NORTH CENTRAL CLIMATE CHANGE ADAPTATION AND MITIGATION PLAN

DECEMBER 2015

Australian Government

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

/northccma @northcentralcma

This Plan has been prepared for the North Central CMA and the Plan's Steering Committee by Mal Brown, Scarlet Consulting Australasia, and Geoff Park, Natural Decisions Pty Ltd

Version December 2015

Acknowledgement of Country

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal people and organisations in the management of land and natural resources.

Document name: North Central Climate Change Adaptation and Mitigation Plan 2015-2018

North Central Catchment Management Authority

PO Box 18 Huntly Vic 3551
T: 03 5448 7124 F: 03 5448 7148

E: info@nccma.vic.gov.au
www.nccma.vic.gov.au

Abbreviations

ACF	Australian Conservation Foundation
AR5	IPCC Fifth Assessment Report
BCG	Birchip Cropping Group
BoM	Bureau of Meteorology
CFI	Carbon Farming Initiative
CMA	Catchment Management Authority
CMIP5	The fifth phase of the Coupled Model Intercomparison Project (World Climate Research Programme)
CoGB	City of Greater Bendigo
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVAF	Central Victorian Agribusiness Forum
CVGA	Central Victorian Greenhouse Alliance
DELWP	Department of Environment, Land Water and Planning
GHG	Greenhouse Gases
GMW	Goulburn Murray Water
GWM Water	Grampians Wimmera Mallee Water
IPCC	International Panel on Climate Change
ISC	Index of Stream Condition
IWC	Index of Wetland Condition
MDBA	Murray Darling Basin Authority
MER	Monitoring Evaluation and Reporting
NGO	Non-Government Organisation
NRM	Natural Resource Management
R&D	Research and Development
RCP4.5 and RCP8.5	Representative Concentration Pathways
RCS	Regional Catchment Strategy
VNPA	Victorian National Parks Association

EXECUTIVE SUMMARY

Land managers and the wider community in the North Central Catchment Management Authority (CMA) region (referred to in this plan as the North Central region) are no strangers to the effects of climate change and climate variability. In recent times they have experienced major climate events including the Millennium drought and the 2010/11 floods. While the floods caused major damage in some areas they also brought significant benefits to biodiversity, especially in our rivers and wetlands.

These events send a strong signal that we need to prepare now if future climate change projections for the region are realised. Such events in the future wil impact significantly on the environment, economy and community.

In order to better prepare for the future challenge of climate change the North Central CMA, with funding from the Australian Government, has worked with partner organisations to develop a regional climate change adaptation and mitigation plan.

The plan aims to:

- Incorporate climate change adaptation and mitigation approaches in future planning
- Guide where bio-sequestration projects should be located in the landscape to maximise the benefits for biodiversity, water and agricultural production
- Identify priority landscapes for carbon plantings and strategies to build landscape integrity and guide adaptation and mitigation actions to address climate change impacts on natural ecosystems.

Protecting the natural assets of the region from the current climate change projections will require an integrated and coordinated effort from government, the broader community and in particular land managers.

Climate Change Projections

The CSIRO and the Bureau of Meteorology (BoM) released climate change projections for Australia that provide updated national and regional information on how the climate may change to the end of the 21st century (CSIRO, 2015).

The detailed projections help inform the impact assessment and planning required in the natural resource management sector. A summary of the projected changes in climate are outlined in Table E1.

Regional Catchment Strategy and Climate Change

This Plan is a sub-strategy of the Regional Catchment Strategy (RCS) and considers how best to protect the region's high priority natural assets in the face of a climate that is likely to be warmer, drier and more variable in the future. The Plan will support the implementation of the RCS and coordinate effort by landholders, partner organisations and the wider community to enable improved adaptation and mitigation responses to climate change.

***Table E1** Climate projections for the North Central region (CSIRO and BoM, January 2015)*

Climate projections for the North Central CMA region	Level of confidence
Average temperatures will continue to increase in all seasons	Very high
More hot days and warm spells	Very high
Fewer, but possibly damaging, frosts	High
By late in the century, less rainfall during the cool season	High
Rainfall will remain unchanged in the warm season	Medium
Even though mean annual rainfall is projected to decline, heavy rainfall intensity is projected to increase	High
A harsher fire-weather climate in the future	High

About the Plan

This Plan is the product of strong scientific and technical input, and wide community and stakeholder engagement.

It draws on:

- The most recent climate change projections
- Review of Australian and international literature on climate change impacts, opportunities and adaptation options
- A vulnerability assessment for natural assets
- An assessment of the impacts of climate change on existing threats.

This Plan has been developed to identify options for climate change adaptation and mitigation for the region's natural assets.

An intergenerational planning timeframe has been used, looking out beyond 2050, to examine the potential issues and opportunities arising from climate change on the natural assets of the region.

Drawing on recent research and investigation as well as local knowledge has provided a strong platform on which to assess adaptation options and mitigation responses to asset vulnerability and the socio-economic factors relevant to the North Central region.

Landholder participation in field days and farm walks provides the opportunity to share knowledge about adapting to climate change.

Flooding on farm land, January 2011.

Climate Change projections and threats to the natural environment

Climate change will continue to affect the natural environment in a variety of ways. Rivers and wetlands will be impacted by changes in the available water quantity (drought, flood, rainfall intensity and the subsequent rate of surface runoff) and also the quality of the available water resource. Water storages and regulated flows can be managed to mitigate some of these effects.

Climate change will affect native flora and fauna in complex and often unpredictable ways. Current threats to biodiversity, including the impact of habitat loss, weeds, pest animals and drought, are expected to intensify. The more vulnerable ecosystems in the region are areas that are vulnerable to moisture stress and increased risk of bushfires.

Species that have survived previous climatic changes have done so by evolving, changing their behaviour, taking refuge in local areas that are buffered from the changes, or moving to areas where the climate is more suitable. Native plants and animals might find it more difficult to use these coping strategies when the change is rapid, especially where their habitat has been degraded, isolated or lost. Climate change won't cause all species to decline. However, changes in climate could lead to new opportunities for the establishment of invasive species, such as weeds and pest animals, as well as some native species.

In developing the Plan a key focus was on identifying and assessing practical, flexible and feasible adaptation options for land managers and communities. Options focused on improving the adaptive capacity of natural assets are described in Table E2.

Table E2 *Adaptation options for each broad type of natural asset assessed against climate change variables.*

ADAPTATION OPTIONS	Reduced and more variable rainfall	Increased temperatures, and extreme heat	Increased intensity and frequency of rainfall events (including flooding)	Increased frequency and intensity of fire
Rivers and floodplains	Increase extent of riparian vegetation. Improve connectivity of corridors to provide shading of rivers. Provide environmental flows. Protect summer base flows (regulation of timing / magnitude of extraction).	Protect refuge areas for fish and aquatic fauna in conjunction with pest species programs. Establish riparian vegetation. Restore in- stream habitat. Control competing aquatic species (plant and animal).	Maintain groundcover in strategic areas. Support geomorphic recovery through works (vegetation and structural). Manage flashy surface water inflows in urban / agricultural environments (swale drains and constructed wetlands). Explore large-scale floodplain restoration to buffer against flooding.	Focus fuel reduction burning to protect vulnerable/fire sensitive vegetation along rivers and floodplains. Plan to mitigate the potential impacts of fuel reduction burning and wildfire on sediment/ pollutant runoff to rivers.
Wetlands	Remove existing artificial barriers or lowering 'commence to fill' levels. Explore opportunities to deliver water to isolated wetlands through irrigation infrastructure. Prevent disturbance to those wetlands subject to over grazing or land use intensification/ cropping.	Control weeds and pests to improve condition and adaptive capacity. Improve connectivity between wetland habitats. Establish buffers of native vegetation and reinstate wetland vegetation.	Reinstate, where possible,natural hydrology to allow for movement and retention of floodwaters. Manage 'flashy' surface water inflows in urban / agricultural environments (swale drains and constructed wetlands).	Focus fuel reduction burning to protect vulnerable/fire sensitive vegetation around wetlands. Consider fire management in wetland planning.
Biodiversity	Protect high quality remnants as reservoirs of regeneration potential. Control weeds to improve quality and condition. Use and range of seed provenances in revegetation programs to maintain/extend genetic diversity. Plan and implement revegetation activities to better match local and seasonal climatic conditions. Improve connectivity through targeted revegetation and remnant management. Actively manage to reduce threats (e.g. over grazing) on existing remnants. Develop and integrate productive tree (and perennial vegetation) systems, including farm forestry, that provide significant benefits in terms of carbon sequestration, run-off, watertable control and water quality.		Increase extent and connectivity of riparian and floodplain vegetation to reduce impact of extreme events. Where appropriate, promote natural regeneration in riparian and floodplain environments.	Match burning / fire regimes to tolerable fire intervals. Identify and protect ecosystems with high sensitivity to fire.
Soils	Change soil management practices that reduce compaction (minimum tillage, and retain stubble. Change to rotational grazing in order to increase soil carbon and improve water retention. Increase on-farm water storage capacity. Increase irrigation efficiency and re-use where applicable. Spread production over a range of areas within the region to different irrigation or rainfall zones. Adopt new varieties more tolerant of water stress. Change crops to more water efficient varieties.	Provide shelter and shade from extreme heat, through vegetation establishment or use of shade structures. Provide sheltered watering points. Trial new pasture and crop varieties. Increase groundcover through grazing management. Shift joining time to avoid birth and lactation during summer periods.	Improve and increase flood warning systems. Maintain groundcover to mitigate against erosion. Adopt alternative grazing strategies. Consider timing of planned burns and risk of rainfall events / flooding to reduce downstream impacts. Use cover crops to protect paddocks at time of high flood risk.	Implement on-farm strategies to protect assets (e.g. firebreaks), fuel reduction burning on freehold land. Purchase additional insurance. Develop property level fire management plans. Increase control of invasive plants and animals after fires.

Region-wide

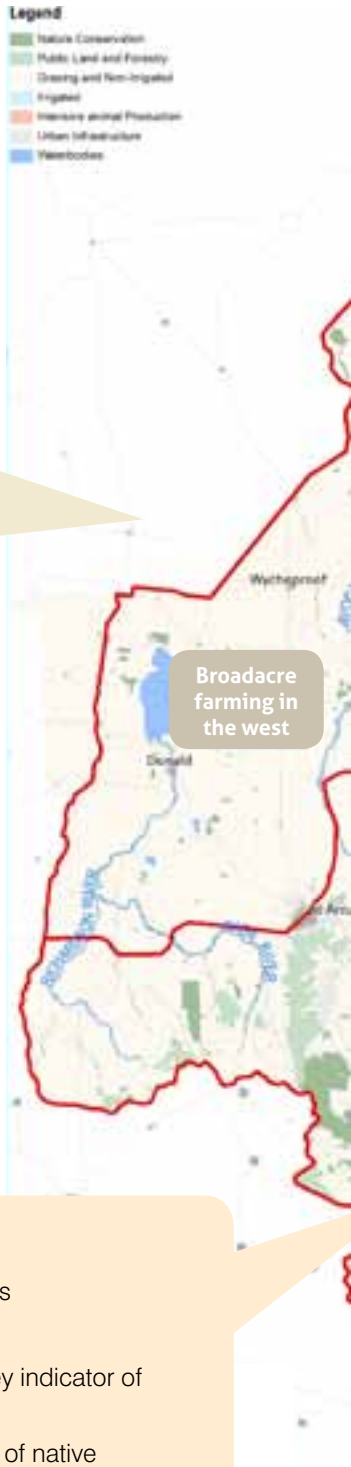
Strategic options:

- Extension: Technology transfer, education, communication, demonstrations, support for community networks with a focus on land managers
- Incentives: grants and direct financial support
- Research and development: Development of improved land management options
- Planning Instruments: working with local government and responsible authorities
- Knowledge brokering: coordination of information provision and delivery across agencies and institutions
- Capacity building: support for increased community participation and involvement.

Broadacre farming in the west

Strategic options:

- Support adaptation of agricultural enterprises through a range of tools that may include extension, incentives and trials
- Work with R&D sector to develop improved crop varieties for use in this area
- Use water from the Wimmera Mallee pipeline for intensive agriculture
- Adopt low input and low risk grazing systems for both productivity and conservation
- Increase the summer dominance of the grasslands by strategic grazing
- Explore the modification of floodplain infrastructure to reinstate more natural hydrology where feasible
- Allow large-scale natural regeneration on the floodplain for carbon storage
- Explore the use of drier country species into the existing Red Gum system (e.g. Black Box, Eumong) through strategic revegetation
- Establish farm forestry plantations for firewood, carbon storage, bioenergy etc
- Support strategic purchase of properties or management rights for conservation benefits (and use local management) in collaboration with NGOs such as Trust for Nature, Bush Heritage.

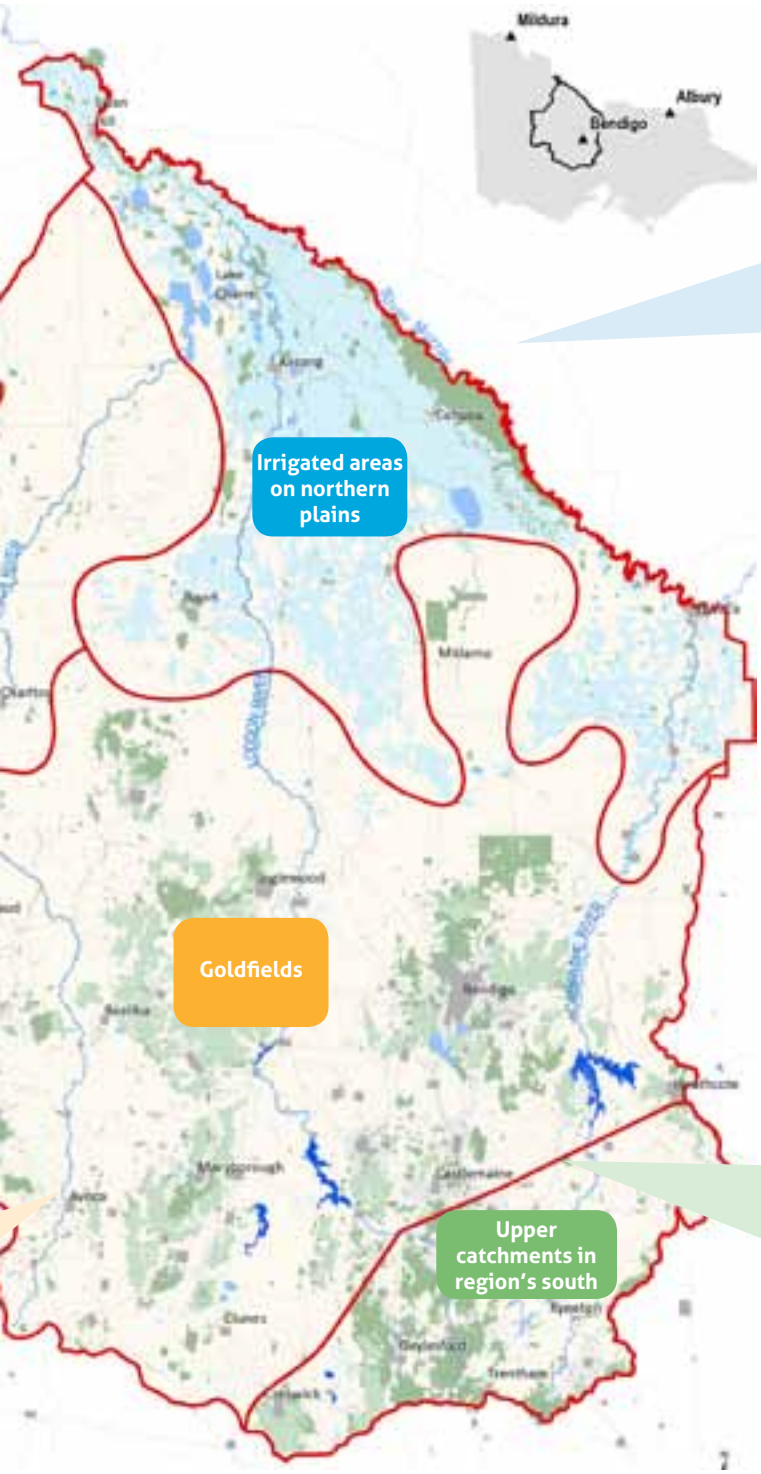


Goldfields

Strategic options:

- Implement a property planning and education program (with a sustainability focus) for landowners
- Enable an ecological thinning program on both public and private land
- Implement a scientifically rigorous, biodiversity monitoring program using woodland birds as a key indicator of ecosystem health
- Implement an on-ground restoration program that achieves connectivity and increases the extent of native vegetation
- Include some drier climate species and wider genetic material of existing species in revegetation programs
- Put stricter controls on development in bushland areas or adjacent to public land
- Support the risk based approach to prescribed burns to protect the community and natural assets
- Manage grazing pressure along rivers to protect the riparian zone
- Support the development of mechanisms in local government planning schemes and the Victorian Planning Provisions that identify and enable strategic biolinks
- Implement large-scale carbon sequestration across the landscape.

Figure E1 *- Map of the North Central region's broad strategic areas for applying climate change adaptation and mitigation options.*



Irrigated areas on northern plains

Strategic options:

- Support initiatives to improve water security for irrigators whilst protecting flows for environmental outcomes
- Support adaptation of agricultural enterprises through extension, incentives and trials
- Support initiatives to improve on-farm water security (groundwater and surface water) and improve the environmental outcomes for wetlands
- Build or modify infrastructure to manage regulated or unregulated flows of water into the wetlands
- Opportunities for farm forestry, carbon planting on non-irrigated land
- Develop a set of protocols for how the wetlands may be adaptively managed, recognising that their values might change under a future climate
- Implement a knowledge sharing program focused on best practice grazing management of the wetlands (recognising stock need water)
- Implement a Farming Systems program for all farmers in the area based on preparedness for the projected climate change scenario (e.g. new variety trials).

Upper catchments in region's south

Strategic options:

- Support programs that aim to reduce fire risk to communities and natural assets across public and freehold land
- Introduce codes of practice that reduce demand for water and support self-sufficient water use (both agricultural and semi-urban properties)
- Establish large-scale carbon sequestration by planting biodiverse plantations/trees on poorer soils or along the riparian zone. Examine drier country species for inclusion in the plantings
- Identify and protect existing biodiversity hotspots and refugia
- Examine the groundwater resources available to secure a future water supply
- Implement an incentive program to stabilise soils on agricultural land in water supply catchments.

Implementation, Monitoring, Evaluation and Reporting

The existing Monitoring Evaluation and Reporting (MER) component of the RCS implementation planning framework describes how the implementation will be monitored and how the effectiveness of the contribution of the management actions towards the land and water resource objectives of the RCS will be assessed. The MER process also provides a consistent basis for communicating implementation results to stakeholders and funding investors.

Supporting mitigation - carbon plantings and connectivity

Revegetation efforts by land managers, Landcare and community groups over recent decades have already made a significant contribution to increasing carbon stores, creating new habitat and protecting land and water assets. This together with active natural regeneration, especially through the Goldfields bioregion, is already mitigating climate change.

Future impacts on biodiversity under a warmer, drier climate will pose additional challenges and be felt at local and regional scales. Rebuilding connected, functioning landscapes and maximising the benefits provided by areas of high habitat value, will require further strategic linkages to be established across the region. These linkages will have benefits for local wildlife, for example woodland birds, support the movement of migratory species, and importantly provide a refuge for species impacted by the effects of climate change in areas beyond north central. They will also improve the resilience of riparian and terrestrial habitat and contribute to supporting essential ecosystems services.

The region's rivers are particularly important for future connectivity options, largely because of their existing intact riparian vegetation.

Wildlife corridors can help conserve biodiversity and strengthen landscapes in the face of climate change. They also help insure against climatic uncertainty through the conservation of a diversity of species and provision of alternative pathways for species' movement and adaptation. Naturally connected landscapes and ecosystems are generally healthier and can store carbon more effectively than degraded landscapes.

Climate adaptation – the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, or to cope with the consequences.

Climate change mitigation – efforts to reduce or prevent emission of greenhouse gases. Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour.

It can be as complex as a plan for a new city, or as a simple as improvements to a cook stove design. Initiatives underway around the world include planting trees; energy efficient housing, lighting and appliances; and adoption of renewable energy.

Supporting communities to adapt

Adaptation is already happening on many levels – land managers and communities have been responding to drought, flood and fire through a range of actions that minimise future risk, improving water security and conserve high value agricultural soils. The work of many Landcare and community groups to buffer remnant vegetation and improve landscape connectivity is supporting adaptation of natural assets though improved participation and coordinated action.

Five broad areas have been identified where similar options apply because of generally similar land use and sociodemographic factors in the area. The strategic adaptation options are described as those that apply to the:

- Region
- Upper catchments in the region's south
- Goldfields
- Irrigated areas on the northern plains
- Broadacre farming systems in the west.

The options outlined here have been identified to support existing programs and initiatives of the Regional Catchment Strategy, but with a view to longer-term 'climate proofing' of the region's most valuable natural assets.

The plan promotes the development of improved land management options that maintain and improve the natural asset base under future climate change, including extended periods of reduced rainfall and extreme climatic events.

The Way Forward

The options outlined below are a selected subset from the Plan that have been identified as immediate priorities for implementation. A Coordinating Group will oversee implementation of the Plan. (This group will show leadership on climate change adaptation and mitigation, share knowledge and facilitate collaboration between key organisations working to protect and enhance the region's highest priority natural assets).

	Region-wide	Upper catchments in the south of the region	Goldfields	Broadacre farming in the west	Irrigated areas on the Northern Plains
Strategic Options	**Research and development:** Develop improved land management options that maintain and improve the natural asset base under future climate change, including extended periods of reduced rainfall and extreme climatic events. **Knowledge brokering:** Coordinate information provision and delivery across agencies and institutions. North Central CMA to play the lead role in the provision and integration of climate related information across the NRM sector. **Capacity building:** North Central CMA to continue providing support for increased community participation in NRM and asset protection under a variable and changing climate.	Support programs that reduce fire risk to communities and natural assets across public and freehold land by: • Working in partnership with key fire management agencies • Utilising best available scientific and expert knowledge to aid evidence based decision making. Improve land use in water supply catchments to secure both water quality and quantity. Identify and protect existing biodiversity hotspots and refugia, including the use and application of available biodiversity mapping and local knowledge.	Explore the benefits of ecological thinning as a future vegetation management option in response to climate change. Implement a scientifically rigorous, biodiversity monitoring program using woodland birds as a key indicator of ecosystem health. Implement an on-ground restoration program that achieves connectivity and increases the extent of native vegetation.	Work with R&D sector to develop improved crop varieties for use in this area. Increase the adoption of low input and low risk grazing systems for both productivity and conservation. Establish farm forestry plantations for firewood, carbon storage, bioenergy etc.	Support initiatives to improve on-farm water security and improve the environmental outcomes for wetlands. Build or modify infrastructure to manage regulated or unregulated flows of water into the wetlands. Implement a Farming Systems program for all farmers in the area based on preparedness for the projected climate change scenario.
Key Action(s)	Commencing January 2016 convene a coordinating group comprising key agencies and other relevant stakeholders. Host an annual forum and share the latest knowledge of climate change science and agency activity in this space. Liaise with key statewide and national agencies (CSIRO, BoM) to ensure best use of available data and knowledge. Conduct regular consultations with landholders across the region to understand current perceptions and behaviours in climate related land and water management – as they relate to management of risk. Identify joint project opportunities that both mitigate against climate change and meet the aspirations of Traditional Owners and aboriginal people.	Develop and implement an Integrated Catchment Plan for the Upper Coliban catchment. Coordinate the provision of a citizen science program that makes biodiversity information more widely available, maps biodiversity assets at risk under future climate scenarios, and communicates about how to implement management options for these assets.	Liaise with Parks Victoria to understand the impacts of a recent ecological thinning trial program to inform future vegetation management options. Convene an expert workshop to: • Share knowledge and understanding of past work on ecological thinning (including results of monitoring) • Explore the feasibility of undertaking an expanded trial of ecological thinning on public and private land in collaboration with State agencies and research institutions. Support community networks and NGOs (eg Connecting Country, Birdlife) to share information on the status and trends of woodland bird populations.	Undertake an economic analysis of the adoption of low input and low risk grazing systems for both productivity and conservation. Compare with conventional high input systems. Use ADOPT, Public Private Benefits Framework and peer reviewed ecological models/ frameworks to evaluate specific options.	Continue to deliver environmental water to priority wetlands, and explore opportunities to provide e-water to other wetland systems. Seek funding to explore a Joint Management Model (involving Parks Victoria and local land managers) for the Kamarooka wetlands, and document the learnings that arise.

1 ACKNOWLEDGING THE REGION'S TRADITIONAL OWNERS

The North Central Climate Change Adaptation and Mitigation Plan aims to identify priority landscapes for carbon plantings and strategies to build landscape integrity and guide adaptation and mitigation actions to address climate change impacts on natural ecosystems.

The Plan also aims to use best available information and to develop actions that are based on collaboration with government, community and other stakeholders.

The region's Traditional Owners have significant experience to contribute to both natural resource management and climate change adaptation and mitigation. The Plan is consistent with existing 'Whole of Country' plans developed by Aboriginal Corporations.

Australia's Aboriginal people have lived and prospered for at least 50,000 years, adapting to continual climate variation and ecosystem change, with around 250 nations spread across the continent before the arrival of Europeans. Consequently, Aboriginal people played, and continue to play, a critical role in shaping the natural landscape.

The North Central region is home to a number of Traditional Owners including the Dja Dja Wurrung, Taungurung, Yorta Yorta, Wadi Wadi, Wamba Wamba and Barapa Barapa peoples.

Aboriginal peoples have an obligation under their traditional law and custom to protect, conserve, and maintain the environment and the ecosystems in their natural state to ensure the sustainability of the whole environment.

The Aboriginal people of the region possess distinct legal, cultural and customary rights and responsibilities including:

- a spiritual connection to the lands, waters and natural resources of the region
- management of significant sites and stories associated with the water and natural resources located in the rivers and their tributaries
- protection of Aboriginal cultural heritage and knowledge
- access to cultural activities such as hunting and fishing, and ceremony.
- Recognition and Settlement Agreement [1]

Although Aboriginal people have successfully adapted to climate variation over many generations, climate change presents a unique risk to the livelihoods of the region's Aboriginal peoples. As the region becomes hotter and drier, Aboriginal peoples face the loss and degradation of the lands, waters and natural resources they have relied upon for generations.

It also poses a major threat to the physical health of Aboriginal communities and their ability to sustain their traditional life, languages, cultures and knowledge.

Aboriginal traditional knowledge, land management and conservation practices can play an important role in responding to climate change, maintaining biological diversity and preserving important ecosystems.

For generations, the environmental assets, particularly rivers and wetlands within the region, have supported and nurtured Aboriginal people. These environmental assets provide Aboriginal people with vital resources including plants, animals, water, minerals and stone, and sustain a lifestyle that not only services basic needs such as food, clothing, tools, medicine, housing and heating, but also a rich cultural life with jewellery, ornaments, transport, mythology, art and crafts.

This plan recognises that whilst important economically, wild plants and animals have cultural importance in contemporary identity building and exploitation of the wild food network presents important opportunities for Aboriginal people.

The plan is also an important regional document that provides the mechanism for exploring collaborative approaches that involve a high degree of inclusive participation and youth through generational engagement leading to greater Traditional Owner connection to country, improving the chances of enhancing the adaptive capacity of individual and collective Aboriginal people.

[1] Negotiated between the State of Victoria and individual Traditional Owner representative groups under under s 4 of the *Traditional Owner Settlement Act 2010* (Vic). As example, Dja Dja Wurrung Recognition and Settlement Agreement, 2013.

2 INTRODUCTION

Guide to Chapter

The North Central region is home to a diversity of natural environments including the Loddon and Campaspe Rivers, Box-Ironbark forest and woodlands, iconic River Red Gum Forests and Riverine Plain grasslands. These habitats contain significant biodiversity, including many endangered flora and fauna species. The North Central region also supports a diverse and productive agriculture sector consisting of irrigation to the north, cropping, grazing and mixed farming to the west and south (North Central CMA, 2013). The management and protection of these important environmental values is guided by The North Central Regional Catchment Strategy developed in 2013.

In March 2015 the Intergovernmental Panel on Climate Change (IPCC) released its Fifth Assessment Report (AR5). This report states *"Human influence on the climate system is clear, and recent anthropogenic emissions of green-house gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems"*. (IPCC AR5, 2015)

The Australian Government has funded the development of a plan to identify options for climate change adaptation and mitigation linked to The North Central Regional Catchment Strategy. The planning process has used a long term planning timeframe to examine the potential issues and opportunities arising from Climate Change on the natural assets of the region. The plan has been developed in conjunction with the community and regional stakeholders and has used recent investigations and climate science data and reports.

2.1 Purpose and planning context

Development of this Plan has been guided by a set of principles (see Appendix 1) established by the Australian Government for the NRM Planning for Climate Change Fund. The aims of this Plan are to:

- identify priority landscapes for carbon plantings and strategies to build landscape integrity and guide adaptation and mitigation actions to address climate change impacts on natural ecosystems
- ensure the planning process is logical, comprehensive, and transparent
- use best available information to develop actions that are based on collaboration with government, community and other stakeholders.

The Plan draws on recent research and investigation as well as local knowledge which have provided a strong platform on which to assess adaptation options and mitigation responses to asset vulnerability and the socio-economic factors relevant to the North Central region.

The Plan has been developed within the context of federal and state policy around climate change and natural resource management (see Appendix 1).

The North Central CMA has prepared this complementary climate change adaption and mitigation plan as a sub-strategy of the Regional Catchment Strategy.

2.2 A Partnership Approach

This Plan aims to identify strategies and options for adaptation and mitigation for both public assets and freehold land managers. It will be implemented as a sub-strategy of the Regional Catchment Strategy, through established partnerships and implementation arrangements with:

- Agencies with direct water management, land management or other relevant legislated responsibilities
- The regional community
- Other stakeholders such as non-government organisations, Landcare, Traditional Owners and other community groups.

