successful regional NRM bodies are coherent and cohesive in matching their on-ground investments to their Regional NRM Plan and to how they present themselves in their community.

A crucial positioning challenge for regional NRM bodies is that between their own structures and decision making processes, and the efforts of voluntary community groups such as landcare. Leading regional NRM bodies are seen as adding value to the efforts of volunteers by building a more strategic framework and helping them to access resources with minimal bureaucracy, without robbing energy or momentum from the grass roots. This is a difficult balancing act, because a consequence of taking a more strategic approach is that not all popular local projects get up. Yet regional NRM bodies must engage the wider community, and this becomes difficult if some of the people most committed to the objectives of the Regional NRM Plan have been alienated.

Again, climate change will underline the importance for regional NRM bodies of adroit positioning with respect to other community, industry and government stakeholders. The depth and breadth of climate change impacts demand huge, society-wide responses that necessarily involve almost all sectors. So developing and implementing responses to climate change will be a crowded field, with lots of scope for petty turf battles and competition for scarce resources.

Regional NRM bodies are "keepers of the long view" with a mandate to speak for the catchment as a whole and to think about impacts across property or land tenure boundaries or industry sectors. This is a very important perspective in climate change debates.

Governance and risk

Successful organisations are well run. They make a difference and they know what their impact is. They strike a good balance between performance (doing things) and conformance (checking, monitoring and reporting things). Because regional NRM bodies are presiding over significant public funding, good governance is not optional. In the public sector, organisations must be seen to be well run. There are reams of publications about governance available from the Australian Institute of Company Directors[66] and about public sector ethics from the Institute of Public Administration of Australia[67] among others. In essence it is about getting a good alignment between strategy, people, finance, risk management, compliance and audit, and instilling a culture of ethical governance throughout the organisation, backed up by robust systems.

Some particular issues to watch in community-based organisations involving highly committed volunteers who often have a high level of relevant expertise, include:

- maintaining clarity around and respect for the distinct roles of the Board, CEO and management;
- developing clear codes of conduct, and sound and transparent mechanisms and processes for anticipating and managing perceptions of conflicts of interest in funding decisions; and
- developing and maintaining clear reporting, risk management and audit frameworks.

Risks associated with climate change impacts should be foremost in the minds of all company directors, and especially board members of regional NRM bodies. The generic risk management framework applied in many organisations in the public and private sectors involves systematically identifying internal and external factors that could adversely affect the business, and evaluating each of them in terms of the probability or likelihood of the event occurring, and the consequences for the organisation if it did. These likelihood and consequence scores are then combined to get an overall risk rating for that risk. High risks demand a detailed risk management strategy and close monitoring of the control regime. As mentioned earlier, the Department of Climate Change has developed specific resources to assist organisations to apply a risk management approach to climate change[68] and the Prime Minister's Science, Engineering and Innovation Council has produced an informative overview[69] of climate change risks for regional Australia.

6. CONCLUSION

Climate change poses enormous challenges for Australia, which will be among the countries most affected by global warming.

Climate change will reach into all aspects of natural resource management in Australia, intersecting with other issues in multifaceted ways. Consequently, adapting to climate change needs to be high on the agenda for Australian regional NRM bodies.

A warming, drying, more variable climate with more extreme weather in most regions will increase the imperative for best practice regional natural resource management approaches. However while it raises the stakes, climate change does not fundamentally change the game for most assets in most regions.

For the moment, risk management and current best practice regional NRM provide a good basis for climate change adaptation, recognising the uncertainties and knowledge gaps regarding the timing, magnitude and distribution of climate change impacts. Climate change needs to be considered in the regional NRM context rather than as a stand alone issue. Climate change adaptation strategies need to be interwoven throughout the planning, investment, monitoring and evaluation activities of regional NRM bodies.

In other words, climate change adaptation is core business for regional NRM bodies.

This primer has attempted to work through the sorts of considerations that regional NRM bodies will need to explore in order to develop their own approaches to climate change in individual regions. It points to some ideas and resources for further support and information, and hopefully will assist in making what can seem an overwhelming issue somewhat more tractable for regional NRM bodies.

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