Roles and responsibilities for adaptation and mitigation align with existing statutory obligations and arrangements for the management of natural assets. That is, government and government agencies are responsible for managing the impacts to, and adaptation responses for, public assets and providing leadership for adaptation and mitigation through appropriate policy and programs, regulation, science and information. Table A3.1 in Appendix 3 outlines the roles and responsibilities of the region's natural resource management stakeholders in climate change adaptation and mitigation.

Adapting and Mitigating against climate change will be a huge challenge for the North Central region and will require a strong partnership approach from governments and the community.

2.3 The North Central Catchment Management Authority

The North Central Catchment Management Authority (CMA) is the lead natural resource management (NRM) agency in north central Victoria, delivering programs in partnership with communities and other agencies to protect and enhance the integrity of the region's four river catchments.

The Authority creates value for communities and the environment by partnering with landholders, community groups, volunteers, agencies and research institutions to deliver a range of services and responsibilities that help to protect and enhance the region's natural assets, including rivers and floodplains, wetlands, soil and biodiversity.

2.4 Regional Catchment Strategy

A Regional Catchment Strategy (RCS) is required for each of Victoria's ten CMA regions under the *Catchment and Land Protection Act (1994)*. The 2013-19 North Central RCS provides the long-term vision for natural resource management (NRM) within the North Central CMA region (North Central region). The RCS sets regional priorities for the management of natural assets, sets overall direction for investment and coordination of effort by landholders, partner organisations and the wider community. It is the primary planning framework for land, water and biodiversity management in the North Central region. The current North Central RCS integrates regional priorities with relevant state and federal legislation and policies regarding NRM. It strives to achieve regional outcomes that will contribute to national NRM targets.

Although the North Central RCS identified climate change as a key threat, it was not able to deal with the issue of climate change in any detail due to a lack of information and knowledge. The evidence of climate change (IPCC, 2015) and the climate change projections for the region (CSIRO, 2015) demonstrate a clear need for this climate change adaptation and mitigation plan.

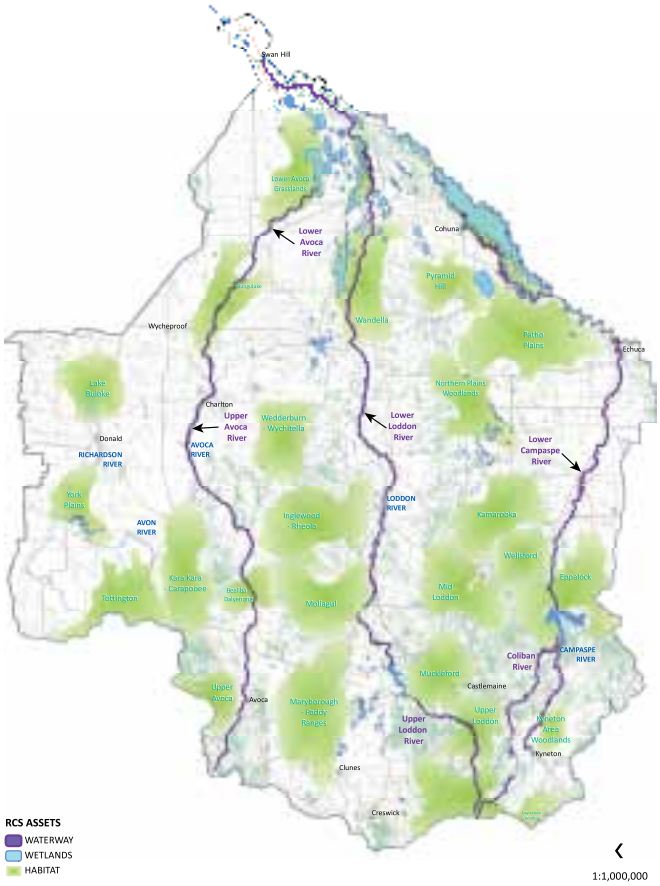


Figure 2.1 *Regional Catchment Asset Priorities map. For a more detailed version of this map see Page 22.*

2.5 About the North Central region

The North Central region covers about three million hectares or 13 per cent of Victoria. It is bounded by the Murray River at its northern edge, Mt Camel Range to the east and the Great Dividing Range to the south and the western boundary of the Avon-Richardson catchment to the west.

The region spans a number of local government areas, incorporating the Loddon Shire, Mount Alexander Shire, Central Goldfields Shire, Hepburn Shire, most of the Gannawarra Shire, City of Greater Bendigo and Campaspe Shire. The northern part of the Northern Grampians Shire, southern part of the Buloke Shire and parts of the Pyrenees Shire, City of Ballarat, Macedon Ranges Shire and Swan Hill Rural City also lie within the region.

Demographics

The region has a population of over 240,000 people, concentrated in the growing regional hub of Bendigo, and townships of Castlemaine, Maryborough, Kyneton, Woodend, Echuca and Swan Hill. The southern part of the region is a popular lifestyle choice for “tree-changers” with the annual population growth projected to continue at almost 50 per cent greater than the average for regional Victoria.

The more densely populated parts of the region are located along the Calder Highway corridor and along the Murray River. The less populated parts of the region are to the north and west where the majority of large broadacre farming operations are located. These more sparsely populated areas continue to experience a decrease in population as farms consolidate and grow larger.

As population shifts continue across the region we will see increased pressure on natural resources where the population is growing. Where the population is declining the ability of people and communities to respond to a changing climate will pose future challenges.

The North Central region is one of Australia’s most highly cleared and fragmented landscapes.

The vulnerability of natural assets and communities will give rise to different capacities to respond to changes in climate across the different densities of human settlements.

Climate

The annual rainfall varies across the region from 300 millimetres (mm) in the north-west to over 1200 mm in the south-east. Temperatures to the south often fall below 1°C during the winter months while to the north regularly reaches above 40°C in summer.

Agriculture

The North Central CMA region is agriculturally diverse. Horticulture and dairying in the irrigation area, and dryland farming - particularly grain cropping and livestock grazing - are the main enterprises.

In the north of the region the efficient use of irrigation water continues to drive population and economic growth. The Loddon/Campaspe irrigation area supports dairy, mixed farming and horticulture. In the southern area, particularly near major population centres, traditional agricultural pursuits are giving way to smaller enterprises and rural living zones. While many profitable farms remain south of Bendigo, this transition is being driven by increased land amenity values, which in most cases exceed the primary production capacity of the land.

Environment

Approximately 13 per cent of the North Central CMA region is public land. The region’s rich natural assets have been reserved as regional and national parks, internationally significant wetlands, flora and fauna reserves and reference areas from the gold-mining era.

The region supports many significant and important natural assets ranging from internationally recognised wetlands, such as Gunbower Forest; regionally important river systems such as the Loddon, Campaspe, Avoca and Avon-Richardson rivers; rare and threatened species such as the McIvor Spider-Orchid and the Eltham Copper Butterfly; and the iconic Box-Ironbark forests and woodlands of Central Victoria.

The Campaspe, Loddon, Avoca and Avon-Richardson rivers and their associated floodplains are diverse and complex ecosystems that support a diversity of native flora and fauna. Rivers provide drinking water to many towns, along with supporting substantial rural and agricultural production.

The internationally recognised Gunbower Forest and Kerang Lakes are listed under the Ramsar convention, and are included as bird breeding sites protected under international agreements. Thirty-six natural features in the region are included on the Register of the National Estate.

3 APPROACH

Guide to Chapter

3. Approach

This Plan is the product of strong scientific and technical input, and a wide community and stakeholder engagement process. It is therefore a pragmatic approach to climate change adaptation and mitigation for the North Central region.

This Plan draws on:

- The most recent climate change projections
- Review of Australian and international literature on climate change impacts, opportunities and adaptation options
- A vulnerability assessment for natural assets
- An assessment of the impacts of climate change on existing threats
- Application of the adaptation pathways planning approach
- Input from local natural resource managers and landholders.

The process to develop the Plan brought together science and research, as well as local knowledge and experience. Planning was completed over a number of stages (see Figure 3.1), including community, stakeholder and technical workshops, along with regular Project Steering Committee meetings, that assisted in identifying the challenges and opportunities associated with future climate.

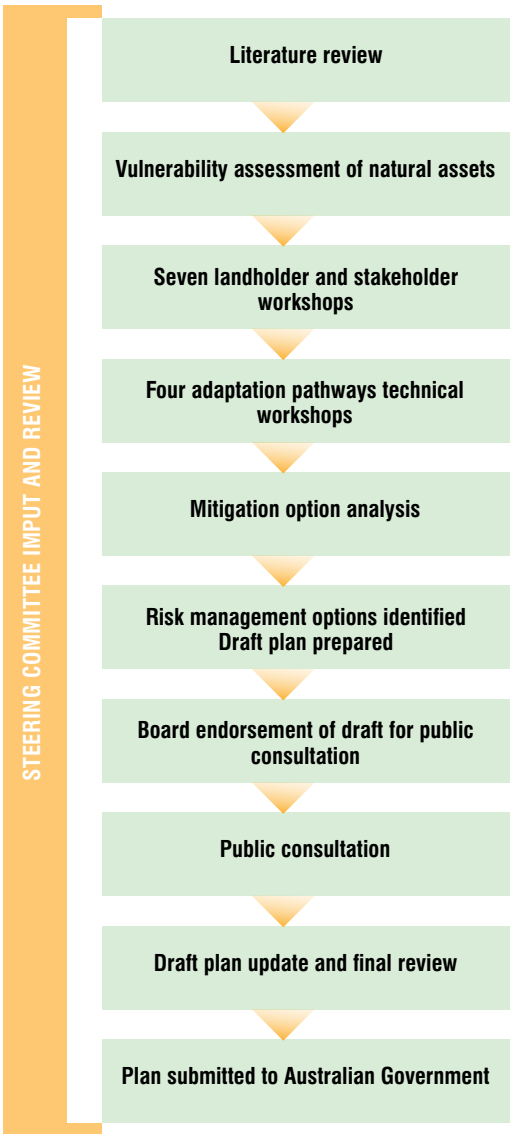


Figure 3.1 *Approach to developing the North Central region's Climate Change Mitigation and Adaptation Plan, including opportunities for managing risk.*

3.1 Climate Change Projections

The most up- to-date climate projections available were used for this Plan. These projections were released by CSIRO in March 2014 and made available for use in NRM planning for climate change projects. The data provided included projected climate changes (relative to the reference period 1986-2005), based on 'CMIP5' global climate models, judged to perform well over Australia. Subsequent to the planning process revised climate data has been made publicly available by CSIRO (Climate Change in Australia, CSIRO, 2015). Examination of this data makes no substantive changes to the results and recommended options.

The climate scenarios considered in the vulnerability assessment in terms of carbon emission projections based on the CMIP5 climate model results provided by CSIRO were:

- Representative Concentration Pathways 4.5 - Moderate scenario (in terms of future carbon emissions)
- Representative Concentration Pathways 8.5 - Extreme scenario (in terms of future carbon emissions)

Representative Concentration Pathways (RCPs) relate to greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. The pathways are used for climate modelling and research. They describe possible climate futures, all of which are considered possible depending on the level of greenhouse gases are emitted in the years to come. The RCPs are consistent with a wide range of possible changes in future anthropogenic (i.e., human) greenhouse gas (GHG) emissions. Emissions in RCP 4.5 peak around 2040, then decline. In RCP 8.5, emissions continue to rise throughout the 21st century (Commonwealth of Australia, 2013).

Given the current extent of vegetation across the region woodland birds are particularly at risk from climate change.

3.2 Vulnerability assessment

The first step in the process involved identifying the assets that are most vulnerable to climate change. A vulnerability and spatial impact assessment was completed to inform NRM planning for climate change (Spatial Vision & Natural Decisions, 2014). The assessment was completed for multiple natural asset classes and values and included the use of available data on the characteristics, values and condition of the assets. The assets considered in the assessment were consistent with those used in the RCS process and included: native vegetation, rivers and streams, wetlands, and soils.

The assessment incorporated multiple projections of future climate over different timeframes and considered the potential climate change impact and vulnerability using the assessment framework presented below. The assessment covered the whole of the state of Victoria.

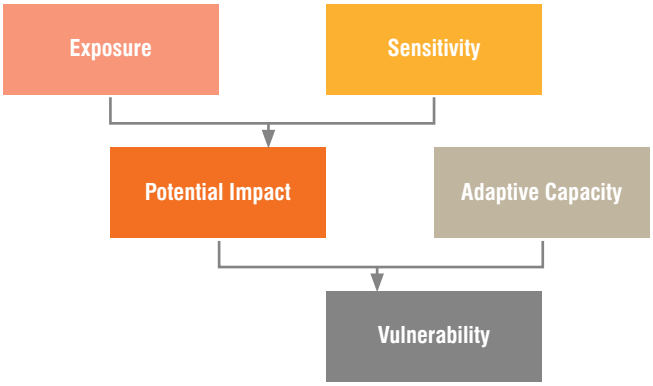


***Figure 3.2** Climate change impact and vulnerability assessment framework (Spatial Vision and Natural Decisions, 2014).*

To develop this Plan, the vulnerability assessment results were examined and reviewed. Relevant results included 'Worst Impact', 'Adaptive Capacity' and 'Vulnerability', each presented by asset class, for the time periods 2030, 2050, 2070 and 2090, and for emissions scenarios RCP 4.5 and 8.5.

In consideration of the vulnerability assessment results, it was decided, for the purposes of this Plan, to use the RCP 8.5 emission scenario for a range of time periods (out to 2090). This is a longer planning horizon than the RCS (20 years), and has been judged to provide a view of possible impacts (assuming emission continue to rise through to 2100), for the most relevant climate factors, particularly changes in temperature and rainfall. The maps of results from the vulnerability assessment for the North Central CMA region are provided in Chapter 4 and Appendix 10.

When considering the impacts of climate change on natural assets and adaption options, it is important to consider long-term trends rather than impacts for a specific time period. For example, the projected impacts for north central Victoria in 2050 are in many cases modest but increase significantly after this time.

In 2015 Australia was almost 3 degrees warmer than usual for the month of October, the biggest deviation from the norm on record (BoM, 2015).

3.3 Community and stakeholder workshops

To inform the plan six community workshops were held across the region focusing on a priority natural asset in the North Central RCS. The asset areas chosen were:

- Bunguluke (vegetation and wetland values)
- Lower reaches of the Campaspe River (a regulated waterway and associated floodplain)
- Lockington Irrigation Area (Land and soils)
- Muckleford priority area (vegetation)
- Upper Loddon River (an unregulated waterway and associated floodplain)
- Kamarooka wetland priority area (wetlands).

The workshop discussion was framed around participant's experience of climate variability, what people are doing to adapt their farming enterprises, the projected future climate, risks and issues associated with the projected future climate, threats and opportunities, carbon farming and supporting communities in extreme events. The findings of these workshops are included in Appendix 6.

A stakeholder workshop involving representatives from a range of agencies and businesses operating in the NRM sector was also held to inform the plan. The findings of this workshop are included in Appendix 7.

3.4 Climate change, adaptive management and the natural environment

Given the uncertainty around the climate and other socio-economic variables in the future, keeping as many management options open as possible is vital. This plan has been framed using the concept of 'adaptation pathways' as one approach to deal with the uncertainty of planning for climate change (SCARP, 2014). This concept is still in its early stages of development and there has been little practical application in natural resource management (NRM) planning in Australia.

The adaptation pathways approach enables decision makers to consider a range of possible management actions and how they will perform under a range of potential futures. The approach is shaped by the consideration of thresholds and tipping points of certain outcomes and management options. Thereby considering if and when a management option might cease to be effective, and what might be the tell-tale signs of the threshold or tipping point being approached or exceeded.

A pathways approach allows us to move forward in the face of uncertainty by considering a range of adaptation actions and sequences as new information and data become available.

This planning approach accords with recognised principles for adaptation: Consider multiple possible futures; plan to learn; be explicit about values and knowledge; and action does not require complete knowledge or consensus.

The principles of an adaptation pathways approach provide for:

- A strategic rather than reactive planning process
- A flexible strategy, by committing to short-term, incremental actions within existing governance arrangements, while monitoring how 'robust' possible options remain across a multitude of possible futures
- Shift planning from vulnerability assessments to strategies that may address the underlying drivers of those vulnerabilities over the longer term
- Provide a means for salient and credible dialogue
- Support synergies with best-practice regional NRM and use existing data, information and planning processes such as risk and vulnerability assessments.

The approach has been modified to include considerations of technical feasibility, landholder adoption, socio-political risk, cost to government and potential for adverse impacts, to ensure that the adaptation options identified have been scrutinised and evaluated in the light of current understandings.

In developing this Plan four 'Adaptation Options' workshops were held each focusing on a selected priority asset in the North Central RCS. The four high value assets explored in the workshops were chosen as representative of similar asset complexes in other parts of the region where the resultant options for climate change adaptation and mitigation might also apply. Each workshop sought to identify a range of adaptation options that would reduce the vulnerability of these high value assets under a drying, warming and more variable climate. Consideration was given to business as usual, business in a changing climate, and a 2050 timeframe. The results of this work are outlined in Appendix 8.

While there is significant uncertainty associated with climate, environmental responses and future socio-economic trends the process identified and evaluated a wide range of adaptation options. These options should be considered and be used as new knowledge and understanding comes to hand, including improved climate modelling and environmental, social and economic monitoring. The adaptation pathways approach is a useful tool in considering multiple futures and should be applied to other RCS assets, particularly prior to significant long-term decisions or investments.

4 CLIMATE CHANGE

Guide to Chapter

This Plan looks ahead to 2050 and beyond and is framed by the future climate change projections for north central Victoria. Looking back over recent decades Victoria has experienced significant climate variability with the wet years of the 1970s; the 1982-83 drought; the 1983 fires that burned 210,000 hectares; the 'big dry' or Millenium Drought (1997-2009); the 2009 fires that affected 430,000 hectares; and the flooding of 2010-11 that affected 3,300 properties and 97 towns. From a natural resources perspective the floods of 2010-11 delivered significant environmental benefits, such as natural regeneration on the floodplain and the rejuvenation of the region's rivers and wetlands.

Beginning in about 1997, declines in rainfall and runoff contributed to widespread crop failures, livestock losses, dust storms, and bushfires. Such are the vagaries of water on the continent with the world's most uncertain and variable climate. If the climate change predictions are right, in the future we are likely to experience even more extreme weather events (Garnaut, 2011).

In January 2015 the CSIRO and the Bureau of Meteorology (BoM) released climate change projections for Australia that provide updated national and regional information on how the climate may change to the end of the 21st century (CSIRO, 2015).

The projections are the most comprehensive ever released for Australia and help inform the impact assessment and planning required in the natural resource management sector. Material has been drawn from observations and from simulations based on up to 40 global climate models and four scenarios of greenhouse gas and aerosol emissions during the 21st century.

The 2015 projections provide greater levels of detail and confidence compared to previous projections. Findings are consistent with previous projections research and analysis for Australia, and incorporate an increased knowledge base.

A suite of additional products, including interactive tools and data associated with the projections, has been developed, with a focus on improving accessibility and uptake of information (CSIRO, 2015).

The North Central region is included in modelling for the Murray Basin cluster comprising NRM regions across New South Wales, Victoria and South Australia. The cluster is relatively dry and temperate, with a warm and dry grassland climate in the north-west ranging to temperate with hot summers further east.

Figure 4.1 *The Murray Basin Cluster area*

4.1 Climate Change projections for the Murray Basin Cluster

With greenhouse gas emissions continuing to increase, the BoM expects the warming trend of the past century to accelerate throughout this century. It also expects changes to rainfall patterns and to the frequency of extreme weather events like cyclones and droughts.

The future climate will depend on whether the world manages to slow and even reduce greenhouse gas emissions. Since greenhouse gases have a long lifetime in the atmosphere, any change in emissions will have a delayed effect on atmospheric concentrations, so these concentrations are expected to increase, leading to further warming and climate change for many decades.

Different emissions scenarios have been modelled based on different assumptions about future demographic change, economic development and technological advances. The concentrations paths are similar up to about 2030, and then diverge markedly.

The North Central CMA has prepared this complementary climate change adaption and mitigation plan as a sub-strategy of the Regional Catchment Strategy. The Plan will assist agencies and freehold land managers make informed decisions that consider uncertainty, risk and feasibility of options for climate change adaptation and mitigation. The Plan will help protect the region's high priority natural assets in the face of the current modelled climate future for the region (see Table 4.1).

***Table 4.1** Confidence levels and climate change projections for the Murray Basin cluster area*

Prediction	Level of confidence
Average temperatures will continue to increase in all seasons	Very high
More hot days and warm spells	Very high
Fewer, but possibly damaging, frosts	High
By late in the century, less rainfall during the cool season	High
Rainfall will remain unchanged in the warm season	Medium
Even though mean annual rainfall is projected to decline, heavy rainfall intensity is projected to increase	High
A harsher fire-weather climate in the future	High

Burning stubble has been dramatically reduced across the broadacre cropping areas of the region. This is contributing to an improvement in soil health.

4.2 CSIRO and Bureau of Meteorology 'State of the Climate 2014' report

In 2015 the CSIRO and the Bureau of Meteorology released their third biennial State of the Climate report. The report highlights that:

- Australian annual average daily mean temperatures have increased by 0.9°C since 1910.
- Seven of the ten warmest years on record have occurred since 1998.
- Heatwaves and hot days, drought and rainfall deficiency, and bushfires dominated the Australian 2013/2014 summer.
- August 2014 was the hottest on record (source: http://www.ncdc.noaa.gov/sotc/global/)
- Global average mean sea level for 2011 was 210 mm above the level in 1880.
- Sea surface temperatures have increased by about 0.8 °C since 1910.
- Autumn and early winter rainfall has mostly been below average in southeast Australia since 1990.
- Annual average global mean CO2 levels reached 395 ppm in 2013, the highest level in at least 2 million years, and levels of the other major greenhouse gases are the highest for at least 800,000 years.
- The CO_2 increase from 2011-13 is the largest two-year increase ever observed in CSIRO's record.
- The main cause of the observed increase in carbon dioxide concentration in the atmosphere is the combustion of fossil fuels since the industrial revolution.
- Australian average temperatures are projected to rise by 1.0 to 5.0 °C by 2070 when compared with the climate of recent decades.

4.3 Community perspectives on climate change and north central Victoria

Extensive community engagement during the development of this Plan identified a range of risks and issues associated with climate change in north central Victoria (see Table 4.2).

***Table 4.2** Climate change risks and issues for north central Victoria*

Key Risks and Issues	Regional community's perspective
Fire	Fire is considered a growing risk in the region. Communities are fearful of fire and tend to bunker down during the summer months. There is a wide variety of approaches to fire preparedness across the region. The removal of grazing from public land is considered a fire risk. The capacity of an ageing volunteer population to respond to fire is also a growing issue.
Water	The projected changes in climate will impact on available water, water quality, water security and water pricing for agricultural enterprises. There will be a need to get the balance right regarding the share between consumptive use and environmental water. The increasingly efficient use of water and piped water supplies are considered vital responses to the issue of climate change. Groundwater recharge and protection of the groundwater resource for both consumptive use and groundwater-dependent ecosystems will be important, as groundwater use in some parts of the region is strong.
Extreme heat days	The projected changes in climate will impact on human health (particularly babies and the elderly), animal health, emergency services, the health system, energy infrastructure and community resilience.
Community capacity to respond	Service provision, social cohesion and an ageing population are issues being faced by smaller rural communities. Resources will be stretched even further under the climate change predictions for the region.
Population increase and appropriate land use planning	Meaningful water supply planning is needed to meet the needs of the growing communities in the upper catchment, along with appropriate planning to protect good agricultural land from sub-division.
Increased summer rainfall	Increased summer rainfall is viewed as a two edged sword – good for lucerne and poor for summer weeds. Many farmers value the opportunity capture and store summer rainfall for future cropping. Fodder storage is considered to take the gamble out of farming. Summer crops are seen as an opportunity. Coliban Water advises that summer rainfall generally has very little impact on water storage volumes.
Threat to natural environment	There is concern across the region for species loss, biological simplification and increased pressure on the environment from population increase, increasing temperatures, as well as pest plant and animal proliferation.
Advocacy for the natural environment	The need for increased protection of productive agricultural land and the natural environment in a changing climate. This is particularly acute in the southern part of the region which is undergoing rapid peri-urban expansion.

Extensive community engagement during the development of this Plan identified a range of NRM threats associated with climate change in north central Victoria (see Table 4.3).

Climate change will continue to affect the natural environment in a variety of ways. Rivers and wetlands will be impacted by changes in the available water quantity (drought, flood, rainfall intensity and the subsequent rate of surface runoff) and also the quality of the available water resource. Water storages and regulated flows can be managed to mitigate some of these effects.

Climate change will affect native flora and fauna in complex and often unpredictable ways. Current threats to biodiversity, including the impact of habitat loss, weeds, pest animals and drought, are expected to intensify. The more vulnerable ecosystems in the region are areas that are vulnerable to moisture stress and increased risk of bushfires.

Species that have survived previous climatic changes have done so by evolving, changing their behaviour, taking refuge in local areas that are buffered from the changes, or moving to areas where the climate is more suitable. Native plants and animals might find it more difficult to use these coping strategies when the change is rapid, especially where their habitat has been degraded, isolated or lost. Climate change won't cause all species to decline. However, changes in climate could lead to new opportunities for the establishment of invasive species, such as weeds and pest animals, as well as some native species.

***Table 4.3** NRM threats as perceived by regional community*

Threat	Regional community's perspective
Fire	Prescribed burning; Destructive nature of megafires
Pest animals	Climate change could exacerbate the damage caused by rabbits
Insect pests	More frequent locust plagues and fruit fly outbreaks; increased threat to bees
Terrestrial Weeds	Mentions include Statis, Wild Vetch, Fleabane, Horehound, Gazania, Stinkweed, Silverleaf Nightshade, Wheel Cactus, Boxthorn
Aquatic weeds	Mentions include Alligator Weed, Senegal Tea, Parrot Feather, Pale Yellow Water Lily
Threat to biodiversity	Species loss (Fauna mentions include Woodland birds, Plains Wanderer, Koalas) Biological simplification; Loss of native grasslands Increasing frequency of algal blooms
Moisture stress	Stress on older trees

Table 4.4 provides a more detailed assessment of how the key threats to natural assets may alter as a result of the threat response to climate variability and the climate change rating (Natural Decisions, 2015). For example, decreased winter and spring rainfall will have a direct negative effect on altered flow regimes but an indirect negative effect on altered fire regimes. Table 4.4 also highlights the key threats to natural assets that are likely to be high under climate change and include soil erosion, invasive plants, altered flow regimes, degraded water quality, loss of native vegetation and habitat fragmentation.

Legend for Table 4.4:

Threat response	Climate change effect	Threat response	Climate change effect
↑ - Direct	High negative	No change	Low negative
↑ - Indirect	Moderate negative	↓ - Direct	Positive
↓ - Indirect	Positive	Unknown	Unknown

Table 4.4 *Assessment of how the key threats to natural assets may alter as a result of climate change*

Climate Factor	Soil erosion, compaction & disturbance	Invasive plants	Invasive animals	Altered fire regimes	Altered flow regimes	Increased salinity & groundwater levels	Degraded water quality & high nutrients	Overgrazing & total grazing pressure	Loss of native vegetation & habitat fragmentation	Levees/ barriers to natural flows
Increased temperature in all seasons	↑ I	↑ D	↑ I	↑ D	↑ D	↓ D	↑ I	↑ I	↑ I	↑ I
Decreased winter & spring and rainfall	↑ I	↑ D	↑ I	↑ I	↑ D	↓ D	↑ D	↑ I	↑ I	↑ D
Increased intensity and frequency of extreme rainfall events	↑ D	↑ I	↑ I	↓ D	↑ I	0	↑ D	↑ D	0	↑ D
Increased evapo-transpiration in all seasons	↑ D	0	↑ I	↑ I	↑ D	↑ D	↑ I	↑ I	↑ I	↑ I
More frequent and severe fires	↑ D	↑ I	↑ D	↑ D	0	0	↑ D	↑ I	↑ D	0
Decreased soil moisture in all seasons	↑ D	↑ I	0	↑ I	↑ I	↓ D	↑ I	↑ I	↑ D	↑ I
SCORE										
COMBINED EFFECT	H	H	M	M	H	L	H	M	H	H

5 CLIMATE CHANGE IMPLICATIONS FOR NATURAL ASSETS

Guide to Chapter

A focus of this plan is to understand the implications of future climate change on the natural assets of the North Central region, so that land managers, communities and organisations can plan strategically for appropriate adaptation and mitigation options.

This chapter of the plan describes how the natural assets, rivers and floodplains, wetlands, biodiversity and soils are likely to be impacted by direct climate changes (e.g. increased temperature, reduced rainfall) and indirect effects such as an increased frequency and intensity of extreme events (e.g. wildfire, flooding).

In this chapter we also describe general adaptation and mitigation responses that may increase the adaptive capacity of these asset classes. Specific adaptation and mitigation options for priority assets are outlined in detail in Chapters 6 and 7.

A key challenge relates to our ability to understand how natural ecosystems might respond as the climate changes. At the level of ecosystems, changes are driven by multiple, interacting drivers. Historical and current drivers, such as the level of clearing or degree of weed invasion, will remain important, while the future climate trends are likely to assume greater importance over time (Steffen et al., 2009). Environmental responses will, in many cases, be non-linear and difficult, perhaps impossible to anticipate when key thresholds may be imminent for natural ecosystems at a range of scales. Steffen et al, 2009, outline a set of key ecological principles that are relevant to species and ecosystem responses, that should be recognised when managing for environmental changes, including those related to climate. These principles highlight that at larger scales, the interactions among ecosystems, particularly the nature and strength of connections among them, become very important as rapid environmental change drives differential response among individual species and groups of species. Therefore adaptation and mitigation responses that maintain ecosystem services, build landscape connectivity, and protect existing biodiverse areas become crucial in providing future options under climate change.

The North Central Regional Catchment Strategy (North Central CMA, 2012) identifies priority areas across a range of asset types; waterways, floodplains, wetlands, terrestrial habitat (including significant species) and soils, that form the building blocks for adaptation and mitigation options at a range of scales (see Figure 5.1). As outlined below, future climate projections highlight the vulnerability of these priority areas, and therefore provide a basis for remedial actions that improve the capacity of these assets to adapt to changes in direct and indirect climate stressors.

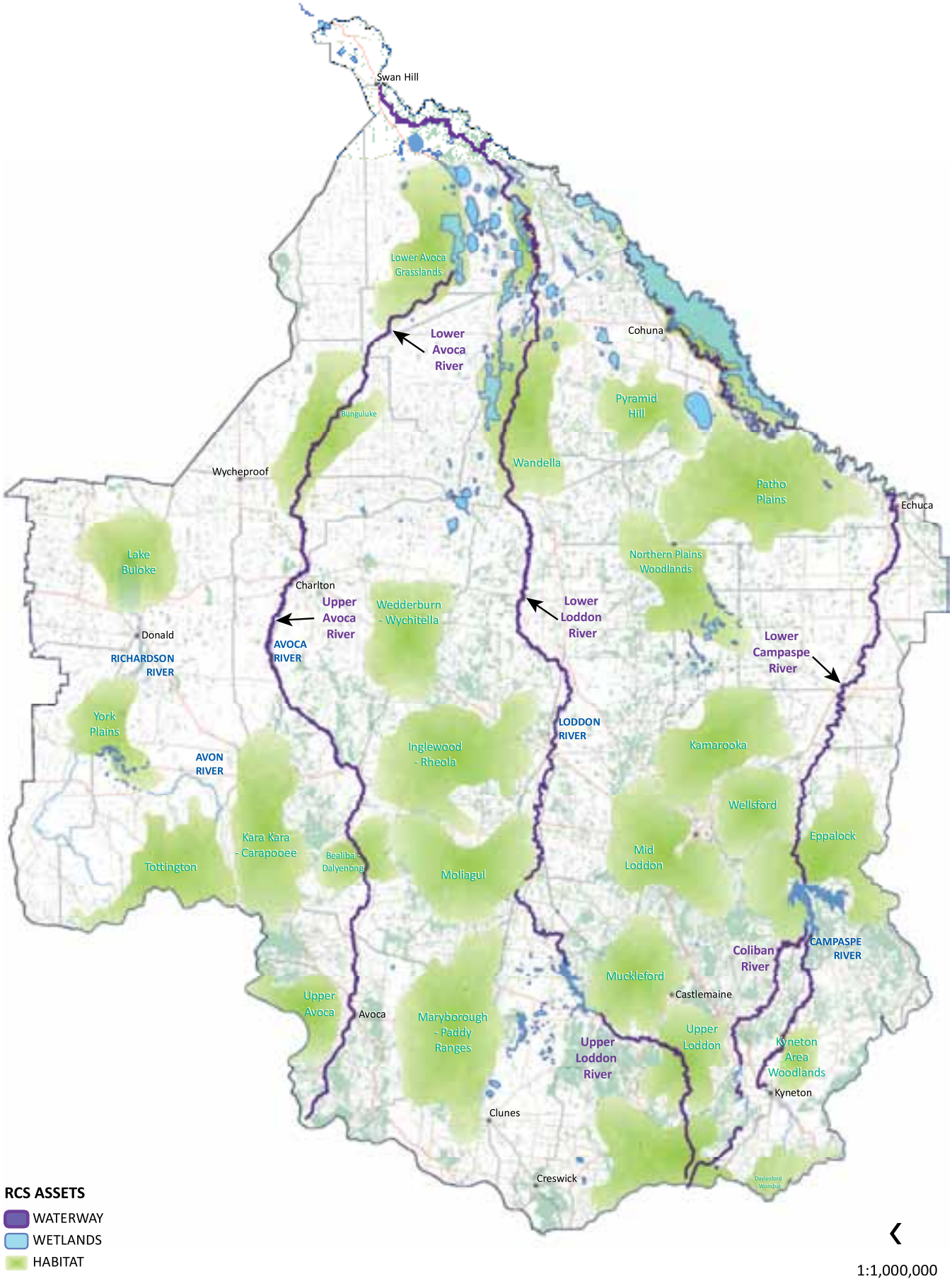


Figure 5.1 *Regional Catchment Asset Priorities map*

5.1 Rivers and floodplains

Rivers and their associated floodplains support a large array of native flora and fauna – many of which are threatened. They are highly important in the movement and cycling of sediment and nutrients through the landscape, and a significant interface between aquatic and terrestrial systems. Rivers provide safe drinking water for people, along with water to support rural production (North Central CMA, 2012).

Over 3,500 km of waterways in the North Central region were assessed in 1999, 2004 and 2010 using the Index of Stream Condition (ISC) condition assessment method. In 2010 none of the region's waterway reaches were assessed to be in excellent condition. One per cent of stream length was in good condition, 46 per cent in moderate condition, 30 per cent in poor and 21 per cent were found to be in very poor condition. The Campaspe basin was the only basin in the region to have any stream length in good or excellent condition (with 7%). The majority of stream length in the Campaspe, Loddon and Avoca basins was in moderate condition (29%, 41% and 74% respectively). More than half (56%) of stream length in the Avon – Richardson river system was in poor condition (Department of Environment and Primary Industries, 2013).

Key threats to rivers in the North Central region include; urbanisation, Inappropriate recreation practices, growth and spread of exotic flora and fauna (both aquatic and terrestrial), poor management of urban runoff and stormwater, grazing and clearing of stream banks, levees and floodplain development, structural woody habitat (snag) removal, in-stream barriers for fish passage and water regulation.

Regulation of rivers in the region has changed the natural flow patterns and caused the health of many river systems to decline. Environmental flow management has become an integral component of improving the health of these regulated river systems (North Central Regional Waterway Stratgey, North Central CMA, 2013).

Issues, opportunities and asset vulnerability

The projected decreases in average rainfall and runoff are likely to have direct impacts on the hydrology of rivers and floodplains with consequent impacts for vegetation and fauna (North Central CMA, 2014). Increased temperatures are also likely to impact on key waterway and floodplain habitats such as, deep pools and refuges, billabongs and floodplain wetlands.

Existing threats including flooding, erosion and sedimentation are likely to be exacerbated by increased frequency and intensity of rainfall events, whilst poor water quality will also be influenced by increased temperatures and low flow conditions in summer and autumn (Hobday & Lough, 2011).

Many of the region's rivers flow through agricultural landscapes where stock access to water and riparian grazing has been a feature of many enterprises. These pressures are likely to increase under future climate change so examination of controlled grazing regimes and provision of off-stream watering sources will be important in protecting vulnerable waterway assets (also see Table 5.1).

"We have two creeks running through our property. My father could always rely on waterholes in the creek to water stock. I can no longer rely on the waterholes in the creek."

(Farmer, Castlemaine workshop)

"As a kid there were always a few waterholes in the Avoca River. It was a very social thing and the reason I came home. My kids think I am mad now. Now it is just a dry river bed. My kids have got no memories of what I had as a child."

(Farmer, Charlton workshop)

"There used to be a fishing club at Wycheproof that would hold a competition every Sunday. But in 1967-68 it started to go dry and the club folded."

(Farmer, Charlton workshop)

Table 5.1 *Adaptation options – Rivers and floodplains*

Climate Change Variables			
Reduced and more variable rainfall	**Increased temperatures, and extreme heat**	**Increased intensity and frequency of rainfall events (including flooding)**	**Increased frequency and intensity of fire**
Increase extent of riparian vegetation and improve connectivity of corridors to provide shading of rivers. Provision of environmental flows. Protection of summer base flows (regulation of timing / magnitude of extraction).	Protection of refuge areas for fish and aquatic fauna in conjunction with pest species programs. Establishment of riparian vegetation. In stream habitat restoration. Control competing aquatic species (plant and animal).	Maintenance of ground cover in strategic areas. Geomorphic recovery through works (vegetation and structural). Management of flashy surface water inflows in urban / agricultural environments through swale drains and constructed wetlands. Explore opportunities for large-scale floodplain restoration to buffer against flooding.	Focus fuel reduction burning to protect vulnerable/fire sensitive vegetation along rivers and floodplains. Plan to mitigate the potential impacts of fuel reduction burning and wildfire on sediment/pollutant runoff to rivers.

Figure 5.2 shows the vulnerability of rivers at a regional scale under the RCP 8.5 emissions scenario for 2070. Rivers in the upper catchment, above major storages, are particularly vulnerable to reductions in rainfall and increased temperatures.

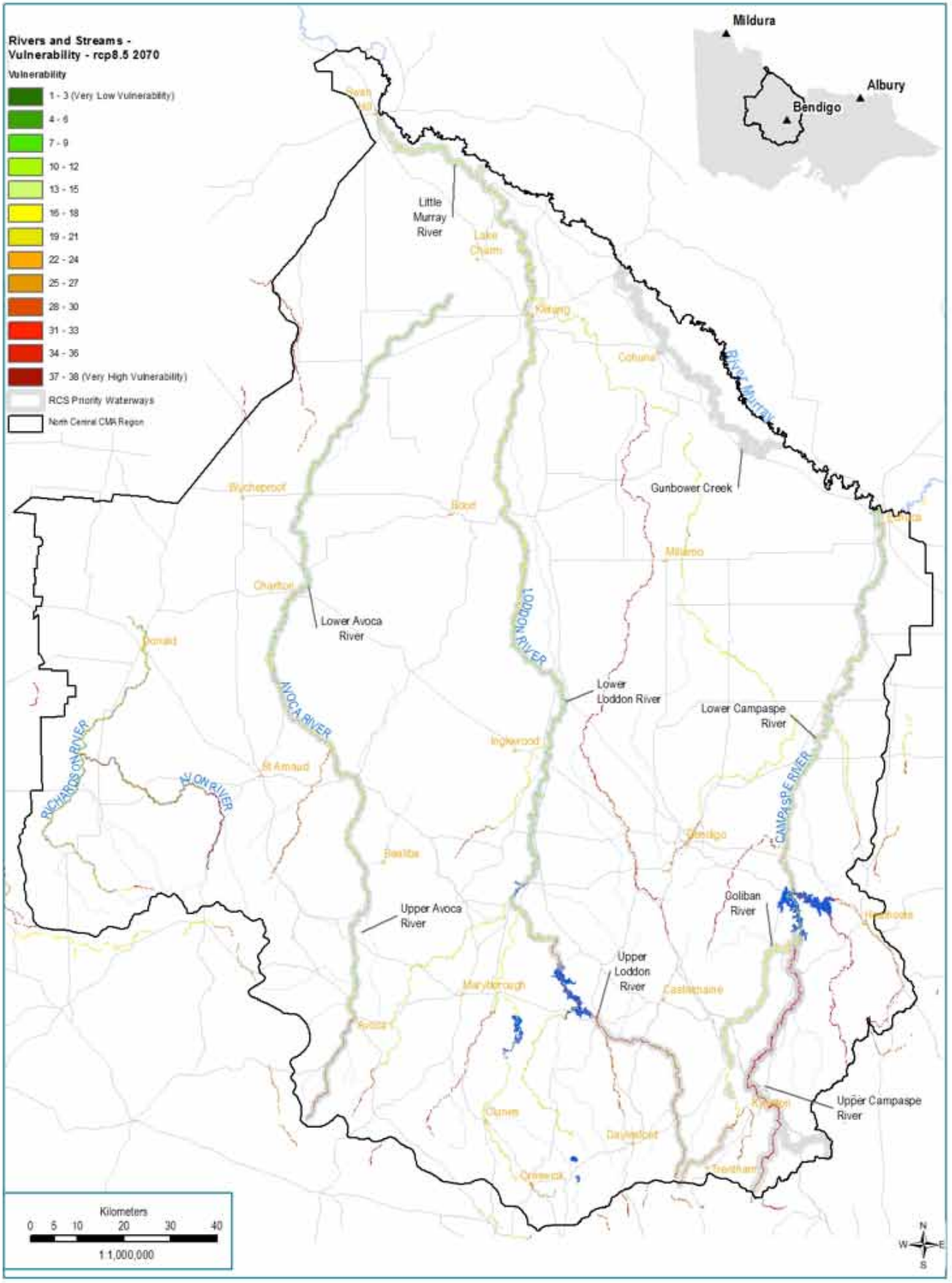


***Figure 5.2**: Vulnerability of priority waterway assets – RCP 8.5 2070*

Case study – Loddon Stressed River Project

The Loddon River is a significant Victorian tributary of the Murray River and was identified as a flow stressed river due to river regulation. It has many significant environmental values, including the occurrence of native flora, fauna fish and vegetation communities considered threatened at a national and state level, and is connected to the significant Boort wetlands system and the Ramsar listed Kerang Lakes system.

Aerial view of riparian buffering on the Loddon River at Serpentine

The North Central CMA delivered the Loddon Stressed River project along the lower Loddon River between 2003 and 2013. The delivery and achievements of the longest running river health project in north central Victoria provide a model for other projects in the region.

The Loddon Stressed River project aimed to:

- Progress towards a fully protected streamside zone along the Loddon River
- Increase the length of river available to fish and improved habitat
- Engage and involve the community.

The project involved community engagement, on-ground activities (riparian fencing, revegetation, erosion control and woody weed management), in-stream habitat restoration and investigations and research.

The project delivered a wide range of on-ground outputs that largely achieved all the set targets. Most notable is the length of waterway and riparian vegetation protected by 390 km of fencing - 56% of river frontage in the project area.

A significant and ongoing program of community engagement involved a wide range of the catchment community, resulting in a high percentage of the target population participating in the project. This had a strong influence on community attitudes to, and appreciation for, river health issues.

Habitat restoration completed at numerous sites improved aquatic habitat for native species. Investigative studies improved regional understanding of fish needs for, and barriers to, migration and were instrumental in attracting funds for future fish habitat and migration projects. These activities are improving the adaptive capacity of the Loddon River and reducing its future vulnerability to climate change.

Future opportunities for the project area include continued support for community groups, mapping and assessment of potential on-ground works for future funding opportunities, addressing barriers to fish migration and ongoing monitoring of project achievements.

The activities outlined above are increasing the adaptive capacity of the Loddon River and its floodplain which will help reduce its vulnerability to future climate change. Future climate projections predict significant decreases in runoff from the upper catchment of the Loddon River which will reduce inflows to key storages (e.g. Cairn Curran Reservoir). As a regulated system there is the ability with reduced water availability to provide environmental water to important refugia along the river. Managing trade-offs between consumptive use and environmental needs will be exacerbated in the future.

5.2 Wetlands

Wetlands support extensive food chains and rich biodiversity by providing a unique ecosystem within the landscape which can support a range of flora and fauna species. They are the sources, sinks and transformers of a wide range of chemical, biological and genetic material. They provide important ecological functions for rivers and floodplains through nutrient and sediment exchange, as well as the dispersal of organic matter and biota. At times they can stabilise water supplies, ameliorating the impacts of floods and drought. They can also clean water passing through them and recharge groundwater supplies (Mitsch & Gosselink, 2007).

There are 1,619 wetlands within the North Central region, with a total area of 84,325 ha or 2.8% of the region. 77% of the total wetland area is considered to be of regional, national or international importance. They include two internationally significant wetlands – Gunbower Forest and the Kerang Wetlands Ramsar sites. Our wetlands provide important recreational opportunities including fishing, swimming, camping, boating and bushwalking. The health of these wetlands underpins many aspects of tourism, jobs and investment in the region (North Central regional Waterway Strategy, North Central CMA,2013).

Key threats to wetlands include altered hydrology and changed water regimes loss of habitat diversity, soil disturbance (including land forming), land use intensification, habitat fragmentation, salinity, elevated nutrient levels, invasive plants and animals, overgrazing and the impacts associated with intensive recreational use (North Central regional Waterway Strategy, North Central CMA,2013).

Issues, opportunities and asset vulnerability

Figure 5.2 shows the vulnerability of wetland assets at a regional scale under the RCP 8.5 emissions scenario for 2070. As is the case for rivers, decreases in average rainfall and runoff are likely to have direct impacts on the hydrology of wetlands, with the periodicity of wetting and drying cycles likely to change significantly. These changes combined with increased temperatures and increased evapotranspiration may lead to permanent and irreversible changes in wetland structure and function.

The North Central region comprises 1,619 wetlands with a total area of 84,325 ha.

The analysis suggests that those floodplain wetlands with tenuous connections to major rivers (such as the Kamarooka wetlands complex) and wetlands that fill solely from surface run-off (such as the Moolort Plains wetlands) are highly vulnerable. In the north-west of the region, the Bunguluke wetlands (including the floodplain of the Avoca River and high value terrestrial habitat) are also highly vulnerable to climate change. Further north, those wetlands associated with the lower reaches of the Loddon system and the Murray River are somewhat less vulnerable to climate change because of the availability of water either through regulated or environmental water delivery.

Figure 5.2 highlights that different wetlands are more vulnerable than others. This is because some wetland types such as ephemeral wetlands (.e.g. freshwater meadows) are more sensitive to the key climate stressors (March to November rainfall and November to April maximum temperatures). The source of water for any particular wetland also affects its sensitivity. The adaptive capacity of wetlands is influenced by the extent and quality of adjacent native vegetation, adjoining land uses and the presence of drains, levees and land use in the wetlands – e.g. cropping (also see Table 5.3).

***Table 5.2** Adaptation options – Wetlands*

Climate Change Variables			
Reduced and more variable rainfall	**Increased temperatures, and extreme heat**	**Increased intensity and frequency of rainfall events (including flooding)**	**Increased frequency and intensity of fire**
Removing existing artificial barriers or lowering 'commence to fill' levels. Explore opportunities to deliver water to isolated wetlands through irrigation infrastructure. Preventing disturbance to those wetlands subject to over grazing or land use intensification/cropping.	Weed and pest control to improve condition and adaptive capacity. Improve connectivity between wetland habitats. Establish buffers of native vegetation and reinstatement of wetland vegetation.	Reinstatement, where possible, of natural hydrology to allow for movement and retention of floodwaters. Management of 'flashy' surface water inflows in urban / agricultural environments through swale drains and constructed wetlands.	Focus fuel reduction burning to protect vulnerable/fire sensitive vegetation around wetlands. Consider fire management in wetland planning.

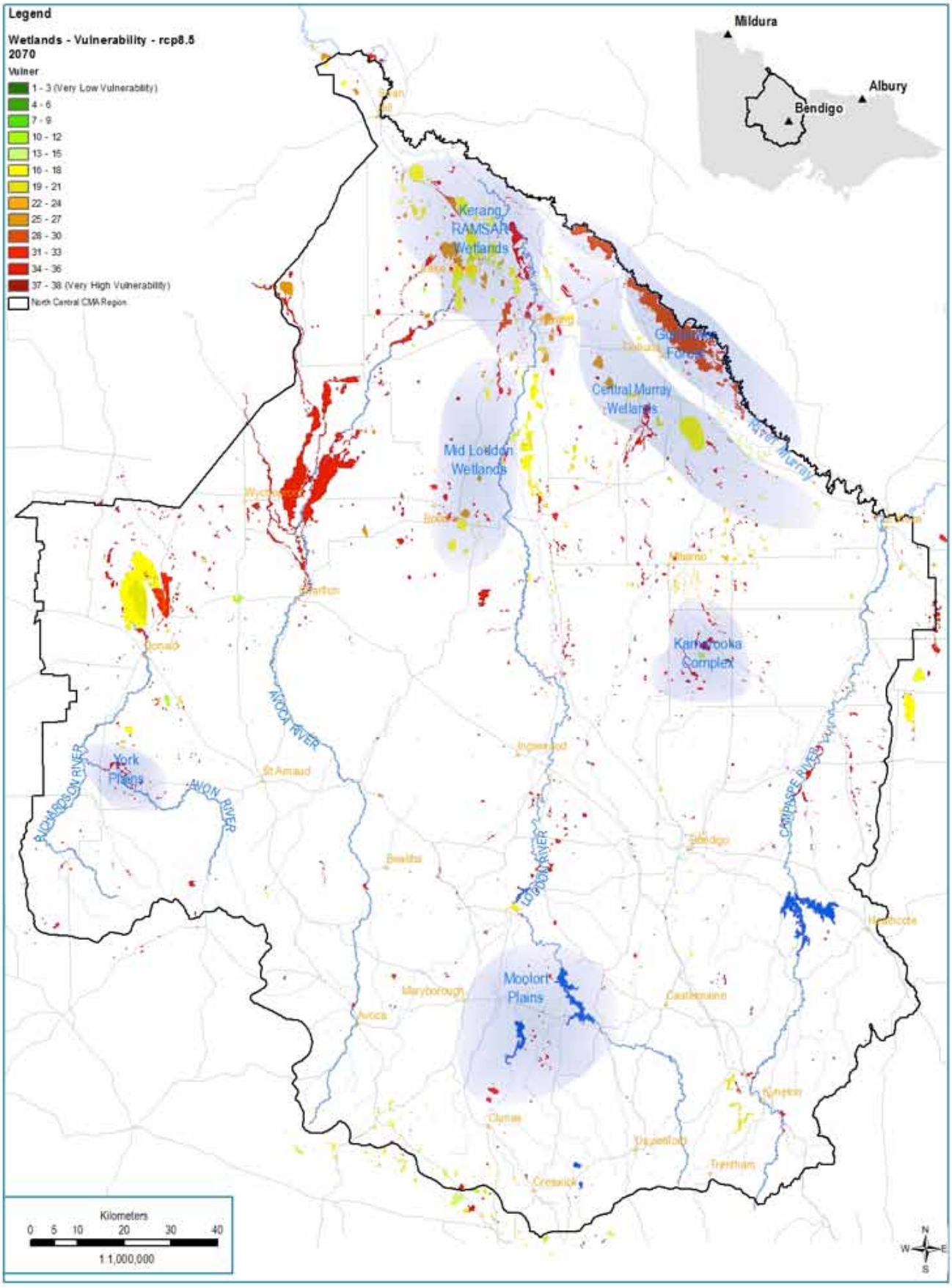


***Figure 5.3**: Vulnerability of priority wetland assets – RCP 8.5 2070*

5.3 Biodiversity

The North Central region is one of Australia's most highly cleared and fragmented landscapes and while this has contributed to a productive and vibrant regional economy it poses many challenges for future biodiversity conservation, especially in the face of climate change. The overall current trajectory is still one of decline as the impact of past actions is yet to be fully realised. For example, woodland bird species extinctions are expected to occur at a local scale even if major landscape restoration is achieved over the next 20 years. The original native vegetation of the region has undergone a dramatic decline in extent and quality since European settlement. Each bioregion has fared differently due to patterns of human land use, especially agricultural preferences for gentle landscapes and fertile soils.

Native vegetation is important as it provides a range of vital ecosystem goods and services that underpin the health of the land and water, the flora and fauna, and the communities of the North Central region. These include provision of drinking water, cultural heritage, carbon sequestration, timber, fire wood and the health of soils. Biodiversity also provides important spiritual and aesthetic values local and broader landscape scales (North Central CMA, 2012).

Extensive past clearing of native vegetation has had a major impact on the integrity of natural ecosystems and created remnant 'islands' that are more susceptible to threatening processes such as weed invasion and feral animals. The viability of the region's vegetation communities (and many flora and fauna species) requires networks and interconnections that link larger blocks of remnant vegetation. The past history of disturbance suggests that the North Central region is one of the most highly vulnerable to future climate change in Australia.

Issues, opportunities and asset vulnerability

Native vegetation is likely to be directly impacted by climate change through changes to annual rainfall and increased temperatures, while these factors are likely to generate flow-on effects such as changes in fire frequency and severity (Kitching et al., 2013).

Figure 5.4 shows the vulnerability of biodiversity and native habitat assets at a regional scale under the RCP 8.5 emissions scenario for 2070. This analysis highlights that while a number of significant, priority areas (e.g. Wedderburn – Wychitella) are especially vulnerable to climate change, additional vulnerabilities exist in areas of potential connectivity between the priority assets, highlighting the need to consider both adaptation and mitigation responses in tandem. For example, facilitating natural regeneration to buffer existing remnants will improve the adaptive capacity of these areas, whilst also promoting carbon sequestration and improved landscape connectivity.

The viability of the region's native flora and fauna species requires networks and interconnections that link larger blocks of remnant vegetation.

Gradual changes in the composition of vegetation communities are likely to occur, as some species are replaced by others, although the exact nature and timing of these transitions is conjectural at best. However, for communities already close to threshold in terms of extent or condition, such as some wetland ecosystems, these changes are likely to occur much sooner.

Indirect impacts on native vegetation may be more severe than direct impacts. Future changes to land management in response to both socio-economic and climate factors are likely to be important drivers of change in vegetation extent and condition. An increase in climate induced severity of existing threats including fire and invasive plants which may be exacerbated by a warmer, drier and more variable climate is also likely. Weed invasion is a major threat in all native vegetation communities leading to loss of native plant species as well as the fauna dependent on those plants. The integrity of priority vegetation communities is threatened by invasion from environmental weeds. In particular, a number of significant Box-Ironbark Ecological Vegetation Classes (EVCs), grassy woodlands, riparian ecosystems and wetlands are at risk of further degradation due to the impact of weed invasion. Pest animals, particularly rabbits, have a major impact on natural regeneration and vegetation establishment. An integrated approach to pest animal control and vegetation management programs will deliver substantial environmental and economic outcomes (North Central CMA, 2005).

The Grey-crowned Babbler is endangered in Victoria. Victoria's population is estimated at fewer than 1,000 birds (DEPI, 2003). The Babbler is threatened by climate change.

Bulbine Lily. Couresy: Robyn McKay NCCMA

In the North Central region the most vulnerable native vegetation communities (Spatial Vision & Natural Decisions, 2014) were those ecosystems with restricted natural climatic range and poor adaptive capacity associated with level of depletion and loss of quality.

Other potential impacts for vegetation communities include:

- Primary production could increase where rain is not limiting, due to increased atmospheric carbon dioxide levels.
- Earlier flowering of a range of flora.
- Change in vegetation community structure through changed fire regimes, including more intense and frequent fires and drying of terrestrial vegetation.
- Increased mortality during drought of heat-sensitive species.
- Breeding failures due to loss/mis-match of pollinators and seasonality of rainfall.
- Seeding and germination failure due to too high temperatures or lack of soil moisture.
- Potential negative impacts of wildfires on long-lived species and irreversible changes to vegetation communities (NCCARF Terrestrial Biodiversity Network, 2013).

Adaption options for protecting biodiversity in response to climate change variables are outline in Table 5.3.

***Table 5.3** Adaptation options – Biodiversity*

Climate Change Variables		
Reduced and more variable rainfall **Increased temperatures, and extreme heat**	**Increased intensity and frequency of rainfall events (including flooding)**	**Increased frequency and intensity of fire**
Protect high quality remnants as reservoirs of regeneration potential. Weed control to improve quality and condition. Use and range of seed provenances in revegetation programs to maintain/extend genetic diversity. Plan and implement revegetation activities to better match local and seasonal climatic conditions. Improve connectivity through targeted revegetation and remnant management. Active management to reduce threats (e.g. over grazing) on existing remnants. Developing and integrating productive tree (and perennial vegetation) systems, including farm forestry, that provide significant benefits in terms of carbon sequestration, run-off, watertable control and water quality.	Increase extent and connectivity of riparian and floodplain vegetation to reduce impact of extreme events. Where appropriate, promote natural regeneration in riparian and floodplain environments.	Match burning / fire regimes to tolerable fire intervals. Identify and protect ecosystems with high sensitivity to fire.

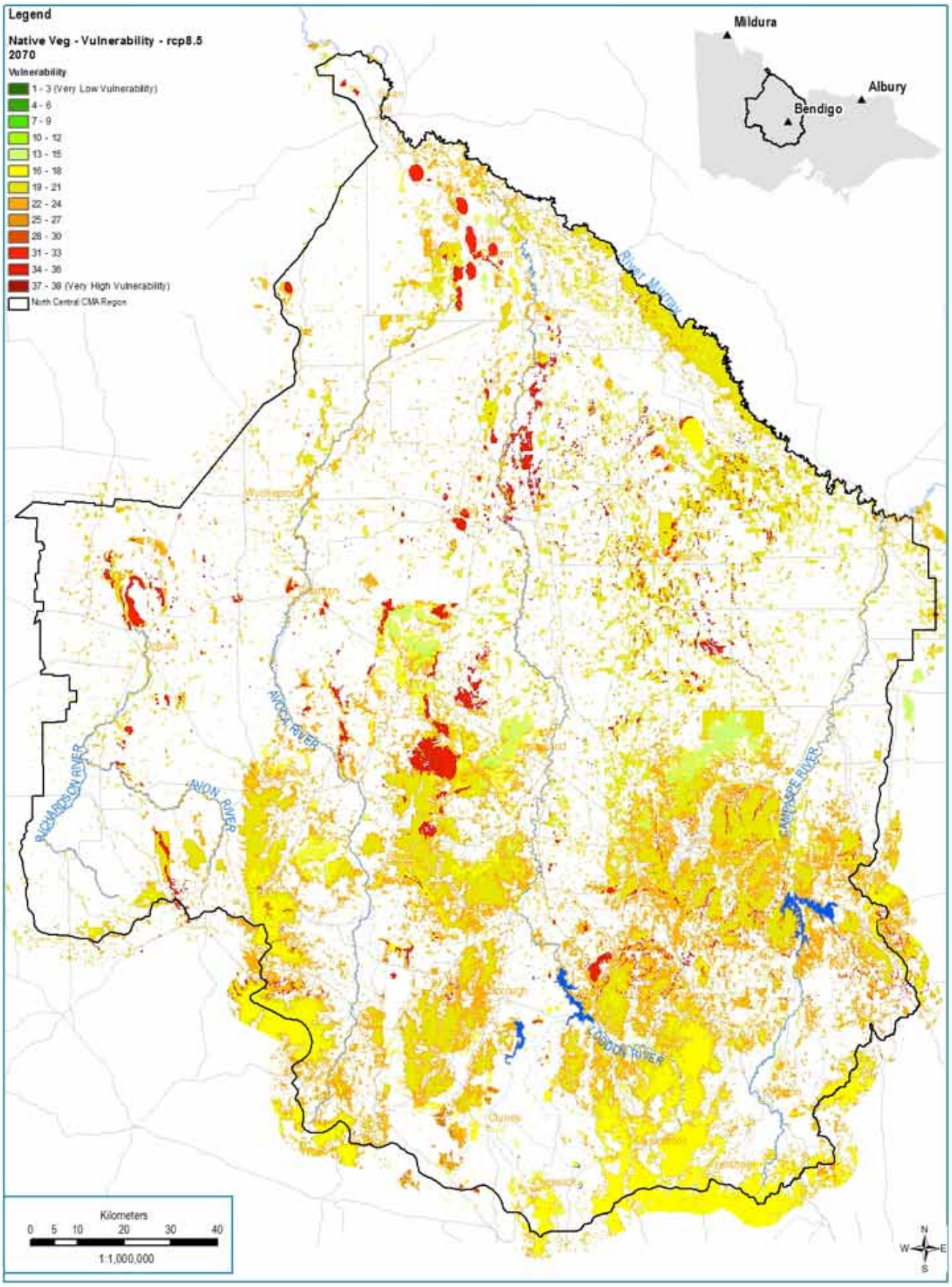


***Figure 5.4**: Vulnerability of priority biodiversity assets – RCP 8.5 2070*

5.4 Soils

The vulnerability of soils to climate change is strongly linked to the type of soil and its inherent characteristics, but is ultimately determined by land use and management. For example, maintaining groundcover on lighter soils, such as those associated with granitic landscapes will reduce the vulnerability of that soil to erosion.

In this Plan the focus for adaptation is on understanding the issues for agricultural land managers in order to develop adaptation options that have benefits for soils and agricultural production.

Issues, opportunities and asset vulnerability

The vulnerability of land and soils to climate change across the North Central region is reflected in a time series of maps (2030-90) included in Appendix 10. The region's soils were assessed as having a lower overall potential vulnerability to climate change compared with the other asset classes. The soils on freehold land with the highest potential vulnerability were those susceptible to wind and water erosion, generally lighter textured soils in areas associated with areas of higher relief. The loss of topsoil is the greatest threat to the productive and environmental value of the region. The mass of soil lost in most years is well in excess of the mass of food produced. Soil is lost at a far greater rate than it is replenished. The main culprits are wind erosion (particularly in the north), water erosion, and dryland salinity.

Adaption options for protecting soils in response to climate change variables are outline in Table 5.4.

Maintaining groundcover will reduce the vulnerability of soil to erosion.

***Table 5.4** Adaptation options – Soils*

Climate Change Variables			
Reduced and more variable rainfall	**Increased temperatures, and extreme heat**	**Increased intensity and frequency of rainfall events (including flooding)**	**Increased frequency and intensity of fire**
Soil management practices to reduce compaction, tillage, and retaining stubble, these reduce potential for nitrous oxide loss and increase soil carbon, while also improving productivity. Change to rotational grazing in order to increase soil carbon and improve water retention. Increase on-farm water storage capacity. Increase irrigation efficiency and re-use where applicable. Spread production over a range of areas within the region to different irrigation or rainfall zones. New varieties more tolerant of water stress. Change crops to more water efficient varieties.	Provide shelter and shade from extreme heat, through vegetation establishment or use of shade structures. Provision of sheltered watering points. Trial of new pasture and crop varieties. Increase ground cover through grazing management. Change to milking times to avoid hottest part of day. Shift joining time to avoid birth and lactation during summer periods.	Improve and increase flood warning systems. Maintain groundcover to mitigate against erosion. Adoption of alternative grazing strategies. Consider timing of planned burns and risk of rainfall events / flooding to reduce downstream impacts. Use ground cover crops to protect paddocks at flood risk during time of year when floods most likely.	On farm strategies to protect assets (e.g. firebreaks), fuel reduction burning on freehold land. Additional insurance Property level fire management plan. Increased effort on invasive plant and animal control after fires.

Case study – Bunguluke

The Bunguluke priority habitat area is approximately 20,000 ha and extends from Charlton in the south to Quambatook in the North. It includes the ephemeral wetland and the surrounding agricultural area. It predominantly consists of floodplain grasslands with isolated patches of semi-arid grassy woodland. It contains the lower branches of the Avoca River, including the Tyrrell, Lalbert and Back creeks, as well as extensive wooded drainage lines.

The Bunguluke area straddles the Avoca River between Charlton and Quambatook (L)

Modelling indicates that the area is highly vulnerable to the projected changes in the climate (R)

A 2012 assessment determined that 5,624 total ha of grasslands and 4,235 ha of grassy woodlands remained within the asset area. The area contains the highly threatened Kangaroo oat grass (*Themeda avenacea*). There are only four known populations in Victoria of which two are in the Bunguluke area, with one of these being the largest in the state.

The area also contains Buloke woodlands, a nationally listed Endangered Ecological Vegetation Community.

The area supports important fauna species such as the Carpet Python, the Plains Wanderer, the Golden Sun Moth, and populations of Grey-crowned Babblers. Bunguluke contains more highly connected Grey crowned Babbler habitat than any other area of Victoria.

Bunguluke is threatened by habitat destruction, cropping, overgrazing, pest plants and animals and climate change. Buffel grass and Wards weed are specific pest plants threatening the area. Lightning strikes and fire, new crop diseases and the declining population – resulting in less resources – also pose a threat.

The immediate actions to protect Bunguluke include fencing and grazing management, along with pest plant and animal control. The longer term options are discussed below.

Adaptation and Mitigation options for the Bunguluke area in a changing climate include:

- Identify and adopt existing crop varieties suited to drier conditions
- Partner with the R&D sector to develop improved crop varieties for use in this area
- Adopt low input and low risk grazing systems for both productivity and conservation
- Highlight to landholders the value of native grass grazing, particularly during drought
- Modify floodplain infrastructure to reinstate more natural hydrology
- Convert current cropland to grazing systems based on native perennials
- Introduce drier country species into the existing Red Gum system (e.g. Black Box, Eumong)
- Establish farm forestry plantations for firewood, carbon storage, bioenergy etc
- Actively put environmental water from the Waranga Channel into the wetlands
- Use water from the Wimmera Mallee pipeline for intensive agriculture
- Strategically purchase properties or management rights for conservation benefits (and use local management)
- Allow large-scale natural regeneration on the floodplain for carbon storage
- Identify and protect areas suitable for cropping that contain high value remnant vegetation
- Increase the extent and quality of the existing woodlands.

For further information on the Bunguluke priority habitat area see Appendix 8.3.

6 ADAPTATION PLAN

Guide to Chapter

6.1 Introduction

This chapter sets out the priorities and options to support adaptation to a drying, warming and more variable climate.

The approach used for adaptation planning has two broad elements:

- Development of adaptation options for individual priority RCS assets; and,
- Development of strategic adaptation options across broader areas, including region wide initiatives.

6.2 Current approaches to adaptation

The community workshops conducted during the development of this plan highlighted the fact that farmers are currently implementing a range of adaptation strategies to deal with climate variability.

As one farmer said, "*Most of the climate change predictions are happening now and we are dealing with them on a regular basis*."

Some mixed dryland farmers have already moved to different farming systems. As one Yandoit farmer described it, "*We have moved to a lower risk farming model. A bit of pasture cropping but no cropping in its own right. That is too high a risk. In 2009 we changed from all breeding to trading sheep. Now we tend to trade more animals. We have more feed so we can get into the market before the others. It flattens the profitability line but is more beneficial in the longer term. We have stubbles up north we can put the sheep on. Diversity is the key. We also have a 1,000 acre native grassland which has high conservation value that we are managing as part of our grazing system*."

Cropping farmers in the Charlton area are still buoyant about the future despite a failed season in 2014. As one farmer related, "*Farmers in the dry South Australian Mallee are still making money out of farming. We need to keep changing our thinking and approach to dryland farming. We have moved from fallows to direct drilling and will continue to change our practices.*"

"Most of us are responding to the variability now by planting earlier and using frost resistant and rust resistant varieties."

Soil carbon was an issue raised at all six landholder meetings and there is widespread recognition of the need to improve soil carbon levels, particularly in changing climate:

"Improving soil carbon is what we are doing as a result of climate change."

Horticulturalists who have experienced a number of extreme events in recent years are finding innovative ways to adapt.

"We are organic fruit growers at Harcourt. We have diversified our business and offer an on-line leadership program teaching fruit growing skills to backyarders and also run winter workshops."

Some mixed farmers are managing risk by buying and establishing complementary farming operations outside the region.

"There was a lack of irrigation water. For a period of time we could not get an allocation so we looked at our debt level and in 2002 we bought a farm at Skipton in the western district where there had been an average rainfall of 27 inches. We put on share farmers who taught us about managing that country and brought fodder and grain back here to maintain our continuity of supply."

The North Central CMA's 'Farming for Sustainable Soils' project highlights the importance of working together to solve local problems using the best available information and science. Farmers continue to adapt their farming operations in the face of climate variability as seen over recent decades. Adaptation strategies include:

- securing access to a more reliable water supply
- switching between enterprises (e.g. cropping and grazing)
- diversifying their source of income
- participating in field days and farm walks to improve their knowledge.

Farmers generally are optimistic about their ability to respond to relatively small incremental changes. This plan highlights the need to consider longer-term options in relation to a changing climate with even greater variability, including more frequent extreme events.

Irrigated lucerne is a foundation of the dairy industry and helps protect the soil.

6.3 Adaptation Plan for priority RCS assets

The results of the vulnerability assessment described in Table 6-1 have been considered in relation to priority assets identified in the North Central RCS. This analysis highlights that different assets are more or less vulnerable to climate change. The vulnerability ratings and the factors contributing to this are described in Table 6.1 for priority RCS assets.

Furthermore, the current threats are predicted to increase over time in response to specific climatic factors associated with climate change – e.g. reduced average rainfall or increased temperature. These effects may be direct or indirect. For example, fire regimes are likely to be directly increased by rising temperatures and indirectly increased by reduced winter/spring rainfall which leads to drier forest conditions over summer. The analysis in Table 6.1 highlights the degree to which threats to priority assets are likely to be amplified by future climate change.

Therefore the adaptation options outlined in Table 6-1 have been identified to improve the adaptive capacity of vulnerable assets, and to reduce the effect of future climate changes on the threats to these assets.

The purpose of these priorities and options is to assist natural resource managers, including organisations, community groups and landholders to make informed and robust decisions about potential impacts and strategic options for adaptation and to inform future planning and implementation programs associated with these assets.

Mitigation options, for example revegetation for carbon sequestration, are described in Chapter 7 and in many cases these options will also improve the adaptive capacity of priority natural assets in the region (see Table 7.3).

Vulnerability ratings in Table 6.1 for biodiversity, river and wetland assets have been calculated as the average across all affected pixels (for RCP 8.5 2070).

Rating	Score
VERY HIGH	(31-38)
HIGH	(22-30)
MODERATE	(13-21)
LOW	(7-12)
VERY LOW	(<12)

The 'Climate X Threat' ratings in Table 5-1 have been calculated through an analysis of the data in Table A2.2 in Appendix 2– High (3), Moderate (2) and Low (1) with the values multiplied.

Case study – Farming for Sustainable Soils

The Farming for Sustainable Soils (FSS) Project involves a sharing of knowledge which encourages positive change in farming practices. It does this by collaborating with the regional farming community to secure the adoption of sustainable land management practices that protect and enhance soil health.

Agronomist Christian Bannan, explaining the effects of different soil conditioners to the Lockington Soils Group on John Wright's property.

To date FSS has supported ten regional community groups and over 800 land managers in an effort to build a new approach to soil protection in north central Victoria. By working with groups of farmers with a well-established social capacity, soil landscape settings prone to water and wind erosion, a mix of agricultural enterprises and a willingness of landholders to actively participate, FSS is making a real difference to securing healthy and productive soils and resilient communities across north central Victoria. A case study of the Lockington Group provides valuable insights into how the project works and how this approach is supporting farmers in tackling soil health challenges. Building the capacity of farmers and dealing with problems collaboratively will also assist in tackling the challenges of climate change.

Lockington Sustainable Soils Group

The Lockington Sustainable Soils Group is located in the lower Campaspe catchment. The group covers an area within approximately a 20 km radius of Lockington, extending south towards Hunter, east to Rochester, west to Mitiamo and north west to the Patho Plains.

The group formed in October 2011 and soon after reached 45 members, all of whom contribute to renewed vigor within the farming community in the Lockington district. Wendy Sims, a local farmer and the group's facilitator, coordinates activities that support the participating local farmers in an effort to minimise the risk of soil erosion and explore opportunities to build soil carbon.

Wendy has a background in education and her farming experience and her organisational skills have been instrumental in growing the group and the member's participation in on-farm trials. Wendy says, "The beauty of this project is that the local community drives it. How we operate suits the local farmers. In fact we have never had a formal meeting, yet we get fantastic numbers to our field days and demonstrations which are all held on participating member's farms. There has been strong community interest in all our events.

"The community has been involved from the very beginning, identifying the soil health issues that matter locally and discussing the mitigation options. Information is also shared between our group and the other participating soils groups across the region. This is a really valuable part of the project. The sharing of knowledge and information is a vital ingredient which unites local communities with common interests.

"We have had a lot of interest in soil moisture probes scattered across the district. We post all the results on the Lockington Landcare soil moisture and weather monitoring website lockingtonlc.weebly.com). The website is optimised for use on a mobile phone so farmers can access data easily while in the field. The local farmers are fascinated by the variation in soil moisture for the different soil types and different management regimes.

"The project is also providing important social benefits for the local community and the opportunity to grow the next generation of leaders in agriculture. The project gives the older 'surviving' farmers with the opportunity to mentor the younger ones, who often come with very different ideas.

"We have a good spread of younger (fifth generation) farmers who recognise that the simple days of farming are gone where you plough the ground, sow the seed, and sit back and watch the crop grow. We have young farmers who left school after Year 11 to go back on the farm. For these guys the project is providing a valuable way to learn about the science of farming.

"I remember approaching one young progressive farmer and inviting him to join the group. He later asked me why he had been invited to join. When I explained, he really appreciated being recognised for 'having a go'. Being a part of the group has given him the confidence to keep pushing the boundaries.

"Probably only half the participating farmers use soil tests. But by providing an independent assessment of soil test results and discussing how to manage different soil types we are observing an empowering of farmers as they gain both knowledge and confidence. A good example is the quality of gypsum delivered to a farm. If it is delivered in big lumps our on-farm trials clearly show that it will never break down. Also the type of gypsum is important, you don't want to be spreading salt on your land. Armed with new knowledge the farmers are now questioning things a lot more. This can only be good for the future," says Wendy.

Wendy's final comment is on the relationship between the Lockington Soils Group and the North Central CMA. *"The CMA has kept the project red tape to a minimum and the farming community really appreciates this. The consultant who helped us put together our Local Area Soil Protection Plan did a great job of using the appropriate terminology that helped us access the available funding. All in all the project staff have been both approachable and flexible and this has contributed to the smooth running of the Lockington Sustainable Soils Group and our on-farm projects."*

Understanding soils is the key to protecting them.

Cover cropping on the region's broadacre farms is lifting crop yields and protecting the soil.

Table 6.1A *The relative vulnerability rating and the factors contributing to vulnerability for priority RCS rivers*

Asset Name	Vulnerability rating	Explanation of vulnerability rating	Climate X Threat Rating	Threats amplified by Climate Change	Asset Adaptation & Mitigation Options
Lower Avoca River	LOW/ MODERATE (13)	Unregulated river and floodplain likely to be impacts by rainfall deficit in winter/spring.	HIGH	Levees/barriers to natural flows, overgrazing & total grazing pressure, loss of native vegetation and habitat fragmentation.	• Investigate opportunities to reconnect river to floodplain. • Encourage natural regeneration of riparian vegetation (esp. River Red-Gum and Black Box) to sequester carbon. • Support ongoing programs to protect riparian values.
Upper Avoca River	MODERATE (18)	Unregulated river with flows likely to be impacted by rainfall deficit in winter/spring.	MODERATE	Overgrazing & total grazing pressure, erosion.	• Establish buffer plantings along riparian areas. • Protect aquatic refugia (pools and areas with intact native vegetation cover).
Lower Campaspe River	MODERATE (20)	Lower reaches of regulated rivers are less vulnerable with the ability to provide environmental flows.	VERY HIGH	Levees/barriers to natural flows, Altered flow regimes, overgrazing & total grazing pressure, weed invasion, invasive animals, loss of native vegetation and habitat fragmentation.	• Establish buffer plantings along riparian areas. • Protect aquatic refugia (pools and areas with intact native vegetation cover. • Manage environmental flows to maintain aquatic and riparian values.
Upper Campaspe and Coliban River	HIGH (20)	Upper catchment rivers are highly vulnerable to climate change impacts. Increase in temperature and reduced rainfall are likely to be the major drivers of change with reduced runoff and increased periods of low/no flow.	HIGH	Invasive animals, weed invasion, overgrazing & total grazing pressure. Development pressure (life style landholders).	• Establish buffer plantings along riparian areas. • Protect aquatic refugia (pools and areas with intact native vegetation cover). • Consider improvements to Local Government Planning Schemes to encourage sustainable development and water use.
Upper Loddon River	HIGH (27)				
Lower Loddon River	MODERATE (15)	Lower reaches of regulated rivers are less vulnerable with the ability to provide environmental flows.	VERY HIGH	Altered flow regimes Overgrazing & total grazing pressure, Weed invasion.	• Establish buffer plantings along riparian areas. • Protect aquatic refugia (pools and areas with intact native vegetation cover). • Manage environmental flows to maintain aquatic and riparian values.
Gunbower Creek	MODERATE (13)	Lower reaches of regulated rivers are less vulnerable with the ability to provide environmental flows.	HIGH	Altered flow regimes, Overgrazing & total grazing pressure, Weed invasion, High nutrient levels/degraded water quality.	• Establish buffer plantings along riparian areas. • Protect aquatic refugia (pools and areas with intact native vegetation cover). • Manage environmental flows to maintain aquatic and riparian values. • Targeted pest animal and aquatic weed control programs to improve adaptive capacity of system.

Table 6.2B *The relative vulnerability rating and the factors contributing to vulnerability for priority RCS biodiversity assets*

Asset Name	Vulnerability rating	Explanation of vulnerability rating	Climate X Threat Rating	Threats amplified by Climate Change	Asset Adaptation & Mitigation Options
Wedderburn-Wychitella (25) Inglewood (22) Rheola (22) Tottington (22) Moliagul (21) Kara Kara-Carapooee (20) Upper Avoca (23) Bealiba-Dalyenong (22)	MODERATE-HIGH (20-25)	Highly diverse box-ironbark ecosystem with good overall vegetation extent, but low in condition/quality.	MODERATE	Altered fire regimes, habitat fragmentation, total grazing pressure (introduced and native species).	Undergoing significant socio-economic change with decline in agricultural viability and increased amenity values. • Enable an ecological thinning program on both public and private land. • Implement an on-ground restoration program that achieves connectivity and increases the extent of native vegetation from 30% of the landscape to 50%. • Include some drier climate species and wider genetic material of existing species in revegetation programs. • Achieve a significant reduction in prescribed burning. • Reduce livestock damage, revegetate and manage the riparian zone along rivers in the asset area. • Implement large-scale carbon sequestration across landscape for biodiversity outcomes in targeted areas.
Pyramid Hill (23) Kamarooka (19) Northern Plains Woodlands (24)	MODERATE-HIGH (19-24)	Highly fragmented/ depleted vegetation types.	HIGH	Habitat destruction and fragmentation, overgrazing and weed invasion.	• Implement a large-scale carbon sequestration and biofuel production program to increase tree cover across the landscape.
Wandella (27) Gunbower (20) Dartagook (20)	MODERATE-HIGH (20-27)	Reasonably intact vegetation cover associated with floodplain environments.	MODERATE	Loss of native vegetation and habitat fragmentation. Reduced floodplain flooding.	• Capitalise on floodplain environments/water availability to sequester carbon (e.g. River Red Gum/Black Box regeneration). • Include some drier climate species and wider genetic material of existing species in revegetation programs. • Revegetate and manage the riparian zone along rivers in the asset area.
Muckleford (22) Maryborough – Paddy Ranges (21) Mid Loddon (21) Eppalock (21) Wellsford (21)	MODERATE (21-22)	Box-ironbark ecosystem with good overall vegetation extent, but low in condition/quality.	MODERATE/ HIGH	Habitat loss and fragmentation, over-grazing, altered fire regimes.	Undergoing significant socio-economic change with decline in agricultural viability and increased amenity values. • Enable an ecological thinning program on both public and private land. • Implement an on-ground restoration program that achieves connectivity and increases the extent of native vegetation from 30% of the landscape to 50%. • Include some drier climate species and wider genetic material of existing species in revegetation programs. • Achieve a significant reduction in prescribed burning. • Reduce livestock damage, revegetate and manage the riparian zone along rivers in the asset area. • Implement large-scale carbon sequestration across landscape for biodiversity outcomes.
Upper Loddon (22) Daylesford- Wombat (19) Kyneton Woodlands (22)	MODERATE (19-22)	Associated with higher rainfall areas of the Central Victorian Uplands.	MODERATE	Weed invasion, development pressure (life style landholders).	Transforming to a largely amenity landscape. • Establish large-scale carbon sequestration by planting biodiverse plantations/trees on poorer soils or along the riparian zone. • Examine drier country species for inclusion in the plantings. • Protect existing biodiversity hotspots (refugia). • Consider improvements to Local Government Planning Schemes to encourage sustainable development and water use.
York Plains (24) Lake Buloke (26).	HIGH (24-26)	High level of vegetation depletion & fragmentation in cropping/mixed farming areas.	MODERATE	Loss of native vegetation and habitat fragmentation.	• Opportunity for establishment of large scale carbon plantings – saltbush, oil Mallee, farm forestry and biodiverse plantings on marginally productive areas.

Table 6.3C *The relative vulnerability rating and the factors contributing to vulnerability for priority RCS wetlands*

Asset Name	Vulnerability rating	Explanation of vulnerability rating	Climate X Threat Rating	Threats amplified by Climate Change	Asset Adaptation & Mitigation Options
Gunbower Forest	HIGH (30)	Sensitive to reductions in floods and wide scale inundation, although Living Murray Infrastructure and delivery of environmental water will partly offset this.	HIGH	Altered flow regimes, Levees/barriers to natural flows, Invasive plants, Invasive animals.	• Implementation and monitoring of current environmental water management plan to improve the health of the wetlands and enhance the diversity of native flora and fauna. • Targeted actions to reduce the impact of invasive animals (e.g. carp) and aquatic weeds • Manage environmental flows to maintain aquatic and riparian values.
Kerang Ramsar wetlands	MODERATE (21)	Many Kerang Lakes wetlands are included in the regulated irrigation systems are less likely to be impacted. Unregulated lakes are at greater risk from reduced rainfall and flooding.	MODERATE	Altered flow regimes, Levees/barriers to natural flows, Invasive plants, Invasive animals.	• Support public and freehold land managers to implement works to manage threats and improve the adaptive capacity of wetlands • Encourage buffer plantings and natural regeneration. • Support the implementation of key actions identified in relevant Ramsar Plans.
Central Murray wetlands	HIGH (26)	Wetlands are less sensitive as they are able to receive environmental water.	MODERATE	Altered flow regimes, Levees/barriers to natural flows, Invasive plants, Invasive animals.	• Support public and freehold land managers to implement works to manage threats and improve the adaptive capacity of wetlands • Encourage buffer plantings and natural regeneration • Manage environmental flows to maintain aquatic and riparian values.
Mid Loddon wetlands	HIGH (24)	Wetlands are less sensitive as they are able to receive environmental water.	MODERATE	Levees/barriers to natural flows, Loss of native vegetation & habitat fragmentation, Overgrazing & Total grazing pressure.	• Investigate reinstatement of natural hydrology • Support public and freehold land managers to implement works to manage threats and improve the adaptive capacity of wetlands • Encourage buffer plantings and natural regeneration. • Manage environmental flows to maintain aquatic and riparian values.
York Plains wetlands	VERY HIGH (34)	High sensitivity to reductions in rainfall and increased temperatures. Moderate adaptive capacity of some wetlands due to relatively intact Red Gum overstorey.	HIGH	Levees/barriers to natural flows, Loss of native vegetation & habitat fragmentation, Overgrazing & Total grazing pressure.	• Implement works to manage threats from current land management practices (grazing, drainage, loss of native vegetation, invasive plants) and improve adaptive capacity in partnership with landholders.
Moolort Plains wetlands.	VERY HIGH (33)	High sensitivity to reductions in rainfall and increased temperatures due to predominant wetland types. Fragmented state in association with intensive cropping landscape has reduced adaptive capacity.	MODERATE	Levees/barriers to natural flows, Loss of native vegetation & habitat fragmentation, Overgrazing & Total grazing pressure.	• Support public and freehold land managers to implement works to manage threats and improve the adaptive capacity of wetlands • Reinstate natural hydrology for Long Swamp • Buffer Red Gum wetlands and encourage natural regeneration.
Kamarooka wetland complex	VERY HIGH (32)	High sensitivity to reductions in rainfall and increased temperatures due to predominant wetland types. Fragmented state in association with intensive cropping landscape has reduced adaptive capacity, as has presence of levees and drains.	VERY HIGH	Altered flow regimes, Levees/barriers to natural flows, Invasive plants, Invasive animals, Loss of native vegetation & habitat fragmentation, Overgrazing & Total grazing pressure.	• Implement a management plan that includes best practice, strategic grazing to reduce the risk of fire and enhance the diversity of wetland flora and fauna • Develop and implement an environmental water management plan to improve the health of the wetlands and enhance the diversity of native flora and fauna • Consider development of infrastructure to enable delivery of environmental water.

6.4 Supporting mitigation – carbon plantings and connectivity

Revegetation efforts by land managers, Landcare and community groups over recent decades have already made a significant contribution to increasing carbon stores, creating new habitat and protecting land and water assets. This together with active natural regeneration, especially through the Goldfields bioregion, is already mitigating climate change.

Future impacts on biodiversity under a warmer, drier climate will pose additional challenges and be felt at local and regional scales. Rebuilding connected, functioning landscapes and maximising the benefits provided by areas of high habitat value, will require further strategic linkages to be established across the region. These linkages will have benefits for local wildlife, for example woodland birds, support the movement of migratory species, and importantly provide a refuge for species impacted by the effects of climate change in areas beyond north central. They will also improve the resilience of riparian and terrestrial habitat and contribute to supporting essential ecosystems services.

The region's rivers are particularly important for future connectivity options, largely because of their existing intact riparian vegetation.

Wildlife corridors can help conserve biodiversity and strengthen landscapes in the face of climate change. They also help insure against climatic uncertainty through the conservation of a diversity of species and provision of alternative pathways for species' movement and adaptation. Naturally connected landscapes and ecosystems are generally healthier and can store carbon more effectively than degraded landscapes.

Naturally connected landscapes can store carbon more effectively than degraded landscapes.

Adaptation is already happening on many levels as land managers and communities respond to drought, flood and fire through a range of actions that minimise future risk.

6.5 Supporting communities to adapt

Adaptation is already happening on many levels – land managers and communities have been responding to drought, flood and fire through a range of actions that minimise future risk, improving water security and conserve high value agricultural soils. The work of many Landcare and community groups to buffer remnant vegetation and improve landscape connectivity is supporting adaptation of natural assets though improved participation and coordinated action.

Five broad areas have been identified where similar options apply because of generally similar land use and sociodemographic factors in the area. The strategic adaptation options are described as those that apply to the:

- Region
- Upper catchments in the region's south
- Goldfields
- Irrigated areas on the northern plains
- Broadacre farming systems in the west.

The options outlined here have been identified to support existing programs and initiatives of the Regional Catchment Strategy, but with a view to longer-term 'climate proofing' of the region's most valuable natural assets.

Figure 6.1 *A map of the North Central region's broad strategic areas for applying climate change adaptation and mitigation options.*

6.5.1 Region wide initiatives

At the regional scale a series of adaptation options have been identified under the following categories:

- **Extension** – Technology transfer, education, communication, demonstrations, support for community networks with a focus on land managers.
- **Incentives** – grants and direct financial support.
- **Research and development** – Development of improved land management options, e.g. through strategic R&D.
- **Planning Instruments** – working with Local Government and responsible authorities.
- **Knowledge brokering** – coordination of information provision and delivery across agencies and institutions
- **Capacity building** – support for increased community participation and involvement.

These options are outlined below.

Extension

- Implement projects in partnership with landholders to retain native vegetation, establish riparian buffers and manage wetlands.
- Encourage the protection of natural regeneration in key areas of connectivity
- Support the establishment of large-scale carbon plantings in key areas of connectivity.

Incentives

- Target incentive programs towards high value assets with high vulnerability and also high feasibility of protection and enhancement.

Research and Development

- Support policy and programs to address spread of new and emerging invasive plants, animals and other pathogens.
- Support the adoption of sustainable practices in grazing systems to sequester soil carbon and maintain groundcover.
- For wetlands throughout the region, investigate the likely tipping points and thresholds for the wetlands in the complex to inform management beyond the planning timeframe.
- Investigate the capacity of wetlands to sequester carbon.
- Evaluate the potential adverse impacts of large-scale revegetation initiatives (e.g. reduced water yield, bushfire risk).

Planning instruments

- Support the review of Planning Schemes to recognise vulnerable natural assets and potential sites for landscape connectivity and improvements in sustainable development in high demands areas in the south of the region.

Knowledge brokering

- Ensure better linkages and integration across agencies who manage the natural assets to achieve on-ground outcomes and outputs.
- Explore the role of the North Central CMA in coordinating and sharing knowledge, information and initiatives regarding to climate change.

Capacity building

- Implement a strategy that reduces demand for water and supports self-sufficient water use (both agricultural and semi-urban properties).
- Implement a research and capacity building program focused on the positive and negative aspects of flooding.
- Introduce a local community citizen science program to collect data on catchment health.
- Introduce a regional community citizen science program to collect data on catchment health and the impacts of climate change (e.g. changes in woodland bird populations as indicators of change).
- Continue to provide landholders with opportunities to learn new approaches that will support adaptation over time i.e. field days, farm walks etc

"Formal learning activities are increasing and are a real opportunity. We are seeing a lot more participants at field days and farm walks. The Federal and State governments should continue to fund projects and activities that increase participation."

(Charlton community workshop participant)

The Charlton community workshop highlighted many of the adaptations already taking place on cropping farms.

6.5.2 Upper catchments in the region's south

This area takes in areas associated with the upper catchment of the Loddon and Campaspe Rivers, in close proximity to regional centres including Daylesford, Kyneton and Trentham. Characterised by general higher rainfall and better soils, this landscape has been historically important for mixed farming and horticulture and contains significant areas of public land such as the Wombat State Forest. Like the box-ironbark landscape, it is undergoing major demographic shifts as land values increase for amenity and lifestyle living, at the expense of traditional farming activities.

The strategic options for the upper catchments are:

- Support programs that aim to reduce fire risk to communities and natural assets across public and freehold land.
- Introduce codes of practice that reduce demand for water and support self-sufficient water use (both agricultural and semi-urban properties).
- Establish large-scale carbon sequestration by planting biodiverse plantations/trees on poorer soils or along the riparian zone. Examine drier country species for inclusion in the plantings.
- Identify and protect existing biodiversity hotspots and refugia.
- Examine the groundwater resources available to secure a future water supply.
- Implement an incentive program to stabilise soils on agricultural land in water supply catchments.

We need to ensure there is recharge of the aquifers that supply drinking water and water for agriculture, and also feed the streams. "We used to water 200 acres with 60-70ML via a windmill on a surface dam. Then we sunk shallow bores (down to 30 metres) but they gave out. Now we are down to 80 metres and so far so good."

(Trentham workshop participant)

6.5.3 Goldfields

This area including the Box-Ironbark ecosystem of the Goldfields is undergoing significant socio-economic and demographic change. Historically important for fine wool production and mixed farming, there are now an increasing number of lifestyle properties and a burgeoning interest in nature conservation (Barr, 2005).

As the importance of commercial agriculture has declined, domestic livestock have been significantly reduced, with areas of marginal land now actively regenerating (Geddes, L. S., Lunt, I. D., Smallbone, L. T., & Morgan, 2011) to provide increased native vegetation cover and wildlife habitat (Smallbone, Matthews, & Lunt, 2014).

The strategic options for the Goldfields are:

- Implement a property planning and education program (with a sustainability focus) for land managers.
- Enable an ecological thinning program on both public and private land.
- Implement a scientifically rigorous, biodiversity monitoring program using woodland birds as a key indicator of ecosystem health.
- Implement an on-ground restoration program that achieves connectivity and increases the extent of native vegetation.
- Include some drier climate species and wider genetic material of existing species in revegetation programs.
- Put stricter controls on development in bushland areas or adjacent to public land
- Support the risk based approach to prescribed burns to protect the community and natural assets
- Manage grazing pressure along rivers to protect the riparian zone
- Support the development of mechanisms in local government planning schemes and the Victorian Planning Provisions (VPP) that identify and enable strategic biolinks.
- Implement large-scale carbon sequestration across the landscape.

"Build on shaded canopies along waterways. Riparian zine represents cooler spaces and green refuges."

(Castlemaine workshop participant)

6.5.4 Irrigation areas on the Northern Plains

This area takes in the productive mixed farming and irrigation areas to the north of Bendigo, including the alluvial plains of the Loddon and Campaspe rivers to where they join with the Murray River. This region has experienced significant drought and flood events over the past 20 years, and the restructuring of the irrigation industry has had a profound effect on the mix of farm businesses.

There has been a marked shift to dryland agriculture in areas that were historically irrigated. Water reform, water trade, climate variability, infrastructure reconfiguration and modernisation, together with fluctuating commodity prices have all resulted in significant structural change in the area.

Yet farmers have adapted, and many have continued farming profitably. This adaptive capacity is reflected in the results of the Innovative Farming Project landholder survey (North Central CMA, 2013) which found that irrigators would maintain a connection to the supply backbone and opportunistically irrigate (i.e. when water availability, climatic conditions and commodity prices were favourable).

This is essentially a risk management strategy where irrigators are using more water when it is affordable and commodity prices warrant its use. Less water is being used when it is scarce. The ability to move in and out of irrigation - and irrigate more or less of the farm area - according to water availability and returns means the area is well suited to adapt to an even more variable climate.

The strategic options for the Northern Plains are:

- Support initiatives to improve water security for irrigators whilst protecting flows for environmental outcomes
- Support adaptation of agricultural enterprises through extension, incentives and trials
- Support initiatives to improve on-farm water security (groundwater and surface water) and improve the environmental outcomes for wetlands
- Build or modify infrastructure to manage regulated or unregulated flows of water into the wetlands
- Opportunities for farm forestry, carbon planting on non-irrigated land
- Develop a set of protocols for how the wetlands may be adaptively managed, recognising that their values might change under a future climate
- Implement a knowledge program focused on best practice grazing management of the wetlands (recognising stock need water)
- Implement a Farming Systems program for all farmers in the area based on preparedness for the projected climate change scenario (e.g. new variety trials).

"There is an Irrigated Red Gum plantation downstream of Barham. The native regeneration on abandoned dairy farms could be managed for carbon."

(Echuca workshop participant)

6.5.5 Broadacre farming in the West

This area encompasses the important grazing and cropping enterprises in the western half of the region, bisected by the floodplains of the Avoca and Avon-Richardson river systems. Like the northern plains this area has experienced extended dry periods, broken by extreme rainfall and flooding in recent times. This region, with limited surface and groundwater resources is perhaps more exposed than most with projected reductions in average annual rainfall and higher temperatures.

"We would have had a lot more crop droughts without the machinery we've got today. There are a lot of crops grown on minimal rainfall. There is a lot more variability in thunderstorms. If you are lucky enough to be under one you can do OK."

(Farmer, Charlton)

The strategic options for the West are:

- Support adaptation of agricultural enterprises through a range of tools that may include extension, incentives and trials.
- Work with R&D sector to develop improved crop varieties for use in this area.
- Use water from the Wimmera Mallee pipeline for intensive agriculture.
- Adopt low input and low risk grazing systems for both productivity and conservation.
- Increase the summer dominance of the grasslands by strategic grazing.
- Explore the modification of floodplain infrastructure to reinstate more natural hydrology where feasible.
- Allow large-scale natural regeneration on the floodplain for carbon storage.
- Explore the use of drier country species into the existing Red Gum system (e.g. Black Box, Eumong) through strategic revegetation.
- Establish farm forestry plantations for firewood, carbon storage, bioenergy etc.
- Support strategic purchase of properties or management rights for conservation benefits (and use local management) in collaboration with NGOs such as Trust for Nature, Bush Heritage.

7 MITIGATION OPTIONS

Guide to Chapter

Climate change mitigation involves direct actions to reduce the rate at which climate change is occurring by decreasing the amount of greenhouse gases (e.g. emission reductions) and/or increasing the sequestration of carbon through activities such as revegetation and soil storage.

Carbon sequestration is the general term used for the capture and long-term storage of carbon dioxide. Capture can occur at the point of emission (e.g. from power plants) or through natural processes (such as photosynthesis), which remove carbon dioxide from the earth's atmosphere and which can be enhanced by appropriate management practices. Sequestration methods include:

- enhancing carbon storage in soil (soil sequestration)
- enhancing the storage of carbon in forests and other vegetation (plant sequestration)
- storing carbon in underground geological formations (geosequestration)
- storing carbon in the ocean (ocean sequestration)
- subjecting carbon to chemical reactions to form inorganic carbonates (mineral carbonation).

In the context of this Plan, there is a range of activities, such as investment in renewable energy sources or transition away from high emission farming systems, which will decrease regional carbon emissions. This chapter however, will focus on sequestration activities that have the ability to increase carbon storage in plants and soils, whilst protecting the values of high value regional assets including rivers, wetlands, terrestrial habitat and agricultural land.

Native vegetation and agricultural land are important to climate change mitigation. Firstly because of the significance of their carbon stock and secondly because their exchange of greenhouse gases between the atmosphere and soils and vegetation can go both ways. Many human activities such as logging, fuel reduction burning, grazing of livestock or cultivation, influence the exchange of greenhouse gases with the atmosphere and ultimately the overall regional carbon footprint.

Carbon dioxide (CO_2) differs from the other major greenhouse gases in that the carbon can be stored in large quantities in the various carbon pools in vegetation, soils and living organisms.

Mitigation options have been considered within the context set by the Australian Government in outlining the Principles that should underpin regional planning for climate change, including:

- identifying priority landscapes for carbon plantings
- identifying strategies to build landscape integrity
- guiding adaptation and mitigation actions to address climate change impacts on natural ecosystems
- avoiding adverse impacts associated with carbon in the landscape.

7.1 Vegetation

New tree plantings can be established in the landscape to sequester carbon dioxide and help-offset greenhouse gas emissions. Revegetation provides a suite of benefits for biodiversity, water quality and timber production, but it is also realised that long-term plantings will be affected by climate change as will flora and fauna, land and water degradation from salinity and rates of timber production.

Biodiversity benefits are often highest (due to better soil and moisture availability) in riparian zones, where much of the current revegetation effort associated with improving waterway health in the region has been successfully focused.

Commercial forestry is best suited to high-rainfall areas. Commercial plantings are likely to accumulate carbon fastest, but are also the most likely to be harvested, so may ultimately stabilise at lower levels of sequestered carbon than permanent plantings in lower rainfall areas. This suggests that high rainfall plantings will give the best short-term benefits but that slower growing plantings subject to minimal harvesting may take over as good long term sinks for carbon (Polglase et al., 2011).

It is also important to appreciate interactions between revegetation, water and climate change. The potential impacts of climate change include reduced runoff, streamflow and ultimately, security of water supply, due to lower rainfall and higher evaporation. Even where rainfall does not change significantly, higher potential evaporation will still contribute to net decreases in runoff. As has been demonstrated in other high rainfall catchments, revegetation will reduce runoff independently of climate change, but will add to the losses caused by climate change (Jones et al, 2006). The potential for adverse impacts, such as reduced water yield, increased risk of wildfire and reservoirs for pest plant and animal invasion should be considered in the context of revegetation programs.

While reforestation for carbon outcomes has received much attention in recent years, Polglase et al. (2011) concluded that under current or plausible future market and policy conditions that few areas are economically viable for carbon forests in Australia and that additional incentives may be needed to target tree establishment in areas which will have other environmental benefits such as biodiversity. Furthermore, where carbon plantings are likely to be more economically viable, other land uses are also likely to outcompete them.

In summary the analysis highlights that large scale carbon planting on arable land is not likely, at least under current policy settings, so revegetation should be encouraged where environmental benefits are highest. This is most likely be achieved through targeted plantings associated with rivers and wetlands, and to buffer existing native vegetation to enhance connectivity.

7.2 Soil

On a global scale soil is estimated to contain three times as much carbon as the atmosphere and nearly four times as much as contained in living matter (Lal, 2002).

However, the carbon content of many agricultural soils has declined over time and there are some estimates of significant opportunities for carbon sequestration through changes to land use and land management (Lal, 2002). The amount of additional carbon sequestered when a new management practice is adopted depends on the initial carbon content, the practice, soil type and climate.

There is much uncertainty and debate, particularly within Australia, around the role of soils in carbon sequestration. This includes issues such as; the total potential of agricultural soils to store additional carbon, the rate at which soils can accumulate carbon, the permanence of the stored carbon, and how best to monitor changes in soil carbon stocks (Sanderman et al, 2010).

Improving soil carbon stocks on agricultural land in the North Central region is strongly linked to the adoption of improved management practices, such as reduced tillage in cropping and horticultural systems or rotational, as opposed to set-stocking, grazing in sheep and beef cattle enterprises.

"We need to sell the soil health benefits of carbon."

(Workshop participant, Castlemaine)

"The whole carbon issue is awfully complex. Measurement and payment is still too daunting."

(Workshop participant, Echuca)

"How far am I from farming carbon on my farm? I want to know whether we are doing it right or wrong now?"

(Workshop participant, Lockington)

Recent research in Australia suggests that improvements in soil carbon from changed land management are likely to be modest. For example Sanderman et al (2010) suggest that on average, improved management of cropland, whether enhanced rotation, adoption of no-till or stubble retention, has resulted in a relative gain of 0.2 – 0.3 metric tonnes per year (Mg C ha-1 yr-1) compared to conventional management across a range of Australian soils. Significant increases in soil carbon are unlikely without more radical shifts in land use.

It is important to note that many of the options available to primary producers to increase soil carbon, for example stubble/biomass retention in cropping and grazing systems, are seen more generally as key strategies in the development of more profitable and sustainable farming systems. The adoption of these practices is not currently being driven by a motivation to participate in initiatives such as the CFI, but rather as a means of achieving long term farm viability and profitability. An overview of the relative potential of a range of land management and land use options for increasing soil carbon sequestration rates is provided in Appendix 5.

The region's soils which are now used for productive agriculture mostly developed under deep-rooted perennial tree, shrub and grass cover, which was largely removed 100-150 years ago to reduce competition for annual crops and pastures. This change in groundcover and land management can lead to potential adverse consequences for these soils because contemporary winter-active, mainly shallow-rooted annual pasture systems do not always use all the water available to them. This can result in an increasing likelihood of soil structure decline and salinisation; and exacerbating or extending periods of waterlogging. These conditions may be able to be reduced through management practices tailored to soil types that aim to increase biomass yield with positive flow-on benefits in the form of soil carbon accumulation.

One option highlighted by primary producers during the consultation phase, involves the adoption of pasture cropping in tandem with rotational grazing systems. This technique has shown promise (Seis, 2007) in increasing biomass in the pasture-crop system, leading to a reduction in both soil water and nitrogen availability, with potential to reduce the risk of waterlogging, and loss of nitrogen through denitrification or nitrate leaching. Higher groundcover in the pasture-crop system may also reduce the risk of soil erosion. Furthermore there is an opportunity to increase soil organic carbon by converting cropping land to permanent pasture, increasing the frequency of pasture phases, changing crop fertiliser regimes and reducing bare ground in pastures (Badgery et al, 2014).

Changes to farming systems are integrally linked to considerations of profitability and long-term sustainability of practice changes. Farmers are unlikely to adopt new practices for increasing soil carbon unless they are seen to increase (or at least maintain) profitability, reduce risk and lead to improvements in their overall soil assets. Continued investment in research and development, such as trials and farm-level economic analysis will provide future insights into the 'best-bet' mitigation options for the region's valuable agricultural soils.

7.3 Carbon farming

The Australian Government program for carbon mitigation with relevance to natural resource management and agriculture is the Carbon Farming Initiative (CFI) (Australian Government 2015).

The CFI allows farmers and land managers to earn carbon credits by storing carbon or reducing greenhouse gas emissions on the land. These credits can then be sold to people and businesses wishing to offset their emissions. The CFI also helps the environment by encouraging sustainable farming and providing a source of funding for landscape restoration projects.

The scope of emissions avoidance and sequestration activities that may be eligible under the Carbon Farming Initiative is defined under the Carbon Credits (Carbon Farming Initiative) Act 2011.

There are a number of CFI approved methods (see Appendix 5 for details).

In order to inform this Plan, a preliminary evaluation of these options has been completed with respect to:

- The carbon sequestration potential of specific options
- Alignment with the objectives of the RCS and the relevance of different options to priority assets
- An assessment of the costs and benefits associated with these options, including a consideration of feasibility, risk and adverse impacts.

Table 7-1 summarises the results of this evaluation together with a brief description of the methods.

***Table 7.1** Carbon Sequestration options for natural assets*

Asset type	Carbon sequestration options	CFI Methodologies
Native vegetation (terrestrial)	• Biodiverse plantings • Natural regeneration • Farm forestry, including woodlots and Mallee plantings • Environmental plantings	• Human-Induced regeneration of a permanent even-aged native forest • Reforestation by Environmental or Mallee Plantings - FullCAM
Rivers	• Riparian plantings • Natural regeneration	• Environmental plantings • Human-Induced regeneration of a permanent even-aged native forest
Wetlands	• Grazing control promoting reestablishment of natural wetland • Vegetation – Buffer plantings – Natural regeneration	• Environmental plantings • Human-Induced regeneration of a permanent even-aged native forest
Soils	• Changed land use – cropping to grazing • 'Improved' cropping systems e.g. no-till • Changed management of grazing land	• Sequestering carbon in soils in grazing systems

7.4 Carbon sequestration options for the North Central region

This Plan will help guide the types and locations of carbon farming and biodiversity activities to help maximise the benefits for biodiversity, water and agricultural production in the region. An adaptive management approach and continued improved strategic planning will ensure development of NRM co-benefits such as maintenance of ecological processes, landscape connectivity and resilience, and wildlife corridors from carbon sequestration projects.

The consideration of carbon mitigation options in this Plan has been made with the objective of enhancing ecological processes, for example, natural regeneration, primary productivity, hydrological processes, formation of biophysical habitats, interactions between species, movements of organisms and natural disturbance regime, together with a need to understand and minimise any potential negative consequences, such as increased fire risk and reduced water yield.

Mitigation options within this Plan will largely be focussed on options to sequester carbon (as opposed to options that aim to reduce emissions of greenhouse gases). With respect to carbon sequestration there are a limited suite of actions that are suitable for the respective natural asset types. These are categorised in Table 7.1 with those relevant to approved CFI methodologies highlighted.

7.4.1 Biodiverse plantings

Biodiverse plantings typically involve establishment of indigenous vegetation through tubestock or direct seeding methods on a range of sites from 'greenfield' to areas with scattered remnants. In recent years there has been a focus on re-establishing the vegetation that occurred prior to clearing, in the form of Ecological Vegetation Classes (EVCs), for which detailed prescriptions exist. These types of plantings have been generally proven to be most beneficial for fauna and maintenance of local ecological processes, however, the degree of site modification plays a key role in what will succeed best in certain locations.

7.4.2 Natural regeneration

Natural regeneration means allowing or assisting the bush to grow back by itself. Generally it is the most effective and most economical way to expand patches of native vegetation and improve their condition. Where existing native seed sources exist, grazing by introduced species, especially sheep, cattle, rabbits and native species, especially kangaroos and wallabies is the key inhibitor of natural regeneration. Existing weed loads, also play a role in reducing the potential of areas to naturally regenerate.

Natural regeneration can be promoted through reducing the intensity of threatening processes, especially overgrazing, weed invasion and soil compaction, allowing existing seed sources to respond and recolonise areas. It is important to note that the past disturbance history plays a significant role in the structure, function and ultimate values of these regenerating areas. In some cases 'unwanted' effects may result, such as the establishment of even-aged thickets of eucalypts on large areas of abandoned grazing country. Ecological research is currently occurring on the biodiversity values of natural regeneration (Smallbone et al., 2014), together with improving our understanding of its socio-economic drivers and perceptions of value and risks associated with the phenomenon (Barr, 2005).

Farm forestry is an appropriate action to increase carbon storage in vegetation.

Across much of central Victoria in recent years a combination of prolonged drought followed by flooding, together with a decline in the viability of the wool industry, has seen a significant regeneration event (Geddes et al, 2011). Largely associated with the Box-Ironbark ecosystem of the Goldfields Bioregion this has the potential to sequester large amounts of carbon in the future. Natural regeneration along the floodplains of the region's major river systems has also been evident.

See http://ianluntecology.com/2013/06/13/natural-regeneration-connecting-regional-australia/ for a broad ranging discussion on the nature and benefits of natural regeneration.

Barr (2005) classified most of central, north-eastern and parts of eastern Victoria as a "rural amenity landscape" zone, in which traditional agriculture was being actively replaced by rural lifestyle development; other areas of the state were in "transition" towards this "amenity landscape" stage.

7.4.3 Farm forestry

Farm forestry means different things to different people. Essentially however, it is the incorporation of commercial tree growing into farming systems. It can take many forms, including timber belts, alleys and widespread tree plantings. Farm forestry can provide farmers with an alternative source of income, through the sale of wood products such as sawlogs, firewood and bioenergy. It can improve agricultural production by providing shelter for stock and crops and can provide substantial environmental benefits such as salinity control.

One specific farm forestry option, Oil Mallee (encompassing a suite of mallee eucalypt species) has been promoted and planted in Australian dryland agricultural systems for various environmental benefits, including erosion control, salinity mitigation and biodiversity. They have significant, but as yet largely unrealised woody crop industry. Small areas of plantings have occurred in the North Central region over the past 20 years.

Farm forestry is almost always established with the intent of future harvesting, often with the ability of rootstocks to regrow to produce additional crops. Any potential carbon sequestration benefits must therefore account for the impact of harvesting rotations.

"Growing biomass remains the only proven method for sequestering carbon. As such, any coherent approach to ameliorating the worst impacts of climate change must include the drawing down of atmospheric carbon through the planting of additional vegetation. Using purpose grown biomass for production of energy, furniture or building materials has the potential to yield ongoing additional carbon sequestration. This approach should also link purpose grown carbon plantations with economic activity on the part of land managers, providing an economic driver for carbon sequestration."

(Workshop participant, Trentham)

7.4.4 Riparian plantings

Riparian plantings are essentially a subset of biodiverse plantings associated with waterway restoration. Located in the most fertile parts of the landscape with high moisture availability, riparian areas usually offer excellent conditions for tree growth and carbon sequestration. Extensive river restoration works have been undertaken along the region's rivers since the establishment of the North Central CMA in 1997 (refer Loddon River Case Study Page 25).

7.4.5 Grazing management

Grazing of agricultural lands by sheep and cattle is a prominent feature of the regional landscape. The timing and intensity of grazing can influence pasture groundcover and soil carbon levels. Changes in grazing management in areas associated with remnant vegetation, riparian areas and wetlands can be an important mechanism in allowing natural regeneration in areas with important biodiversity values. The role of grazing in relation to soil carbon more generally is covered in Section 7.2 above.

Extensive river restoration works have been undertaken along the region's rivers in the last 20 years.

7.4.6 Changed land use – cropping to grazing

Recent years have seen significant shifts in the pattern of grazing and cropping enterprises across the region. A drop in average rainfall (associated with the Millennium drought) and a trend towards larger, episodic summer events has spurred an increase in cereal and oilseed cropping, particularly in the north of the region. Long-term conversion of pasture to cropland will lead to an overall decrease in soil carbon. History shows that such shifts are often not long-term and there is anecdotal evidence that the pendulum is already swinging back in some area to 'mixed farming' systems. The large-scale drivers of these trends are a combination of financial returns and risk, rather than the perceived environmental benefits associated with sustainable grazing systems.

Within cropping systems themselves there has been widespread adoption of 'no-till or minimum-till' technologies over the past 20 years, involving less cultivation and stubble burning, with consequent increases in soil carbon storage.

7.5 Assessing carbon potential

An assessment was made of the carbon sequestration potential associated with establishment of new environmental plantings across the region. This assessment was based on the relative potential of biodiverse plantings to sequester carbon according to the specific Ecological Vegetation Class (EVC) appropriate to the landscape location of the proposed plantings.

The carbon sequestration potential of terrestrial vegetation depends on the type and condition of the vegetation, that is, species composition, structure, and (in the case of forests) age distribution. Also important are site conditions, including climate and soils, natural disturbances, and management.

Under the CFI Methodology Determination, abatement is calculated as the change in the amount of carbon stored in a project area (through growth of trees, natural decay and disturbance events such as fire, pests, disease and storms), minus emissions resulting from fire, and minus emissions from fuel used to establish and maintain the project (Australian Government, 2012).

While there has been a great deal of research into the carbon sequestration potential of different ecosystems, especially forests, there is significant uncertainty associated with absolute values, expressed as tonnes of CO2/yr for different ecosystem types.

For this reason we established a relative scaling approach to assign values (from 1 - 5) according to different EVGs across the North Central region. For example wet forest was assigned a value of 5, herb-rich woodlands a value of 3 and grassland a value of 1. These values were then moderated for rainfall and temperature by applying a multiplier according to the bioregion. For example herb-rich woodlands in the Central Victorian Uplands Bioregion, with higher rainfall and better soils were given a multiplier of 1, while the same vegetation in the Goldfields Bioregion was given a multiplier of 0.8 to adjust for the lower average rainfall and less fertile soils. The results of this analysis are shown in Figure 7.1.

The analysis highlights that the areas with greatest potential for carbon sequestration through native vegetation establishment (on per hectare basis) are in the southern parts of the catchment along the Great Dividing Range, locations associated with floodplain systems.

7.6 Carbon options assessment for priority assets

While a range of different options are possible for increasing carbon stocks in soil, terrestrial and aquatic environments have been outlined above, four have been assessed as particularly relevant to the priority assets in the North Central RCS. These are:

1. **Grazing system change** – to increase soil carbon in broad acre beef and sheep production systems as a result of implementing management actions such as reduced stocking rates, rotational grazing.
2. **Environmental plantings** – to increase terrestrial carbon stocks through revegetation, especially along rivers and to buffer and connect high value remnant vegetation.
3. **Human induced natural regeneration** – to increase carbon stocks associated with existing native habitat or in areas suitable for land use change such as marginally productive or degraded areas.
4. **Farm forestry**, especially mallee plantings with the ability to sequester carbon in lower rainfall broad acre land systems.

Table 7.2 outlines the potential for implementation of four carbon sequestration options across the priority asset areas. It is important to note that this analysis is not a measure of the amount of carbon sequestered, but rather a rating of the applicability of the options.

For each priority asset an expert assessment was made on the relative value (High, Medium or Low) that mitigation actions would contribute to improving overall landscape connectivity.

Grazing system changes can increase soil carbon in broad acre production systems.

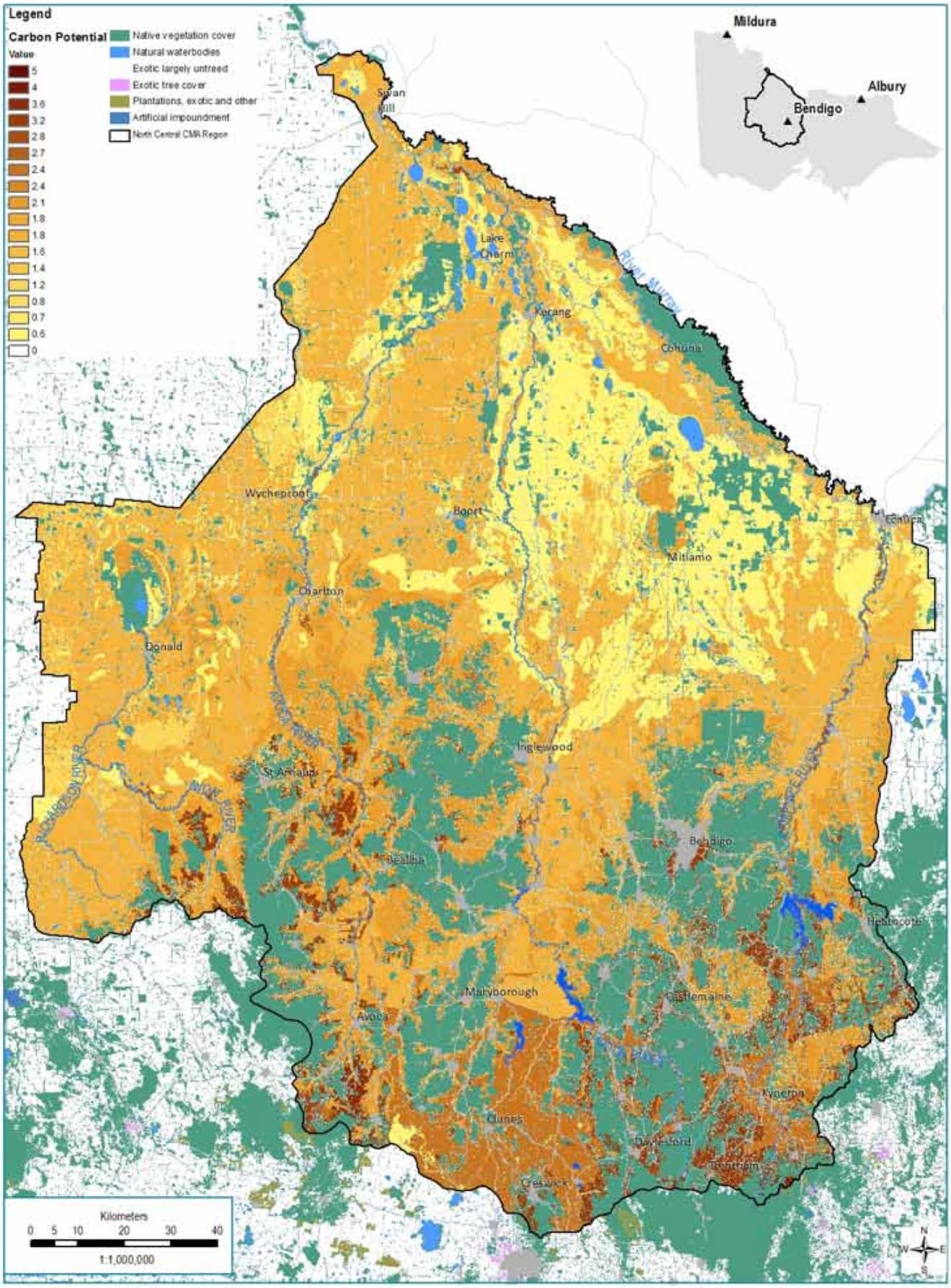


Figure 7.1 *Map of Carbon Potential across the North Central region*

***Table 7.2** Assessment of Carbon mitigation options for priority assets in the North Central region*

Asset type	Priority Asset	Grazing system change	Environmental plantings	Human induced natural regeneration	Mallee plantings	Connectivity requirement (H,M,L,N)
Rivers	Lower Avoca River	✓	✓	✓		H
	Upper Avoca River	✓	✓	✓		H
	Lower Campaspe River	✓	✓	✓		H
	Upper Campaspe and Coliban River	✓	✓	✓		M
	Lower Loddon River	✓	✓	✓		H
	Upper Loddon River	✓	✓	✓		M
	Gunbower Creek		✓	✓		M
Wetlands	Gunbower Forest		✓	✓		L
	Kerang Ramsar Wetlands		✓	✓		L
	Central Murray Wetlands		✓	✓		M
	Mid Loddon Wetlands	✓	✓	✓		M
	York Plains Wetlands	✓	✓	✓		M
	Moolort Plains Wetlands	✓	✓	✓		M
	Kamarooka Wetland Complex	✓	✓	✓		M
Native habitat	Lower Avoca Grasslands	✓				L
	Patho Plains	✓				L
	Bunguluke	✓	✓	✓	✓	M
	Wedderburn – Wychitella	✓	✓	✓	✓	H
	Bealiba – Dalyenong	✓	✓	✓	✓	H
	Pyramid Hill	✓	✓	✓	✓	M
	Wandella	✓	✓	✓	✓	M
	Northern Plains Woodlands	✓	✓	✓	✓	L/M
	Mid Loddon	✓	✓	✓		M
	Upper Loddon	✓	✓	✓		H
	Inglewood-Rheola	v	✓	✓	✓	H
	Tottington	✓	✓	✓	✓	H
	Maryborough – Paddy Ranges	✓	✓	✓		H
	Moliagul	✓	✓	✓	✓	H
	Kara Kara – Carapooee	✓	✓	✓	✓	H
	Muckleford	✓	✓	✓		H
	Eppalock	✓	✓	✓		H
	Wellsford	✓	✓	✓		H
	Kamarooka	✓	✓	✓	✓	H
	York Plains	✓	✓	✓	✓	M
	Daylesford-Wombat		✓	✓		H
	Upper Avoca	✓	✓	✓		H
	Kyneton area woodlands	✓	✓	✓		M
	Gunbower		✓	✓		L
	Dartagook		✓	✓		M
	Lake Buloke	✓	✓	✓	✓	L/M

Note: Connectivity requirement – Qualitative judgement made on the relative benefit to the asset of improving landscape connectivity through revegetation, both within asset zone and linkages to other priority assets.

Table 7.2 Legend:

✓	Potential not rated	NA	Not appropriate
✓	High carbon potential	H	High
✓	Moderate carbon potential	M	Moderate
✓	Low carbon potential	L	Low

7.7 Connectivity Planning

There is growing recognition that in order to rebuild connected, functioning landscapes and maximise the benefits provided by areas of high habitat value, it is necessary to strategically link these areas across all lands (Australian Government, 2012).

Landscape fragmentation reduces the capacity of species and ecosystems to adapt to altered climatic conditions. In the North Central region, historical clearing has reduced the overall extent and condition of native vegetation to a significant degree, reducing the ability of significant species to remain viable. The future impacts of climate change pose additional challenges for such species.

Wildlife corridors are one of the most effective tools available for conserving biodiversity and strengthening landscapes in the face of climate change. They can help insure against climatic uncertainty through the conservation of a diversity of species and provision of alternative pathways for species' movement and adaptation. Naturally connected landscapes and ecosystems are generally healthier and can store carbon more effectively than degraded landscapes. Establishing a network of wildlife corridors can help create and protect natural stores of carbon in the environment and contribute to mitigating the effects of climate change (Australian Government, 2012).

Bennett et al. (1992) found that the parks and reserves estate is relatively well located in relation to climatic refugia but with a major gap in central Victoria and along the Murray River. The elevated areas of central Victoria and its east-west orientation appear significant at the continental level, particularly for woodlands if connectivity could be restored.

The location of a number of priority biodiversity areas throughout the Box-Ironbark ecosystem (North Central RCS, 2013), highlight the opportunity to build east-west connectivity between these nodes, as well as using augmenting existing riparian corridors along the Loddon, Campaspe and Avoca river systems to enhance north-south connectivity. Woodland birds, regarded as a high value component of the Goldfields and Victorian Riverina bioregions are likely to benefit from improved connectivity as they seek to adjust their range in response to climate change (Stephen Garnett and Donald Franklin, 2014).

Connectivity Planning is also a feature of the work of NGOs such as Trust for Nature. A number of planning tools and mapping products have been developed to assist with conservation planning (Trust for Nature Statewide Conservation Plan, 2013).

Whilst the ecological need for improving landscape connectivity has been well established a number of philosophical, technical, practical and socio-economic considerations exist.

For example:

1. What values are most important in building connectivity across the landscape?
2. How much more habitat, and of what quality is sought to be established and improved as a result of connectivity projects?
3. Where is this habitat to be located and what are the implications for existing land management in these areas?
4. What are the most cost-effective strategies for establishing wildlife corridors?
5. What is the potential for adverse (e.g. increased bushfire risk) or perverse (increased predation by feral animals) impacts associated with wildlife corridors?

In developing this Plan, a set of indicative linkage zones have been identified (See Figure 7.3) to enhance landscape connectivity. These areas have been identified on the basis that they will:

- Complement high value biodiversity assets identified as priorities in the RCS.
- Improve the adaptive capacity of high value biodiversity assets that are vulnerable to climate change.
- Contribute to enhanced north-south and east-west connectivity at a landscape-scale.
- Minimise the potential for adverse impacts.

Revegetation efforts by land managers, Landcare and community groups over recent decades have already made a significant contribution to increasing carbon stores, creating new habitat and protecting land and water assets.

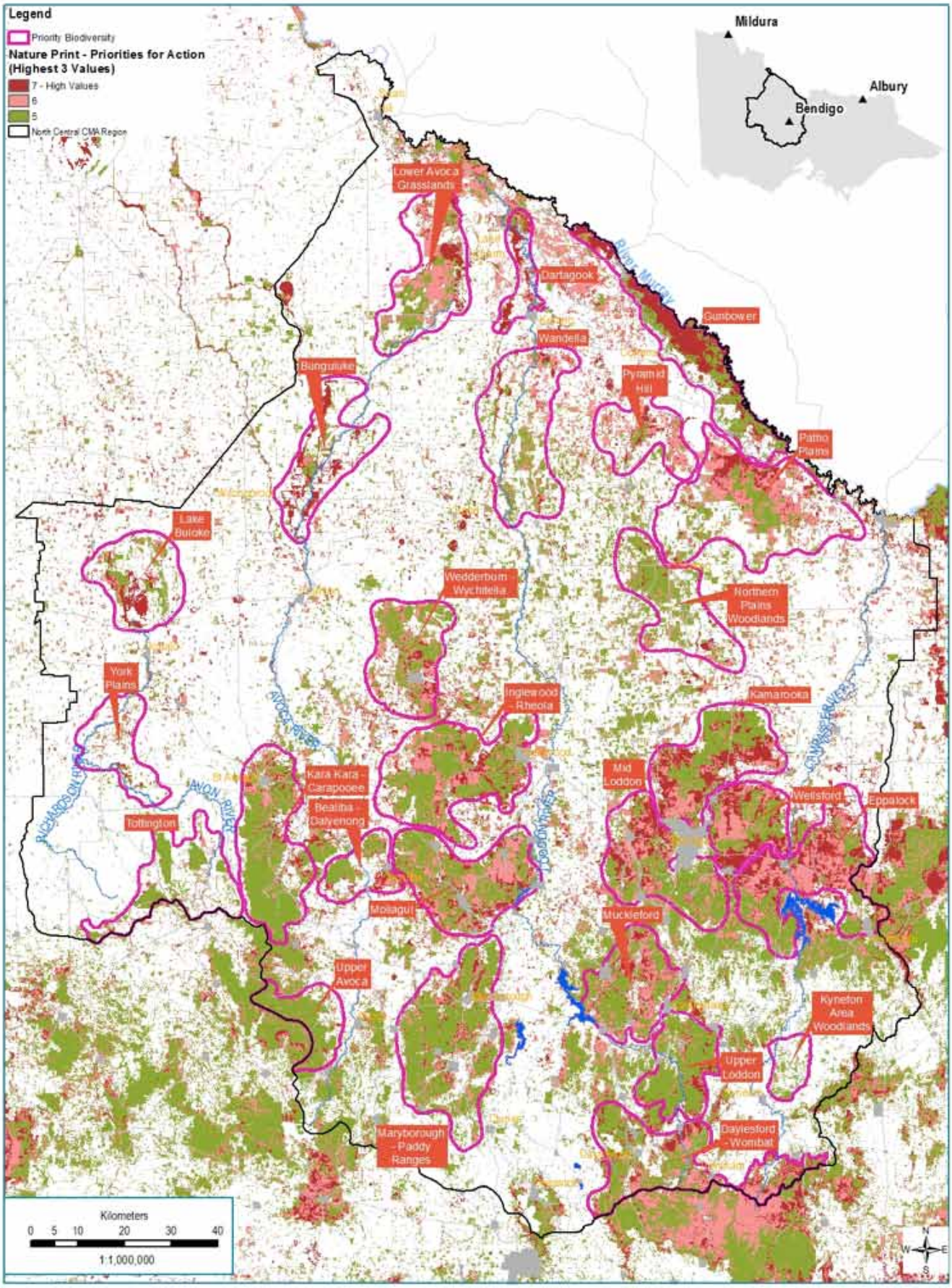


Figure 7.2 *Map of the high value biodiversity assets identified as priorities in the North Central RCS*

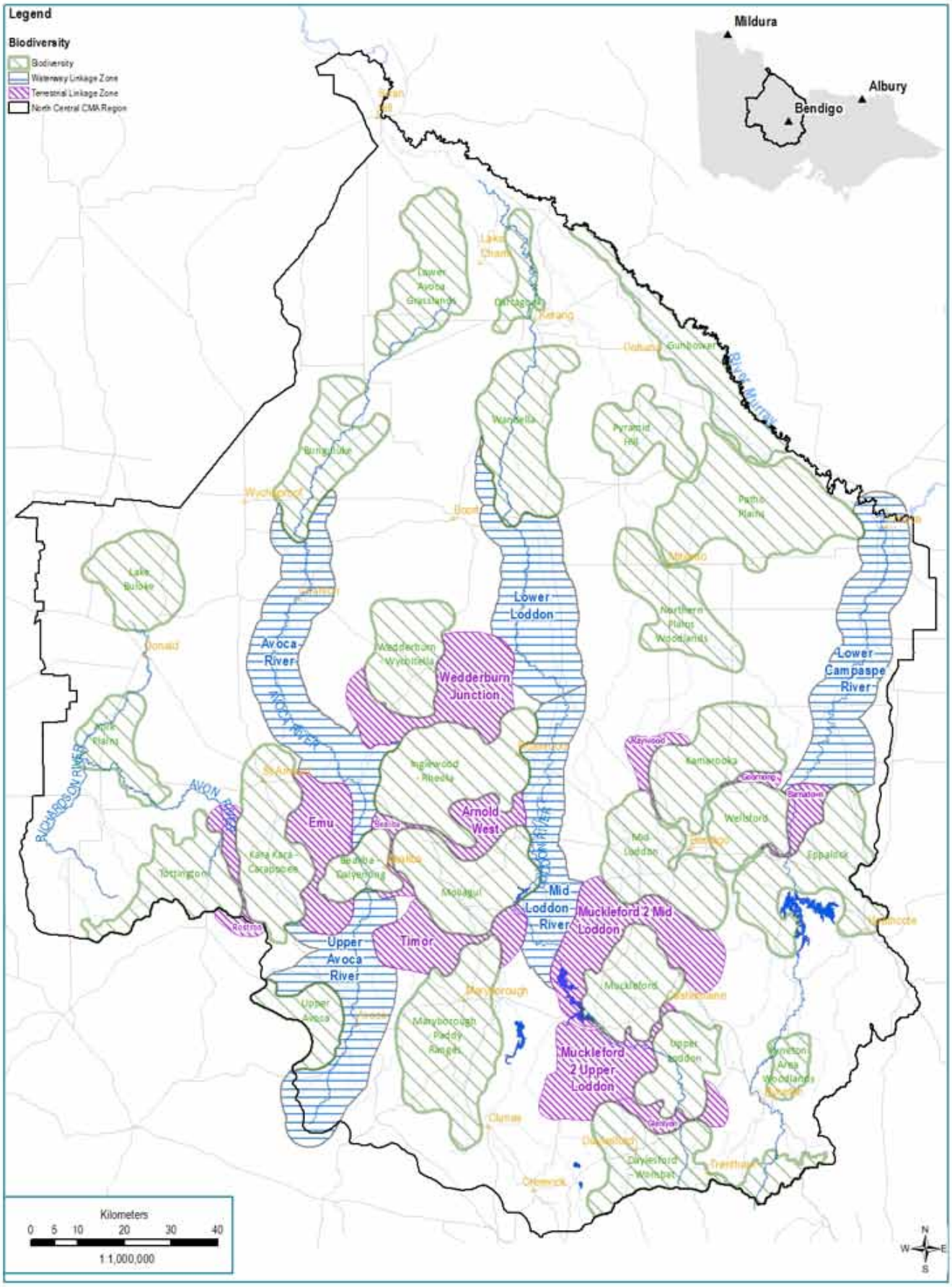


Figure 7.3 *Map of Biodiversity assets showing connectivity options and linkage zones*

In order to assess the potential benefits (and costs) of enhancing connectivity, a preliminary analysis of both priority asset areas and associated linkage zones has been undertaken to inform future project implementation. The results of this analysis are set out below, summarising the benefits and risks associated with connectivity projects in the respective areas.

In each case, the assessment has been assisted by preliminary modelling of habitat establishment that is focused on increasing extent by establishing newly vegetated buffers around existing remnant patches and along riparian areas.

The benefits of each area have been rated (High, Medium, and Low) according to the following criteria.

1. **Carbon** – what is the relative amount of carbon sequestered?
2. **Fauna** – to what extent does the work benefit significant and threatened species of fauna or faunal groups such as woodland birds?
3. **Allied NRM benefits** such as improved water quality and enhanced aquatic ecosystems.

The risks associated with each area have been rated (High, Medium, and Low) according to the following criteria:

1. **Technical feasibility** – How practical is large-scale establishment of native vegetation, assuming appropriate cost-effective methods?
2. **Risk** – What is the risk of failure due to socio-political (e.g. local outrage) or administrative factors (e.g. planning restrictions)?
3. **Adoption** – What is the likelihood of landholder adoption/participation? This will be influenced by factors such as land values and current land use.
4. **Adverse impacts** – What is the likely magnitude of any potential adverse impacts associated with carbon mitigation (e.g. increased fire risk, reduced water yield)?

The results of this preliminary analysis highlight that some areas appear to be good candidates for focusing connectivity activities to optimise carbon, fauna and allied NRM benefits, such as water quality. In particular areas throughout the box-ironbark ecosystem (e.g. Wedderburn-Wychitella, Muckleford) have the potential to generate significant benefits, with factors including technical feasibility and adoption appearing quite favourable. Conversely other locations appear less favourable due to lower levels of benefits (e.g. Northern Plains' woodlands) or higher levels of risks such as adoption and technical feasibility (e.g. Daylesford-Wombat).

Further work is justified to assess the options for connectivity within the region in order to prioritise the works.

Remnant vegetation protection at Kamarooka.

Fast growing eucalypts sink large amounts of carbon.

Table 7.3 *Assessment of benefits and risks associated with improving connectivity around priority asset areas*

Area of focus – Priority assets	Benefits			Risks				Comment
	Carbon	Fauna	Allied NRM benefits	Technical feasibility	Socio-political risk	Likely adoption	Adverse impacts	
PRIORITY ASSETS								
Lower Avoca Grasslands, Patho Plains	M	H	M	M	M	L	M	Opportunity for grazing management change.
Bunguluke	M	H	H	H	L	M	L	Reinstatement of floodplain hydrology, natural regeneration
Wedderburn - Wychitella	H	H	M	H	L	H	L	Modest land values may facilitate land use change.
Bealiba - Dalyenong	L	M	M	H	L	H	L	Modest land values may facilitate land use change.
Pyramid Hill	L	H	M	M	M	L	L	Opportunity for grazing management change
Wandella	M	H	H	M	M	M	L	Reinstatement of floodplain hydrology, natural regeneration
Northern Plains Woodlands	L	M	M	M	L	L	L	Potentially important linkage – commercially oriented farmers
Mid Loddon	H	H	H	H	L	M	L	Area transitioning from farming to lifestyle
Upper Loddon	H	M	H	M	M	M	M	Area transitioning from farming to lifestyle – high amenity value
Inglewood-Rheola	H	H	M	H	L	H	L	Modest land values may facilitate land use change.
Tottington	M	M	M	H	L	H	L	Modest land values may facilitate land use change.
Maryborough - Paddy Ranges	H	H	M	H	L	M	M	Area transitioning from farming to lifestyle – high amenity value
Moliagul	H	H	M	H	L	H	L	Modest land values may facilitate land use change.
Kara Kara - Carapooee	H	M	M	H	L	H	L	Modest land values may facilitate land use change.
Muckleford	H	H	H	H	L	M	M	Area transitioning from farming to lifestyle
Eppalock	H	H	H	M	L	M	M	Area transitioning from farming to lifestyle
Wellsford	M	H	M	M	L	M	M	Area transitioning from farming to lifestyle
Kamarooka	H	M	M	H	L	M	L	Potentially important linkage – commercially oriented farmers
York Plains	L	M	M	H	L	M	L	Opportunities for floodplain restoration
Daylesford-Wombat	H	M	H	M	M	L	M	Area transitioning from farming to lifestyle – high amenity value
Upper Avoca	M	M	H	H	L	M	L	Modest land values may facilitate land use change.
Kyneton area woodlands	L	M	M	M	M	L	M	Area transitioning from farming to lifestyle – high amenity value
Gunbower	H	H	H	M	M	L	L	Opportunities for use of environmental water/ floodplain restoration
Dartagook	L	H	H	M	M	L	L	Opportunities for use of environmental water/ floodplain restoration
Lake Buloke	L	M	M	H	L	M	L	Opportunity for income diversification (mallee, savannah systems)

Table 7.4 *Assessment of benefits and risks associated with improving connectivity in associated linkage zones*

Area of focus – linkage zone	Benefits			Risks				Comment
	Carbon	Fauna	Allied NRM benefits	Technical feasibility	Socio-political risk	Likely adoption	Adverse impacts	
Muckleford 2 Mid-Loddon; Muckleford 2 Upper Loddon	H	H	M	H	L	M	M	Area transitioning from farming to lifestyle. Potential to elevate fire risk
Wedderburn Junction, Emu, Timor	M	H	M	H	L	H	L	Modest land values may facilitate land use change.
Glenlyon	L	M	M	M	M	L	M	Area transitioning from farming to lifestyle – high amenity value
Barnadown	L	M	M	H	M	L	L	Important linkage to Campaspe.
Arnold West, Rostron, Raywood, Goornong	L	M	M	H	L	M	L	Modest land values may facilitate land use change.
Bealiba	L	M	M	H	L	M	M	Modest land values may facilitate land use change,
Upper Campaspe, Upper Loddon, Coliban (Riparian)	M	M	M	M	L	M	L	Important linkage between Goldfields and Central Victorian Uplands bioregions.
Lower Campaspe, Mid Loddon (Riparian)	M	M	M	H	L	M	L	Key linkage from Murray corridor to Goldfields.
Upper Avoca, Mid Avoca (Riparian)	M	M	M	H	L	M	L	Important linkage between Goldfields and Central Victorian Uplands bioregions.

Disclaimer
The information in Table 7.4 may be of assistance to you, but the North Central CMA and its employees do not guarantee that the information is without flaw of any kind, or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on this information.

8 IMPLEMENTATION, MONITORING AND EVALUATION

Guide to Chapter

8.1 Implementation approach

This Plan is a sub-strategy to the North Central RCS and as such the implementation of this Plan will occur through the arrangements established for the RCS.

This Plan will be implemented through partnerships involving:

- agencies with land management or other relevant legislated responsibilities outlined in the RCS
- communities in the North Central region
- other key stakeholders such as non-government organisations, Landcare and other community groups.

The North Central CMA and its delivery partners are responsible for implementing the RCS. This integration approach builds on previous and current collaboration practice in the region, evident through the delivery of the RCS, and development of this Plan.

The North Central CMA is responsible for coordinating specific aspects of RCS implementation within programs or themes. These responsibilities will be extended to include consideration of the options presented in this Plan when developing:

- implementation targets
- action planning, updated annually
- targeted investment proposals
- integrated delivery arrangements
- coordinated monitoring and evaluation of implementation, including integrated reporting against targets
- adaptive management.

Resourcing implementation

Investment proposals to support options within this Plan will be developed as investment opportunities arise. Project proposals will be prepared in conjunction with delivery partners and will be structured to reflect the RCS regional programs and their associated themes.

Implementation will be influenced by available funding and resources. The implementation approach that will be applied in the North Central region will be to coordinate the prioritisation of management actions so that maximum benefit is achieved with the available resources.

Throughout the implementation of this Plan the North Central CMA will work with our delivery partners to bring the best available information tools to support the establishment of annual priorities e.g. in the case of threatened species, populations or communities, using databases and other tools developed and maintained by DELWP. The North Central CMA will also seek to better describe assets using updated and new spatial datasets and tools as they become available.

8.2 Monitoring and Evaluation

The Monitoring Evaluation and Reporting (MER) component of the RCS implementation planning framework describes how the implementation will be monitored and how the effectiveness of the contribution of the management actions towards the land and water resource objectives of the RCS will be assessed. The MER process also provides a consistent basis for communicating implementation results to stakeholders and funding investors.

In 2012, catchment management authorities and DSE developed a MER framework to apply to all NRM activities in Victoria. The North Central CMA MER approach complies with this framework.

RCS MER planning uses program logic to describe the expected cause and effect relationships between management actions and their immediate outputs, and longer-term objectives concerning asset condition. Describing program logic provides a framework to monitor and evaluate the effectiveness of RCS implementation.

The North Central CMA will coordinate with partner agencies to collect and collate the data needed for effective monitoring, evaluating and reporting.

Monitoring

The North Central CMA will monitor the implementation of the RCS by collecting and collating quantitative measures from regional NRM agencies and partners. In particular, monitoring focuses on measuring progress towards targets set in the RCS implementation plan (North Central CMA, 2014).

Monitoring will contribute to the ability to apply adaptive management and be undertaken in an integrated manner to reflect the nature of the region's program delivery (multiple delivery partners, multiple investment sources).

Evaluation

Program evaluation will be used to test the validity of assumptions that underpin the program logic about how and why particular management activities will contribute to the RCS objectives.

Data from our monitoring activities will be used to consider evaluation questions, designed to affirm or adapt the assumptions upon which the program logic relies.

Examples of evaluation questions are:

- To what extent were the strategy implementation actions completed (during the life of the RCS)?
- How effective were the implemented measures (actions)?
- How have completed actions contributed towards the agreed targets and RCS objectives?

Program evaluation will make a significant contribution to the three-year and six-year RCS reviews.

The North Central CMA will coordinate with partner agencies to collect and collate the data needed for effective monitoring, evaluating and reporting.

Reporting

It is recognised that all delivery partners have internal reporting obligations for activities they undertake and have various arrangements to meet these obligations. A role of the North Central CMA is to ensure that reporting obligations are met for funding that is directed to the region via the North Central CMA, and to coordinate the development of a regional picture that reflects the aggregate of activities by delivery partners that contribute to the implementation of the RCS.

Reporting on RCS implementation will involve annual reporting of RCS management actions to delivery partners, the North Central CMA Board and DELWP, complemented by more comprehensive three-year and six-year reporting of progress towards targets.

RCS review

In accordance with the CaLP Act, a mid-term evaluation of the RCS and its implementation will be completed by July 2016. A more comprehensive review of the RCS at the conclusion of its six-year term will be completed by July 2018.

Carbon sequestration – is the general term used for the capture and long-term storage of carbon dioxide. Capture can occur at the point of emission (e.g. from power plants) or through natural processes (such as growing trees), which remove carbon dioxide from the earth's atmosphere and which can be enhanced by appropriate management practices.

Climate – weather averaged out over time. Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate adaptation – the ability of a system or people to adjust to climate change (including climate variability and extremes), to reduce potential damage, to take advantage of opportunities, or to cope with the consequences.

Climate change – a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels (Oxford Dictionary, 2015).

Climate change mitigation – Human intervention to reduce the human forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions, protecting natural carbon sinks like forests, or creating new sinks through silviculture or green agriculture.

Climate variability – The way climate fluctuates yearly above or below a long-term average value.

The term is often used to denote deviations of climatic statistics over a given period of time (e.g. a month, season or year) from the long-term statistics relating to the corresponding calendar period. In this sense, climate variability is measured by those deviations, which are usually termed anomalies.

Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). Common drivers of climate variability include El Niño and La Niña events.

A key difference between climate variability and change is in persistence of "anomalous" conditions. In other words, events that used to be rare occur more frequently (summertime maximum air temperatures increasingly break records each year), or vice-versa (duration and thickness of seasonal lake ice decreasing with time).

Connectivity – 'Connectivity' can be broken down into 'structural connectivity' and 'functional connectivity.' Structural connectivity refers to the physical relationship between landscape elements whereas functional connectivity describes the degree to which landscapes actually facilitate or impede the movement of organisms and processes. Functional connectivity is a product of both landscape structure and the response of organisms and processes to this structure. Thus, functional connectivity is both species-specific and landscape-specific. Distinguishing between these two types of connectivity is important because structural connectivity does not imply functional connectivity. In general, when we use the term 'connectivity' we are using the functional definition.

Global warming – a gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, Chlorinated Flouro-Carbons (CFCs), and other pollutants.

Habitat corridor/biolink – component of the landscape that facilitates the movement of organisms and processes between areas of intact habitat.

Vulnerability – the diminished capacity of an individual, group, or natural asset to cope with, resist and recover from the impact of a natural or man-made hazard.

Weather – the chaotic and unpredictable state of the atmosphere at a particular place and time as regards heat, cloudiness, dryness, sunshine, wind, rain, etc.

Source: http://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-a-d.html (or as referenced).

Australian Government. (2015). The Carbon Farming Initiative. Retrieved from http://www.cleanenergyregulator.gov.au/Carbon-Farming-Initiative/Pages/default.aspx accessed 17 March 2015.

Barr, N. (2005). U. R. V. M. D. of P. (2005). *Understanding Rural Victoria.*

CSIRO (2015) Climate Change in Australia - Projections for Australia's NRM regions

http://www.climatechange inaustralia.gov.au

Department of Sustainability and Environment. (2011). Index of Stream Condition sited at *http://www.water.vic.gov.au/monitoring/river-health/isc/results*.

Garnaut (2011) Australia in the Global Response to Climate Change.

Geddes, L. S., Lunt, I. D., Smallbone, L. T., & Morgan, J. W. (2011). (2011). Old field colonizationby native trees and shrubs following land use change: Could this be Victoria'slargest example of landscape recovery? *Ecological Management & Restoration,* 12(1), 31–36.

Hobday, A., & Lough, J. (2011). Projected climate change in Australian marine and freshwater environments. *Marine and Freshwater Research*, 62, 1000–1014.

Kitching, R., Boulter, S., Hobbs, R., Mansergh, I., McKellar, R., Stafford Smith, M, W., & Stadler, F. (2013). 2013 *National Climate Change Adaptation Research Plan Terrestrial Biodiversity: Update 2013*,.

Mitsch & Gosselink. (2007). *Wetland Ecosystems (4 ed.)*. New York: John Wiley & Sons, Inc. ((4 ed.)). New York: John Wiley & Sons, Inc.

NCCARF Terrestrial Biodiversity Network. (2013). Terrestrial Report Card 2013: *Climate change impacts and adaptation on Australian Biodiversity.*

North Central Catchment Management Authority. (2005). *North Central Native Vegetation Plan.*

North Central Catchment Management Authority. (2012). *North Central regional Catchment Strategy* (pp. 1–55).

North Central Catchment Management Authority. (2014). *North Central Waterway Strategy.*

SCARP. (2014a). Adaptation Pathways Planning Playbook. Unpublished Draft - 15 September 2014.

Smallbone, L. T., Matthews, A., & Lunt, I. D. (2014). Regrowth provides complementary habitat for woodland birds of conservation concern in a regenerating agricultural landscape. *Landscape and Urban Planning*, 124, 43–52. doi:10.1016/j.landurbplan.2014.01.003

Spatial Vision, & Natural Decisions. (2014). *Final Project Report 1 – Impact and Vulnerability Assessment Process and Spatial Outputs. Report by Spatial Vision and Natural Decisions.*

Steffen, W., Burbidge, A. a, Hughes, L., Kitching, R., Musgrave, W., Smith, M. S., & Werner, P. a. (2009). *Australia' s Biodiversity and Climate Change. Governance An International Journal Of Policy And Administration* (pp. 1–303). doi:Commonwealth of Australian

Stephen Garnett and Donald Franklin. (2014). *Climate Change Adaptation Plan for Australian Birds.* CSIRO.

APPENDICES

Appendix 1 – Federal Government principles

This plan will be assessed by the Federal Government against the following principles:

1. Does the plan maximise environmental benefits by identifying priority landscapes for carbon plantings?
2. Does the plan maximise environmental benefits by identifying strategies to build landscape integrity?
3. Does the plan maximise environmental benefits by guiding adaptation and mitigation actions to address climate change impacts on natural ecosystems?
4. Does the plan avoid adverse impacts associated with carbon in the landscape?
5. Has the planning process been logical, comprehensive, and transparent?
6. Does the plan align with planning requirements and NRM policies?
7. Has the development of the plan meaningfully engaged community and stakeholders?
8. Does the plan clearly identify roles and responsibilities for regional partners?
9. Does the plan integrate biophysical, socio-economic and climate change information?
10. Does the plan reflect regional stakeholder and community aspirations and objectives?
11. Does the plan demonstrate clear understanding of the North Central CMA's roles and responsibilities?
12. Does the plan use information at appropriate scale?
13. Does the plan identify priority areas in landscape for carbon sequestration projects?
14. Does the plan respond to new information and guiding improvements as knowledge improves?
15. Does the plan show evidence of cross regional cooperation (impacts and land use planning)?

Appendix 2 – Legislation and policy

Commonwealth policy context

The Australian Government has a range of programs that aim to reduce greenhouse emissions and provide for adaptation to climate change. The Emissions Reduction Fund is the centrepiece of the Australian Government's policy suite to reduce emissions. Through a competitive process community and business projects will be contracted to implement projects that will lead to real emissions reductions. Projects must use legislated methods to estimate emissions reductions (Commonwealth of Australia, 2014b).

Natural resource management activities including reforesting and revegetating land and improving agricultural soils will be eligible once methods have been developed and approved. The establishment of the Emissions Reduction Fund builds on the previously established Carbon Farming Initiative (CFI).

The Carbon Farming Initiative Amendment Bill 2014 was passed by the Parliament in November 2014 CFI is a legislated, Australian voluntary carbon offsets scheme administered by the Clean Energy Regulator. The CFI allows land managers to earn carbon credits by reducing greenhouse gas emissions and increasing carbon sequestration in vegetation and soils through changes to agricultural and land management practices (Australian Government, 2015)

State policy context

The *Climate Change Act 2010* (the Act) provides guidance on the Victorian Government's roles and responsibilities in responding strategically to climate change in the context of national climate change policy settings. The Act requires decision makers to take climate change into account when making decisions under key pieces of legislation including the *Catchment and Land Protection Act 1994*, *Environment Protection Act 1970*, *Flora and Fauna Guarantee Act 1988, and Water Act 1989*. The Climate Change Act requires the Victorian Government to develop a Climate Change Adaptation Plan every four years, to outline the potential

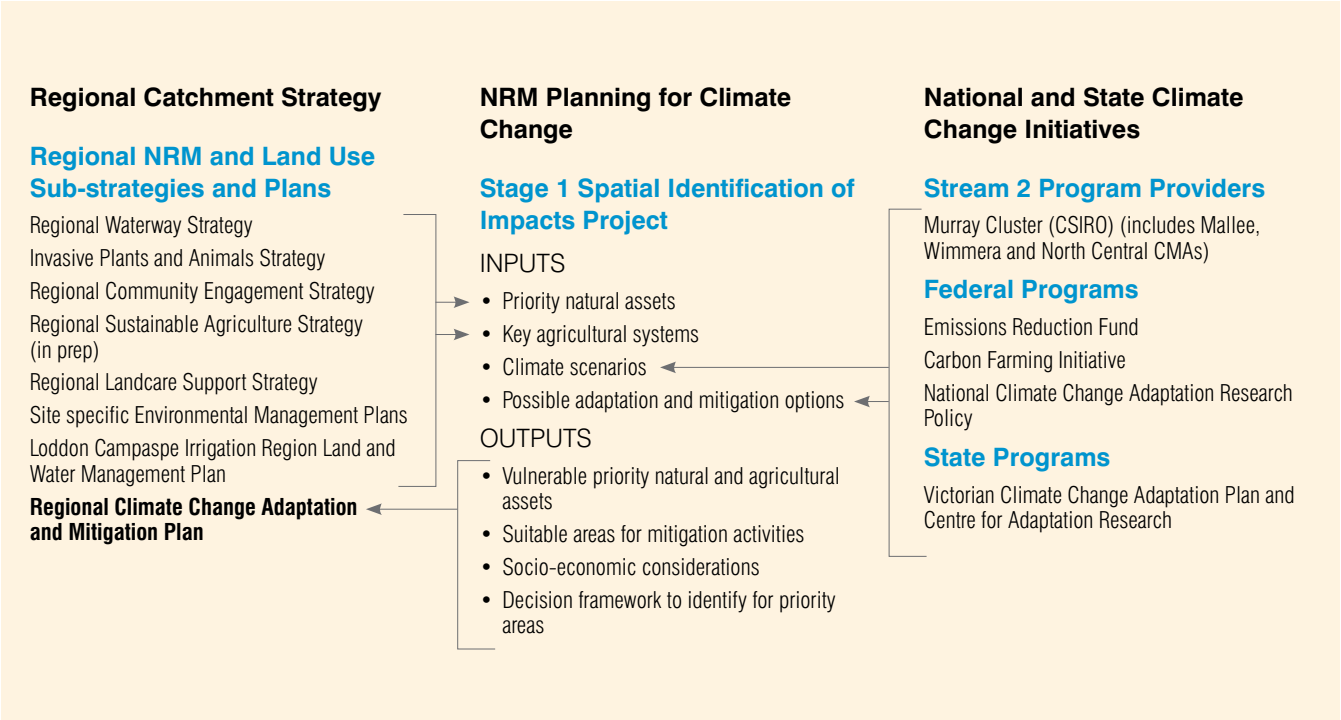


Figure A2.1 *Policy and Decision Making Framework for The North Central Climate Change Adaptation and Mitigation Plan*

impacts and risks associated with a changing climate. The first Victorian Climate Change Adaptation Plan released in 2013 provides the framework for managing climate risks to critical Victorian Government assets and services. It aims to help position the Victorian Government to prepare for future climate challenges and to adapt to change.

The *Victorian Climate Change Act 2010* also requires decision makers to take climate change into account when making specified decisions under the *Catchment and Land Protection Act 1994*, *Environment Protection Act 1970*, *Flora and Fauna Guarantee Act 1988*, *Public Health and Wellbeing Act 2008* and *Water Act 1989*. The Act also creates new arrangements for the ownership, registration and transfer of forestry and carbon sequestration rights to help Victorian landholders take part in carbon sequestration projects under the Commonwealth Government's Carbon Farming Initiative.

Appendix 3 – Roles and responsibilities

This Plan aims to identify strategies and options for adaptation and mitigation for both public assets and freehold land managers. It will be implemented as a sub-strategy of the Regional Catchment Strategy, through established partnerships and implementation arrangements with:

- Agencies with direct water management, land management or other relevant legislated responsibilities
- The regional community
- Other stakeholders such as non-government organisations, Landcare, Traditional Owners or other community groups.

Roles and responsibilities for adaptation and mitigation align with existing statutory obligations and arrangements for the management of natural assets. That is, government and government agencies are responsible for managing the impacts to, and adaptation responses for, public assets and providing leadership for adaptation and mitigation through appropriate policy and programs, regulation, science and information. Table A3.1 outlines the roles and responsibilities of the region's natural resource management stakeholders in climate change adaptation and mitigation.

The owners and managers of freehold land are responsible for managing their land, including managing impacts from climate change, and adaptation to those impacts. All levels of government play a key role in supporting these managers and the wider community, including through the provision of planning to support appropriate adaptation and mitigation responses.

Table A3.1 *Roles and responsibilities of natural resource management stakeholders in climate change adaptation and mitigation*

Stakeholder	Role / responsibility
North Central CMA	• Development, implementation and monitoring of Regional Catchment Strategy, and sub-strategies including the Regional Climate Change Mitigation and Adaptation Plan • Identify priority assets for protection from threats, including climate change • Community engagement and education
Commonwealth Government (Department of the Environment, Department of Agriculture)	• Integrating climate change adaptation and mitigation into NRM regional planning • Funding programs (e.g. CFI, Biodiversity Fund)
State Government (Department of Environment, Land, Water and Planning, Parks Victoria, Department of Economic Development, Jobs, Transport and Resources) Health Department	• Managing risks to public assets and services managed by the Victorian Government – including embedding climate change considerations into risk management and business planning for assets and critical service delivery. • Managing risks to Victoria's natural assets and natural resource-based industries – including developing overarching policy settings and direction for addressing climate risks to biodiversity, soils, waterways and land. • Building disaster resilience and integrated emergency management – including reviewing and reforming emergency management arrangements. • Improving access to research and information for decision-making – by supporting coordinated research and information provision to assist all parties to adapt. • Supporting private sector adaptation – by developing policy settings that support appropriate risk allocation, remove barriers to effective adaptation and promote business innovation. • Partnering with local government and communities – including providing a basis for ongoing engagement with Victorian councils and their communities.
Water Authorities	• Impacts of different climate scenarios on inflows to storages and rivers systems • Reducing costs associated with energy consumption and minimising GHG emissions • Research into customer's water consumption changes under different climate scenarios • Providing environmental and recreational water • Infrastructure and water use efficiency projects • Participation in development of Sustainable Water Strategies and Groundwater Management Plans
Local Government	• Managing risks and impacts to public assets owned and managed by local government and to local government service delivery • Collaborating across councils and, with the Victorian Government, managing regional climate change risks. • Working in partnership with the community, locally based organisations and stakeholders to manage relevant climate risks. • Implementing relevant legislation to promote adaptation • Contributing appropriate resources to prepare, prevent, respond and recover from detrimental climate impacts.
Farmers / land managers	• Management of land, including consideration of sustainable land management practices that improve adaptive capacity of vulnerable natural assets • On-ground projects to sequester carbon in soils, native vegetation and wetlands
Soils Groups and Productivity Groups	• Agronomic and farming systems research and development • Research into climate variability and climate change, including social dimensions • Direct extension programs with farmers – information provision, technical guidance, awareness raising
Traditional Owners and aboriginal people	• Climate change and cultural heritage • Working on Country (employment opportunities associated with getting carbon in the landscape) • Recognition and Settlement Agreements made under the *Traditional Owner Settlement Act 2010* (Vic). For example Dja Dja Wurrung Recognition and Settlement Agreement, 2013
Landcare Networks and Landcare Groups	• Local information sharing and awareness raising • Direct implementation of projects (e.g. revegetation, weed control) funded by State and Federal Government • Community capacity building
Regional Sustainability Groups	• Building community capacity and resilience • Community engagement and education • Reducing the community's environmental footprint
Environmental Advocacy Organisations	• Advocacy and engagement with government • Provide independent critique and evaluation of public policy • Market research, education and awareness raising • Campaign coordination
NGOs with NRM and biodiversity focus	• Statewide conservation planning for biodiversity and connectivity • Direct land management • Scientific and technical advice for land managers

Appendix 4 – Personal, community and organisational responses to climate change

(see also Chapter 3 Approach)

The community engagement that took place during the development of this plan identified the stakeholder activities in response to climate change. There was also a strong call for the North Central CMA to coordinate and lead the activity in this space.

Table A4.1 *Personal, community and organisational responses to climate change*

Stakeholder	Activity in this space
North Central CMA	• Regional Catchment Strategy (RCS) • Regional Climate Change Adaptation and Mitigation Plan • Farming for Sustainable Soils Project • Farming for Australian Conditions • Boosting soil carbon (Kilter) • Carbon Farming Roadshow
Federal Government (Department of Environment, DAFF, MDBA)	• Emissions Reduction Fund • Climate Change Authority • Stream 1 Regional NRM organisations updating regional plans • Stream 2 regional-level information • Carbon Farming Initiative • Biodiversity Fund • Water Planning and addressing over-allocation • Basin Plan - Managing for future climate
State Government (DELWP, Commissioner for Environmental Sustainability, PV, Department of Economic Development, Jobs, Transport and Resources) Department of Health	• Victorian Climate Change Adaptation Plan (VASP) • *Climate Change Act 2010* – Carbon sequestration rights on private and crown land – Forest and Carbon Management Agreements – Carbon Rights attached to the land • State of the Environment Report 2013 • Northern & Western Regions Sustainable Water Strategies
Water Authorities (GMW, GWMWater, Coliban, Lower Murray Water)	• Coliban Water's Waterplan 2055 • GWM Water Wimmera Mallee Pipeline • GMW Strategic Connections Project
Local Government (CoGB, Hepburn SC, Macedon Ranges SC, Mt Alexander SC, Buloke SC, Campaspe SC, Loddon SC, Central Goldfields SC)	• 2014 Regional Climate Adaptation Plan (Bendigo, Buloke, Macedon, Mt Alexander, Loddon, Central Goldfields) – Community health and individual wellbeing – Energy, water and other utility infrastructure – Emergency management – Water resources – Rural commercial activities – Buildings and development • 2012 Macedon Ranges Climate Change and Adaptation Report
Climate Science research community (BoM, CSIRO)	• Climate and water outlook videos • State of the Climate 2014 report • Australian Climate Change Science Program
Farmers / land managers / Soils Groups / Productivity Groups / BCG/ R&D community / CVAF	• Innovation • Trials, Field Days and Farm walks • Soil carbon testing • Changes to farming systems
Traditional Owners	• Working on Country Plans • Recognition and Settlement Agreements made under the Traditional Owner Settlement Act 2010 (Vic). For example Dja Dja Wurrung Recognition and Settlement Agreement, 2013
Landcare Networks & Groups	• Connecting Country • Local planning and action • Community education and engagement
Regional Sustainability Groups	• Bendigo Sustainability Group - Election Forum on Climate • Mt Alexander Sustainability Group - Carbon Reduction Action groups • Macedon Ranges Sustainability Group (Trentham Sustainability Group • Central Victorian Greenhouse Alliance (CVGA)
Environmental Advocacy Organisations (NGOs with NRM and biodiversity focus)	• Environment Victoria's Safe Climate Campaign • Trust for Nature Conservation bulletin • ACF – 'Climate Change is on my agenda' • VNPA • Bush Heritage • Central Victorian Biolinks
Philanthropic organisations	• Norman Wettenhall Foundation • Bjarne Dahl Trust

Appendix 5 – Detailed approach and methodology

A5.1 Vulnerability and threat assessment

An assessment of potential impact and vulnerability to climate change was completed for the natural assets of the North Central region as part of a state-wide process (Spatial Vision & Natural Decisions, 2014). The assessment of potential impacts and vulnerability required consideration of the sensitivity and adaptive capacity of the relevant assets.

Important definitions

Assets are tangible, physical elements of the environment, which are valued by people for a variety of reasons. The asset-based approach to NRM planning focuses on protecting or maintaining biophysical items that are of most value (ecological, social, cultural and economic) to people.

The asset-based approach framework combines information about asset values, threats to assets and the risks of not addressing these threats. The asset based approach in the RCS has been guided by the DEPI guidelines 'Applying the Asset-Based Approach for the development of Regional Catchment Strategies'. The North Central RCS describes the following asset types; rivers and floodplains, wetlands, biodiversity, and soils.

Exposure refers to the type and magnitude of local and regional biophysical stressors that assets will likely face as a result of climate change, including direct climatic variables (such as temperature, rainfall, seasonality, frost days) and indirect climatic impacts, such as flooding and bushfire frequency. Exposure is specifically related to the ***amount*** of a factor to which an asset is exposed to.

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct or indirect. Sensitivity is refers to the "dose-response relationship" between a system or asset's exposure and the potential for that to result in impacts. Differences in sensitivity between assets relate to the differences in responses between them to the same amount of climate variability or change.

Potential Impacts of climate change involve the interaction of asset ***exposure*** (the magnitude of change an asset will face due to modifications to the climate) and asset ***sensitivity*** (how much the asset will be affected by those changes).

Adaptive capacity relates to the ability of a system via intrinsic mechanisms to adjust to changes in climate parameters, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities or to cope with the consequences. ***Sensitivity*** and ***Adaptive Capacity*** are theoretically similar and interrelated concepts. For example, a system which has been degraded by the impacts of invasive weed species may have a high sensitivity to increases in temperature (i.e. a large-dose dependent response), compared to a habitat not impacted by invasive species. In addition, reduced seed dispersal rates due to changes in population age structures of plant species due to the impact of weed species can reduce their adaptive capacity. Care must be taken to clearly delineate between these concepts, to ensure that the final spatial model is not impacted by "double-counting" of various factors.

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity.

Vulnerability assessment process

The process involved identifying the sensitivity of an asset type to two different climate exposures (or climatic stressors under a particular climate scenario), and adaptive capacity, and using this information to determine the potential impact, and assessed vulnerability rating.

The general steps undertaken for each natural asset type in application of the vulnerability assessment process were as follows:

1. Identify two key **Climate Stressors**/**Exposures** (and potential changes)
2. Identify **Asset Classes** relevant to Stressors
3. Assign likely **Sensitivity** to Climate Stressors (likely response to change)
4. Calculate **Potential Impact** for each Climate Stressor (Exposure) for the change anticipated for a given climate scenario and time frame
5. Calculate the **Worst Potential Impact** for each combination of Climate Stressors (Exposure) for a given climate scenario and time frame
6. Develop a likely **Adaptive Capacity** measure (based on current condition) for NRM asset
7. Calculate **Vulnerability** based on potential impact and intrinsic adaptive capacity based on current state for a given climate scenario and time frame

***Table A5.1** Summary of Climate Stressors (Exposures), Climate Stressor Sensitivity considerations and Adaptive Capacity inputs (Spatial Vision & Natural Decisions, 2014)*

Asset Type	Climate Stressor	Sensitivity Input	Adaptive Capacity
Native Vegetation	• Total Rainfall • Nov to April - daily Max Temp	• EVC sub-groups	• Site condition • Landscape connectivity
Wetlands	• Mar to Nov - Rainfall • Nov to April - daily Max Temp	• Wetland type (FW meadows, marshes etc) • Water Source (river, groundwater)	• % native veg presence within 50m • Quality of native veg within 50m • Land use within 50m • Presence of drain, levee or cropping
Rivers and Streams	• Mar to Nov - Rainfall • Nov to April - daily Max Temp	• Regulated or not • Perennial / permanent • Terrain category – plains, intermediate, upper	• % native veg presence within 100m • Quality of native veg within 100m • ISC – hydrology & streamside zone rating
Soils and Land	• Total Rainfall • Nov to April - daily Max Temp	• Land system based soils • Susceptibility to wind erosion • Susceptibility to water erosion & terrain type	• Native vegetation cover/ground cover • Site condition & landscape context • Land degradation (salinity, erosion)

The results from the vulnerability assessment using the RCP 8.5 emission scenario for the 2050 time period have been used as the basis of this Plan, with consideration also given to the results for the 2090 timeframe. This scenario has been chosen because it provides a slightly longer planning horizon than the Regional Catchment Strategy (35 year compared with 20 years), and has been judged to provide a realistic view of possible impacts, under specific changes in climate factors, particularly changes in temperature and rainfall.

A5.2 Assessment of climate change impact on threats to natural assets

A review of the threat levels for assets identified in the North Central RCS in light of project climate change impacts was completed to help inform the Plan. Together with the results of vulnerability assessment and consultation with regional stakeholders, this review will assist with the identification of priorities for climate change adaptation and mitigation in the region.

The first step for this review was to define the relationship between climate variables and threats to natural assets (see Table A5.1). This involved identifying which climate variables had a relationship to particular threats, then the nature of the threat response was defined, firstly as either magnifying or decreasing the threat and whether it was a direct or indirect effect (Table 4.4), an overall ranking over the threat/climate variable relationship was defined (see Table A5.2) using the categories in Table 4.4.

The preliminary analysis identified that soil erosion, compaction and disturbance, invasive plants, altered flow regimes, degraded water quality and loss of native vegetation and habitat fragmentation were the threats most likely to be amplified by a changing climate.

Altered flow regimes and degraded water quality are just two threats that are likely to be amplified by a changing climate.

Table A5.2 *Climate factors and climate threat ratings*

Climate Factor	Soil erosion, compaction & disturbance	Invasive plants	Invasive animals	Altered fire regimes	Altered flow regimes	Increased salinity & groundwater levels	Degraded water quality & high nutrients	Overgrazing & total grazing pressure	Loss of native vegetation & habitat fragmentation	Levees/barriers to natural flows	CLIMATE THREAT RATING
Combined Effect	H	H	M	M	H	L	H	M	H	M	
RIVERS											
Lower Avoca River	M	M	M	L	L	M	M	H	H	H	H
Upper Avoca River	M	M	L	M	L	L	L	H	M	L	M
Lower Campaspe River, Lower Loddon River	M	M	H	L	H	M	M	H	H	H	H
Upper Loddon River, Coliban, Upper Campaspe	M	H	H	M	M	L	M	M	M	L	M
Gunbower Creek	L	H	H	L	M	M	M	L	M	M	M
WETLANDS											
Gunbower Forest	L	H	H	L	M	M	M	L	M	M	M
Kerang Ramsar Wetlands	L	M	H	L	M	M	M	L	M	M	M
Central Murray Wetlands	L	M	H	L	M	M	M	L	M	M	M
Mid Loddon Wetlands	M	M	M	L	M	M	M	M	H	H	M
York Plains Wetlands	M	L	M	M	M	M	L	M	H	H	M
Moolort Plains Wetlands	M	L	M	L	L	M	L	M	H	H	M
Kamarooka Wetland Complex	M	M	M	M	M	M	M	H	H	H	H
BIODIVERSITY											
Lower Avoca Grasslands, Patho Plains, Bunguluke	M	M	M	L	M	L	N/A	H	H	L	M
Northern Plains Woodlands, Kamarooka, Pyramid Hill	M	M	M	L	N/A	L	N/A	H	H	L	M
Wedderburn – Wychitella, Inglewood-Rheola, Tottington, Moliagul, Kara Kara – Carapooee, Bealiba – Dalyenong	M	L	M	H	N/A	L	N/A	M	M	N/A	M
Maryborough – Paddy Ranges, Muckleford, Mid Loddon, Eppalock, Wellsford, Upper Avoca	M	L	M	H	N/A	L	N/A	M	M	N/A	M
Gunbower, Dartagook, Wandella	L	M	M	L	M	M	M	M	H	M	M
York Plains, Lake Buloke	M	M	M	L	N/A	M	L	M	H	M	M
Daylesford-Wombat, Upper Loddon, Kyneton area woodlands	M	H	M	M	N/A	L	N/A	M	M	N/A	M

Note: Assets with similar threats have been grouped

Appendix 6 – Community Workshops report

Narrative is a lens through which humans process the information we encounter. Thus one of the most effective ways to change attitudes and provide new information is by telling a good story. Movements and campaigns that push for sweeping changes in current policies must first and foremost win in the realm of ideas by changing the story that the public has around the issue. They can do this by combining an understanding of narrative power with traditional movement building skills to create story-based strategies. The power of story can thus be used to develop an integrated strategy with the goal of changing a dominant cultural narrative. By placing story at the centre of a campaign or action, organisers can amplify their effectiveness by articulating their political vision through a common narrative that ties together messaging, media, advocacy and organising strategy.

Local farmers deep in discussion at the 2014 Charlton community workshop.

Charlton workshop notes

Thursday 2 October, Cricket Club Hotel, Charlton

Participants: Ken Coates; Geoff Park; Mal Brown; Denis Watts; Glendon Watts; Stuart McLean; Robert Elder; Leo Parker; Ellen White; John White; Will Parker; Doug Todd; Elizabeth Todd; David Coats; Glenys Coats.

Participants experience of climate variability.

"I remember back in 1967 the dams on our property were always full, we always had springs, but in the last 15-20 years the climate has changed."

"When it used to be wet in the lower Avoca catchment the farmers used to say "build a few more dams in the upper catchment". Then it dried up and they blamed the vineyards for capturing water and not letting it flow downstream...."

"As a kid there were always a few water holes in the Avoca River. It was a very social thing and the reason I came home. My kids think I am mad now. Now it is just a dry river bed. My kids have got no memories of what I had as a child."

"There used to be a fishing club at Wycheproof that would hold a competition every Sunday. But in 1967-68 it started to go dry and the club folded."

"Down south they used to get too much rain. In those days they grew crops on raised beds. Now they are growing crops with much less rainfall."

"I can't make up my mind. Is it fair to say with such a relatively small data set (120 years over millenia) that the climate is changing? Farming practices are always adapting to lock carbon in the soil. We are always looking for best practices and being vigilant of costs, and focusing on the margins. If you fence out native regeneration you are just really locking up water which is so important to producing food in this landscape. I also question how much of our risk is attributable to government decision making and management. If you lock up vegetation and don't graze it then you increase the risk of bushfire. During the floods of 2010-11 nothing natural was damaged. It was all man-made infrastructure (bridges, roads, fences etc. that were damaged, so we are partly responsible for the problems."

"As far as I am concerned climate change is a reality, it is not a belief system. The science is conclusive and it is a global phenomenon. I have lived in this area for 15 years and in that time I have been amazed by the adaptations of landholders. In that time dust storms have stopped, largely due to practice change. By building up carbon in the soil it will give us more choices in the future. Active adaptation is happening. There is a lot more knowledge being shared today in a lot more formal ways than in the past."

"As far as I am concerned the wineries that were established in the upper catchment is a big issue for us in the lower catchment. Over centuries there have been wet times and dry times. The native vegetation looks great and then it looks sad."

"We would have had a lot more crop droughts without the machinery we've got today. There are a lot of crops grown on minimal rainfall. There is a lot more variability in thunderstorms. If you are lucky enough to be under one you can do OK."

""The plant breeders have done well. There needs to be a lot more R&D in this area."

"In the 1960s we would cut and bale lucerne three times over summer and cart it to the pellet mill in Kerang. If we got an inch of rain in the catchment we could irrigate 60-70 acres of lucerne from the river and almost live off the income from cutting that. Now it just doesn't rain."

We had bores in the 1960s but then the channel came in the 1970s and we haven't used a bore in thirty years."

"I am very interested in the discussion so far. There are some very valid points being made. I am certainly appreciative of the plant breeders, and I do think the risk of bushfire does come down to how we manage native vegetation."

Risks and issues associated with the projected future climate

"Service provision. The town's populations will decrease and businesses will keep closing. Farms are getting bigger and the services are getting further and further away.

"Long spells of similar conditions. Since the 1982 drought we have experienced long wet spells and long dry spells."

"The minimum overnight temperature is predicted to increase and we will experience higher evaporation. The frosts really hurt you when it is dry."

"Most of the predictions are happening now and we are dealing with them on a regular basis."

"The sun seems to burn you more these days. It has much more kick in it now compared to when I was a kid."

"Profitability. Should we be moving to irrigation country? Should we be looking north?"

"Social cohesion. It is already a tough game socially. Entertainment is getting further away. We will soon have to go to Bendigo for a night out."

"My fiancé was plucked out of the city and has done well to adjust to a more isolated rural life, but the limited social life is a big issue."

"Ageing population. Keeping our young people. A truck turned up at a fire near Wycheproof and the youngest aged person on the truck was 65."

"Farmers in the dry SA Mallee are still making money out of farming. We need to keep changing our thinking and approach to dryland farming. We have moved from fallows to direct drilling and will continue to change our practices."

"We will continue to see more intensive farming operations on the larger farms. We have never said it won't work. That's why we are still here."

"Costs and returns. We are price takers. If wool was a pound for a pound in the 1950s then it should be worth $30 per kilogram today. Break even for croppers in the future might be a 'two and half tonne to the acre' crop."

"The cost of chemicals is going up. A number of people are doing contract work to generate a bit more income."

"Major towns all have stormwater management plans. Green areas are vital for social interaction around sport in all towns. Wycheproof needs 48ML for its green fields. The town can capture about 42ML of stormwater in an average year. The Shire purchased an allocation to make up the difference."

"The pipeline adds value and security to our operation."

"Formal learning activities are increasing and are a real opportunity. We are seeing a lot more participants in field days and farm walks. The Federal and State governments should continue to fund projects and activities that increase participation."

"In schools today the students are being taught about food. It has come full circle. The schools are involving students in the whole cycle – growing, harvesting, preparing, cooking and eating. The students are learning to socialise around food."

"There has been a lot of riparian work done in this part of the region. Unfortunately it has created wonderful habitat for kangaroos. But there is greater awareness now of the natural environment and there is a strong will out there for people to innovate."

"Some serious R&D is needed. E.g. we should be breeding different dual purpose grain for use in a 'Graze and grain' system."

"We need to be adaptable and not get locked into any one rotational system. Today's machinery gives you more options."

"Nature is resilient. Farmers need to maintain their viability. Maybe we have to completely change our farming practices. Should we be growing crops here hydroponically in a controlled environment? We need open, free thinking and polices to support different approaches."

Threats of future climate changes to the natural environment

"Rabbits. They love dry conditions and are a very big issue right now. The increase in trees is providing habitat for them. They might increase in the future."

"Climate change is a threat to biodiversity. The indigenous plants and animals of the area might change."

"Weeds are a threat. We are seeing new problem weeds (including Status, Wild Vetch, Fleabane)

"Insects are a threat. There are 40 different insects that needed to be managed to grow a canola crop."

"The impact on bees is likely to be an issue."

"Older trees seem to be under more stress and are dying. The landscape is changing. The older ones are falling over."

"Trees that came up in the floods of the 1970s now need thinning to reduce competition. Now we have 20-30 trees threatening one really big old tree, and some of the larger trees are 600-700 years old. There is potential for the

smaller ones to be turned into firewood."

"We used to be able to see the traffic on the Charlton Swan Hill Road. Now we can't see the traffic for the trees.

"The name Bunguluke is derived from the Aboriginal Bunjilook. Bunjil (there were many eagles in the area), 'oo' means water, and 'k' means creek."

"We know the Bunguluke area as the Tyrell Marsh."

"The wetlands need water. It was wrong to see the sills pulled out at great cost. The structures were there if you ever wanted to get water into the wetlands. Now they are gone. Why should we have those blokes in charge?"

"The wetlands comprise beautiful big trees and the river itself. The area needs some ecological thinning. A bit of earthworks could hold back water if you wanted to give the trees a drink."

Carbon farming

"Tree growing is such a big commitment. The timeframes are far too long.

"The key decision is 'what income can be generated off that land?"

"Farmers should be paid to manage native vegetation on their farms. If you can get paid to plant the trees, why can't you get paid to manage them?"

"A Melbourne company recently bought the creekline country on one property. They did not want the paddocks, just the trees (for carbon we presume)."

"Alley farming may have had a future, but it was a bit ahead of its time."

"You can't grow a crop near a tree."

"Improving soil carbon is what we are doing as a result of climate change."

"Are you going to sting us each time we cultivate and release carbon into the atmosphere?"

"There's a world demand for food. You can't eat a tree."

"Is our country considered marginal? Will they (the government) select our area for tree planting?"

"There is an opportunity to recycle green waste and use it on the land to improve the carbon content of the soil. Both liquid and solid waste can be spread on paddocks."

Supporting communities in extreme events

We now know the risks. We have a much better understanding of flooding in our area and we are proactive in dealing with it (flood plans)."

"We need better forecasting and we urgently need a BoM radar at Horsham."

Echuca workshop participants.

Echuca workshop notes

Participants: Greg Callaway, Kevin H'uillier, Kathy Long, Steven Brown, Daniel Toohey, Dianne Bowles, Margot Henty, Peter Williams, Rohan Hogan; Geoff Park; Mal Brown.

Observations about climate change/climate variability/historic climate

"The length of the millenium drought was staggering. I remember the '82 drought, but now I am observing more algal blooms in the river."

"I remember 40 years ago the frozen ice on the top of the puddles."

"Three years ago we had three really wet summers. We had to implement summer weed control. Now we have had two normal dry summers."

"There are more visitors to the river every year. Wake boarding is now popular but it is causing massive erosion. The volume of water held by the Torrumbarry weir pool is down 20%. The weir pool used to be 75' deep now it is only 20' deep. It is silting up. Carp is a big problem, but the native fish are doing well now that big fish (>10cm) are being introduced."

"The rain is incredibly variable. The neighbour got an inch of rain just half a kilometre away and we got nothing."

"We have had periods of 45-47C in the summers. We had one week of 45-48C. We just bunker down, but it is dangerous for the elderly. One baby was taken to hospital. Big healthy stock could not dissipate the heat."

"I remember lying on the lino as a young girl and going to bed with a towel over my head because it was so hot."

"I married into dairying nine years ago (during the drought). The flood drew the community together. It created ways for farmers to communicate."

In the 1980s we had wet winters which we had to deal with. We could not even walk the cows down the laneways for all the mud."

"The wet winters destroy pastures and affect the cows when they are up their knees in mud."

"We have a travelling irrigator at Torrumbarry that has never failed."

"Too much water is being tipped into the wetlands. This means irrigation and salinity are issues. Our last flood was in 1994/95. We are back into the same cycle. We are due for a drought this year."

"An article in The Australian reported that 16% of scientists underestimate the ability of plants to soak up carbon."

"We have had a 25% increase in the cost of water in 3 years and 50% increase in the cost of power in 5 years."

"Shortening carbon to C is offensive. The shire, G-MW etc all have it in their best interests to be on the payroll when it comes to carbon."

"The price of oil is going to drop. Fracking is a cheap source of energy production."

What are people doing?

"We are all doing things to adapt and manage. But we are almost being bulldozed by the chemical use around our homes and along the channels."

"We implement 100% re-use. It simply involves all the environmentally friendly things that make sense."

"We are being squeezed. Environmental water was sold under duress. The water pool is now much smaller and the super funds are coming in."

"Young dairy farmers buying temporary water find it particularly hard not having access to permanent water."

"If we get summer rainfall we try and save it."

Issues and risks associated with the climate projections

"Bushfire - more fuel and no stock. People are planting trees."

"Summer rainfall is a nuisance."

"Every 1 mm in rainfall equals 20 kg of cereal grown."

"In the future we are not going to have the patterns we used to have."

"The change to lucerne pasture has been invaluable."

'We crop 5,000 acres and if we get 30 mm rainfall in late spring we are ecstatic. Stuff the hay, 30 mm of rainfall puts dollars in my pocket."

"The silage scene takes the gamble out of farming. While the hay season is not as popular, lucerne is a much bigger player."

"The predictability of water availability. Carry over etc."

"Lifestyle dams in the foothills are a big issue. They trap up to 35% of available water in an average year."

"The general trends have been researched very well. A 2 degree Celsius average increase in this area and we will lose 40% of the inflow into the Murray catchment. That scares and concerns me. People plant trees but don't have the water to get them established. I planted 1,000 trees on my property and installed dripper lines. They won't grow without water. You need time and infrastructure."

Why does the CMA cut down willows if trees are needed to tackle climate change?

'The environmental movement is hijacking environmental water. Water security is essential to the farm business."

"It is OK to tip water into the forest but not now."

"When the forest is watered the water comes out of the pool. The forest got enough water in 2010-11. How can farmers plan, particularly rice farmers, especially when it gets tough again."

"In a dry year when allocations go to say 70% what will temporary water be worth then?"

"Torrumbarry Weir was paid for by irrigators along with $40M from the federal government."

"Water is the big concern. We can't farm without water. Tourism, the river, wetlands and lakes all deserve a share of the available water. Dams are also an issue. In a normal flood year the wetlands get water."

"The growth of farmers markets is a great response to the dual monopoly - local food for local people. There is a trend back to more self-sustaining ways of living on the land. We don't need to import oranges from California."

Adaptation

"Summer rainfall is good for perennial pasture (lucerne) or you could plant a summer crop (millet). Another option is to not irrigate at all in summer and just live off silage made in the spring."

"Farmers think in terms of preservation insurance. Build more hay sheds or buy more silos."

"The area depends on irrigation."

"The semi-arid desert of the north is creeping south."

"It would be semi-aid here without irrigation."

"It would be worth considering building another dam. We rely locally on the Torrumbarry Weir."

NRM future impacts and threats

"Each year algal blooms are getting worse in the river."

"Aquatic weeds will become a bigger problem if it gets warmer – the big ones are Alligator Weed, Senegal Tea, Parrot Feather, Pale Yellow Water Lily."

"20 km up on the pondage you have to wade through about 20 metres of aquatic weeds to get to open water."

"Horehound is another weed that might increase."

"Native grasslands are at risk under changed climatic conditions. Will they be displaced? They might disappear altogether. Can native grasslands be protected?"

"We farm on the Patho Plains and run stock in one of the

reserves. There is mostly rye grass coming in and grassland pastures don't perform. The Plains Wanderers are gone from the reserve - the hawks and eagles pick them off. We find more Plains Wanderers in our stubble."

"The Plains Wanderer likes a bit of cover and a bit of open space."

"The Patho Plains is significant, but its health depends on how you manage it. Eris O'Brien has shown that grazing is beneficial."

"Rabbits are a threat. If we get big downpours followed by dry periods they will go gangbusters."

Opportunities

- "We had 12 weeks of flooding and then the water left. Three weeks later we made haylage (in May) and it was the best feed ever. We didn't pump the land and the flooded land recovered really well."
- Dryland lucerne is an opportunity. We sow at 5 kg/ha on the Patho Plains rather than 25 kg/ha on a dairy farm. The trick is to get it going. It is impossible to kill."
- "There are social opportunities if we can get past the red tape. In Italy they make generators to go in the bed of streams. Unique geophysical structures lend themselves to energy opportunities. Farmers can farm and also innovate, making the most of off-farm opportunities."
- "Recreational water."
- "Wifi is affected badly by weather and the internet connection can drop out."
- "Biofuels. An ethanol plant is going to go in at Moama."

Carbon

- "Tree planting on marginal land is an opportunity. All small lifestyle properties north of the highway would be a good place to put trees. They are not viable farming enterprises."
- "Carbon farming is like snake oil. We need some certainty around carbon."
- "There is an Irrigated Red Gum plantation downstream of Barham."
- "The native regeneration on abandoned dairy farms could be managed for carbon."
- "We can't be expected to guarantee that we will lock up carbon in the soil for 99 years. It is not practical and it won't happen. You won't get 30% of my farm planted to trees or anyone's farm."
- "On my farm where the trees are fenced out they can't provide shade for the stock."
- "We have plenty of trees and plenty of shade."
- "The scale of the farming operation determines whether you have trees or not."
- "If you could lock up the carbon in the soil for 99 years you would get a credit."
- "Measuring soil carbon is still a big problem."
- "Is any research being done on the density of trees being grown? Historically big mature trees grew about 70 metres apart. With the flooding of Gunbower Island the trees coming up are too dense. It is a danger to the forest and the trees. There is a need for ecological thinning in the forest."
- "I have a 20 year old plantation that I actively manage. Managed trees need pruning."
- "How far am I from farming carbon on my farm? I want to know whether we are doing it right or wrong now?"
- "Farmers are not environmental vandals. If you damage the environment you will go broke."
- "There is a diversity of environments in this area. The Murray River corridor vs the Patho Plains. The right trees need to be planted in the right places."

Other comments

- "Education, education, education. We need Council and others to champion the cause."
- "The importance of recreational water and green grass to the local community."
- "Need to manage our waterways, including aquatic weeds, as efficiently as possible."
- "The world has 8.2 billion people and there is just enough fresh water for this many people."
- "Gunbower Lagoon is an aesthetic asset. Should the lagoons be dried out occasionally?"
  - "If they dried out the lagoon how are we going to water our farms?"
  - "They are talking about bypassing the lagoon, not taking water from irrigators."
- "Stop reading the Weekly Times."
- "We looked at buying property near Ararat. But land here is $500-600 per acre and it is $3,000 per acre at Ararat."
- "The return on the asset in this part of the world is the best in Victoria."
- "Small holdings (family farms) make a big contribution to food production in this area."
- "Victoria is the last bastion of the family farm."
- If you have 100% temporary water, then you have no permanent water to give up for infrastructure upgrades."
- "My wife and I could not have afforded to buy a small farm. We had to borrow to buy a big farm that was capable of making money."
- "The plan needs to recognise the diversity of landscapes and farm businesses."

Lockington workshop notes

Participants: Brian Smith, Laurie Maxted, Wendy Sims, John Wright, Alwyn Broad, John Childs, Rohan Hogan; Geoff Park; Mal Brown.

Observations about climate change/climate variability/historic climate

"1982 was the worst drought on record. Fortunately it broke in March 1983."

"I remember 1982 because I had to go off the farm and back into teaching."

"My dad watered the tops of the bays to have a bit of green."

"I remember in 1982 watching the clouds going over. Any other year we would get an inch of rain, but not that year."

"In 1982 we had 30% sales water and they were predicting a 30% allocation for the next year. Then we got a spectacular autumn break in 1983."

"In 1983 the soil was very friable (loose) and every seed germinated. The place turned green overnight."

"Salinity was a big issue that has turned around dramatically. Drainage, water pricing, lasering, etc., have had a big impact on runoff and groundwater accessions. The Tragowel Sanctuary is a good example of the regeneration in the area."

"We used to have 255,000 ML in the district and now we have 130,000 ML of allocation."

"In 1976 we had bore water at the surface. Water was never too dear to put out just too much water was applied. In the Pyramid area there was always water in the side cuts."

"The politics of bushfire management is a real issue. Especially the relationship between the CFA and DEPI. The two organisations must be compatible. In the Mitiamo fire the DEPI changed its policy to just look at wind speed."

"There needs to be a lot more education to reduce the risk of crazy human behaviour on catastrophic fire days."

What are people doing?

"There was a lack of irrigation water. For a period of time we could not get an allocation so we looked at our debt level and in 2002 we bought a farm at Skipton in the western district where there had been an average rainfall of 27 inches. We put on share farmers who taught us about managing that country and brought fodder and grain back here to maintain our continuity of supply."

"In the Emu Creek catchment the forest company planted 250,000 trees every day. The Emu Creek stopped flowing. Western Water did something similar and there was no runoff into the tributaries at all. The Skipton farmers went to Birchip where there was cheaper land. Now all the blue gums have been pulled out. "

"In Skipton we have only had one year of failure due to frost."

Pine Vale farmer Grant Sims applies liquids at sowing time which increases crop yields and improves soil structure.

"I planted lucerne at Skipton and it lasted eight years. Lucerne has revolutionised farming down there. They are now cropping successfully whereas they used to have to crop on raised beds. We used to get good yields but not quite the same any more. One year the oats went 72 bags to the acre and barley 45 bags to the acre."

Issues and risks associated with the climate projections

"In the early 1990s the government removed the link tying water to land. The farmer response to climate change was to trade water. Some farmers made the most money trading in times of low allocation. Water can be moved to areas of higher productivity and more efficient use. But this comes with a high social cost."

"In 1995 we put in an apple orchard to complement our dryland cropping and grazing enterprise. We made money in the dry years, because low allocation was not a problem. It made us look like futurists."

"Permanent water has gone out of the area. (Rochester is similar to the Pyramid Hill area). So the pool reduces and the price of water goes up. Water is already too dear. When water is $120/ML on the market it is much more volatile for the dairy industry."

"Having permanent water allows you to budget for it. Buying temporary water makes your budgeting much more volatile."

"We have had to pull apples off the tees because of frosting and sunburn. We might need to net the tees in the future. Frost is our greatest threat.

"Australia is a small fish in a big pond. If the larger countries continue to emit there is not much we can do."

Adaptation

"Most of us are responding to the variability now by planting earlier and using frost resistant and rust resistant varieties."

"There is now greater reliance on lucerne on non-irrigated land."

"It is very important to know the amount of sub-soil moisture in the profile."

"Our landcare group has installed moisture meters across the district. This is leading to a lot more trial work and a lot more formal learning opportunities."

"We are living with a very shallow topsoil so it is critical to increase soil depth and get ground cover. We must reduce evaporation."

"We have gone into liquid fertilisers. There are still too many conventional farmers. There is nothing to assist farmers to change. No incentive to trial changed practices. Since we have been using liquid fertilisers people who come on farm walks can't believe how friable our soils are."

"Early adopters will always adopt and pay the cost."

"There is a lack of R&D into both agriculture and natural resource management."

"There is a big increase in formal learning in our area. We have 35 farmers who regularly come to field days and farm walks."

"The need for shade is a big issue so I am planting more trees."

"Some landcare group members request 100 trees or even just 20 trees, mainly for shade. It would be great to have a small grants program that could meet this need."

Extreme heat days. In our 500 cow dairy the animals start to show signs of distress around 11 am. From 12 noon to midnight they spend time on concrete and under sprinklers. It can cause health issues, such as infections."

"Less water."

"Summer rainfall affecting catchment."

"Trees must be planted across the bottom of the bays. There is no loss of production and the trees soak up the excess water."

"North-South planting is best."

NRM future impacts and threats

"More insect problems. Locust plagues."

"Possibly more rabbits."

"I found the rabbits did not breed as well in the dry years."

"Weeds are a huge problem. Roadsides are a source of the spread. Wheel cactus. The Loddon Plains Landcare Network (LPLN) is working with the Loddon Shire and educating the Council about coming on board."

"Dry times are changing the weeds we have. Weed education is important. Thorn apples, Fleabane, Gazania and Stinkweed are problem weeds around here."Silverleaf Nightshade is out of control in the Calivil area."

"Shires have responsibility for roadsides, but farmers slash some roadsides to reduce the fire risk."

"Boxthorn is a problem in the Calivil Creek. The LPLN has organised a project where DEPI will ultimately come in with enforcement."

Opportunities

- "New crops. Possibly cotton. There are also some local poppy trials happening. Industrial hemp."
- "A poppy trial near Boort found that the plants had not been properly established and a wind event destroyed them. We need to cut the red tape and allow for planting of new varieties. Permits must come through on time."
- "The Lockington Cropping and Sustainable Soils Group has been a real positive."
- "Once we were told to look 200 km north and that will be our future climate. Now they say look 400 km to the north and that's what we will be growing."
- "We need a mix of vegetation in what we produce, not a monoculture."
- "We need more R&D, particularly into local pasture cropping."
- "Education. The FSS Program had the flexibility to use program money to meet local farmer's needs. People would say 'let us know when you will have the next farm walk'."

Carbon

- "Soil carbon – liquid fertiliser is working to improve soil carbon in marginal country (in a dry season)."
- "We need education about the carbon cycle and the role of N and P to put the carbon into the soil."
- "I can't see it making money."
- "We are better off reducing our NO2 pollution rather than putting carbon in the soil."
- "Carbon improves soil structure and water holding capacity. It is not just about the price for carbon."
- "There is no real incentive."
- "Trees for carbon could be planted along creek lines and across the bottom of bays."
- "There is no certainty around carbon."
- "What happens if we cultivate or there is a bushfire?"
- "There is a need for a farm carbon budget, not a global budget."

Castlemaine workshop notes

Participants: Julie Markoff, Chris Timewell, Christine Johnson, Jarrod Coote, Max Schlacter, Malcolm Fyffe, Terry White, John van Tiggelen, Katie Finlay, Hugh Finlay, Clare Claydon, Paul Righetti, Beth Mellick; Rohan Hogan; Geoff Park; Mal Brown.

Observations about climate change/climate variability/historic climate

"In 1956 Cairn Curran had just been constructed and it filled in one year."

"I remember the summer rains as a kid. Lucerne and perennial pasture would get a nudge along."

"I have strong memories of the millennium drought."

"I grew up in suburban Melbourne near a railway line and I can remember the massive flooding that built up against the line."

"I arrived in Australia in 1981 and endured the 1981-82 drought. I thought, this is what happens in Australia. I remember my children dancing in their knickers while holding Chinese umbrellas when the drought broke in 1983. There was a small fire in our yard that just took off and the ground was so dry that the fire burnt a fence post."

"We moved from Holland to Australia in 1975 and settled in East Gippsland. I was a bit of a 'birdo' and loved collecting frog's eggs. At the time there were frogs everywhere. We went back to Holland and returned to Australia in 1983. I vividly remember how there were no ibis, no frogs, no egrets, no white faced herons. There used to be black swans breeding on the dam, but after 1982 they never bred again. In 2005 we moved to Castlemaine and in 2006 the kids experienced their first real rain event in November of that year."

"We moved to Ingham, Queensland from Lebanon. I remember orange everywhere. We had to get to school in a boat. My parents say the cyclones are much fiercer now. The extremes are very noticeable."

"Not many years are average any more."

"We have two creeks running through our property. My father could always rely on waterholes in the creek to water stock. I can no longer rely on the waterholes in the creek."

"I've noticed a link between momentum for on-ground works and demographics. House sales increase in September and so do landcare projects. People get excited again by the warmer weather."

"There has been a shift towards increased variability and it's the farmers who have had to face it head on. Around Pyramid Hill they don't complain about the fairness of it all, they just get on with it.""

"We are organic fruit growers at Harcourt. We have diversified our business and offer an on-line leadership program teaching fruit growing skills to backyarders and also run winter workshops."

"We farm mainly Merino sheep at Yandoit and Clunes. We have moved from a high input system to a low input system based on rotational grazing."

Yandoit farmer Paul Righetti explained his move from a high input to a low-input farming system at the 2014 Castlemaine workshop.

"Buying a few more tanks saved me money."

"I experienced the St Andrews fires and nearly didn't get out. I saw people lose all physical attachment to houses and landscapes. The important questions being asked were: Are the kids alright? Am I alright? The important things come to the fore."

"The variability. We can no longer rely on previously reliable dates. You can't predict so you have to plan. The follow up weather is also unreliable."

What are people doing?

"We just have to be more responsive. There is no more normal now. We respond to the triggers by doing more monitoring. For the trees we commence our spring monitoring in the depths of winter. For the soil we monitor carbon, nutrients, and moisture (using tensiometers). We also monitor the weather. At the end of winter the soil this year was cold and dry so we needed to start irrigating very early."

"In Harcourt in recent times we have had the drought, many frost events and major hailstone damage. And of course we had flooding. Many growers packed it in, mainly through exhaustion. We had 28 growers 15 years ago now there are 9-10 remaining. We saw the disassociation from the land. People sold up and orchards were pulled out. The area under apples has shrunk."

"We saw something similar in the Wimmera. They kept putting crops in through the drought. In 2010 the crops were good and prices were good and the planets seemed to be aligned. But in 2011 the grain that was stored in bunkers got flooded, and people said 'I can't take this any more'."

"Decades ago the years were characterised by good total rainfall and good starts to the season. Now the seasons are incredibly variable."

"We have moved to a lower risk farming model. A bit of pasture cropping but no cropping in its own right. That is too high a risk. We tend to trade more animals. We have more feed so we can get into the market before the others. It flattens the profitability line but is more beneficial in the longer term. In 2009 we changed from all breeding to trading. We have stubbles up north we can out the sheep on. Diversity is the key."

"We have diversified into teaching and it is working."

"The importance of the psychological response that comes with diversifying."

"No landcare groups have climate change on their agenda for planning."

"People have adapted to change. There are no biodiverse plantings at all any more."

"A presentation was being made to farmers in the Southern Farming Systems program recently and the slides associated with climate change were left out of the presentation."

"The difference is what you want from the land – productivity or conservation. Farmers are not deniers, they just want to have a place in this country."

"I think the farmer response to the millenium drought became more collegiate. It was informed by the DPI response which encouraged stock containment exclusion areas. And the extension staff talked about climate change. In the local pubs the conversation seems to be more accepting of climate change."

"We are experiencing incredible climate variability at the moment."

"The policy landscape is uncertain."

"The projections are only a continuation of what we have been experiencing for the last ten years."

Issues and risks associated with the climate projections

"That the industry we are in is not suitable." We would either have to move or sell."

"We may need low till or high till varieties so we can adapt. We have a long way to go."

"Increased rainfall can be really destructive for fruit."

"The impact of climate change weakens the attachment people feel to their place. More dependable, less cold is more pleasant. Extremes become more intolerable to the body. We have not evolved to cope with the extremes."

"Biodiversity and the need for refuge areas. If climate variability makes it less suitable for the current species then they won't have anywhere to go. Species will drop out. Change is then inevitable and we will get new species moving in."

"Bushfire issues and how the community will react. How will they respond to the sense of fear? Fear is very powerful."

"If in doubt clear vegetation away from the house, if it is a threat."

"People are increasingly worried about summer fires and CFA crews are being called out earlier and earlier. Also the capacity of people to fight fires. We don't go away over summer. We don't program any social events in January or February. We bunker down at home."

Adaptation

"Trees in the landscape and fire. There is work being done by the CFA in partnership with the NWF Landscape Restoration Group on a landscape restoration project that considers where to put trees and to not put trees from a fire risk perspective. Also considering trees on roadsides. There are two school of thought – trees are wicks and trees slow down fire."

"Adaptation is about gathering data and making decisions about grazing operations etc."

"Lasering paddocks around Kerang became a fad to trap as much moisture as possible."

"Having good soil structure and trapping moisture is the key to more resilience."

"Astroturf is being laid in school grounds. Flowers are giving way to succulents. Pebbles are replacing lawn."

"There are fewer areas of farming close to Castlemaine. Farmers close to Castlemaine are walking away. There is an increase in the area of land just being managed for its biodiversity value."

"This change in land use is good for biodiversity but less positive for the fire risk."

"We have a 1,000 acre native grassland which has high conservation value that we are managing as part of our grazing system."

"The sub-division is happening too fast for the water supply we have in this area."

NRM future impacts and threats

"We have some very fragile species and some very robust species. Biological simplification could occur if all those predictions come true. The Maryborough Field Nats were distressed by the number of birds not raising chicks at the end of the millennium drought."

"When do they drop out? After 50 years? 200 years?"

"Koalas may not be here for my kids to enjoy in the future."

"We are seeing biological simplification already – bushfires and loss of species are all interrelated negatively."

"Perhaps we should not be funding recovery programs for species that are likely to drop out!!!"

"It would be great to have the information on the impact of climate change on biodiversity. It has the potential to undo all the great landscape restoration work that has happened over the last 60 years."

"The more carbon you can store the more resilient is your farming system. The more carbon the faster you recover from drought and flood.

"Insect pests: Fruit fly; locust explosions."

"The severity of megafires which are so destructive. Three years of intense fire in a row will reduce a forest to grassland."

"Weeds such as wheel cactus will spread."

Opportunities

- "Design communities are going gangbusters designing cities that are habitable, including storing water. The fearsome threats are causing people to adapt creatively and quickly."
- "Build on shaded canopies along waterways. Riparian zine represents cooler spaces and green refuges."
- "Take a profitable system into people's marginal farming operations."
- "Food and animal waste. Get producers and consumers together."
- "Very intensive farming will happen in the future. This will suit Monsanto's green technology."
- "Will the family farm survive?" A bloke can make $100K in the city and $30K on the farm."
- The North Central CMA has a responsibility to put the carbon message across."
- "We need conscious strategies and discussion across the region. We need to design a completely different future. Education is not changing. Buildings are being rebuilt inappropriately. In Scandinavia they have life-long education. We need both systems and system responses in place."
- "Water flow planning. Bendigo should not be drawing water from another catchment. Plan for the pinch points."
- "The counsellors who followed the Black Saturday fires did a great job. They spent time with families and provided access to information. It can be very hard to deal with the issues after a natural disaster. They were invaluable to connecting the local community."

Carbon

- "The whole carbon issue is awfully complex. Measurement and payment is still too daunting."
- "Sell the soil health benefits of carbon."
- Climate variability and the issue around permanence is a barrier."
- At $8/tonne on the open market I can't see the opportunity in central Victoria."
- "At $50/tonne the concept is exciting. Even at $25. At $8 no way."
- "Carbon farming is an option on my marginal land. I will continue to maintain a low benchmark for my soil carbon levels."
- Philanthropy is active in the sustainable agriculture space in NSW."

Trentham workshop notes

Participants: Ian MacBean; John Cable; Jill Teschendorff; Damian Leonard; John Dinwoodie; Barry Elliot; Justin Walsh; Gayle Osborne; Russel Fisher; Sebastian Klein; Rod May; Lyn Kelson; Ralf Thesing; Rohan Hogan; Geoff Park; Mal Brown.

Observations about climate change/climate variability/historic climate

"I remember the early 1990s were lush and green around here. There used to be more reliable rainfall."

"I remember the intensity of the 1998 fire that spread from Spring Hill to Woodend."

"I remember the drought in the early 80s. I bought a tractor in 1982. It was cheap because no other farmers were buying machinery at that time. Things were tough."

"I remember the 1960s were wet. As I walked to the school bus there was always water running down the side of the road. I also remember bringing the cows in for my dad and all the mud during winter."

"I remember living in Melbourne and the frosts. We would skate on the ice, and this was in Northcote. Closer to home, Percy Bruton remembers getting snowed in at Trentham and not being able to go to school."

"When looking at past 'wettest or driest year on record', remember that each year changes the average with which you then compare the current year."

"The population of Trentham doubled in the ten years to 2011 and continues to grow. I don't like the Coliban Water long-term supply and demand plan. It just does not work."

"On 23 October 2000 there was six inches of rain and Cairn Curran filled in 24 hours."

"We used to live near Boort on the Boort-Charlton Rd. We would ride our billy carts down the dam banks. Then my father moved from dryland farming to irrigation country. Now there are even bigger farms, GPS and precision ag technology, direct seeding, etc. There is a lot more chemical needed but you have many more options such as undersowing with different crops/perennials."

"My dad used to say if there is no rain in August and September you can kiss your crops goodbye. Now after three years of good times it looks like we are heading back into drier times."

"I remember rock picking, steeping, hay making, and winters that were so cold that there was not enough feed around and my parents would move stock off the farm. Now I don't have to move stock off the farm and by rotating them around the farm I have grass all year round."

"I remember the 82-83 drought and also how dry year it was in 2000. We have moved to varieties that require a shorter growing period. We have also saved water by moving from travelling irrigators to sprinkler irrigation."

"Looking at the rainfall data shows that there is somewhat of a cyclic pattern and that the variability is defensible."

"All the temperature readings are taken at airports where the built environment is getting hotter."

Trentham Falls

"Ploughing paddocks for potatoes used to create localised dust. The move to minimum till means the soils no longer blow anymore. Commercial potatoes are declining and a number of paddocks are returning to grazing."

"There is minimal soil loss from potato growing. With the increased size of the machinery we make far fewer passes these days."

"Practice change is most noticeable in the Mallee where new fences used to be built on top of old fences."

"There are 300 members in our Energy Group. We have a renewable energy focus and we aim to lower our carbon emissions. We are working on getting a wind farm off the ground at Woodend. We also focus on organic food growing. Climate change is the most important priority for Environment Victoria. The main reason people join our group is because of government inaction."

Issues and risks associated with the climate projections

- Increased fire risk.
- Diminished recharge of the aquifers that supply drinking water and water for agriculture, and also feed the streams. Maintaining the last vestiges of water. "We used to water 200 acres with 60-70ML via a windmill on a surface dam. Then we sunk shallow bores (down to 30 metres) but they gave out. Now we are down to 80 metres and so far so good."
- Looking to use water more efficiently. "On our Riverina farm we used to use 740 ML now the same farm only uses 200-300 ML in any one year. Centre pivot irrigation is more efficient than the travelling irrigator."
- The increasing population.
  - "We are now semi-urban not semi-rural. This is placing stress on all the natural resources. Population increase is not always good."
  - "Coliban Water does not have a viable solution to deal with the increasing population. One solution put up is to buy water. From where? They might have to pump more water from the East Trentham bore."
- Changing land use. "If northern Victoria dries out, the cropping area might move south. There may be interest in growing crops here. Alternatively, the cost of land may never make it economic to grow crops in this area."
- "The North Central CMA region is very diverse so we are going to need quite a variety of adaptation and mitigation strategies."
- Advocacy for the environment in local government.
  - "Some recent decisions on sub-division have been irresponsible. On one occasion the staff recommended against sub-division of agricultural land but the councillors voted in favour of the sub-division. The CMA is the small 'p' in planning and local government is the big 'p'. The CMA is up against local government's lack of capacity to adapt."
  - "Organisations are not equipped to adequately deal with planning, governance and decision making. Coliban Water supplies town water, G-MW is responsible for licensing dams and groundwater use. Neither organisation is fully equipped to deal with the wholistic water management issue. Any adaptive plan will come up against this."
  - "Hepburn Shire is not part of the per-urban group of councils (going south) and the population is coming north."
- Public land and climate change. "How do we achieve landscape resilience on public land? We are already witnessing massive extinction of species, so the current management is not working. Nature is an entire system. Fungi, leaf litter, birds, insects etc all have their place in the system. Controlled burning of the forest and track degradation is not helping. We need large areas of native vegetation in working order. Even without climate change the forest is degraded and fragmented. Wombat Forest is being trashed. Climate change is just putting even more pressure on the natural environment."
- "The conversation is often about more of the same. Practice change needs to be the focus going forward. For example, if cropping does move south it is likely to be very different to how things are done at the moment."
- Capacity of the community to respond.
  - How is the health system going to respond to more heat waves?
  - Are fire guards adequate?
  - Community connectedness.
  - People move from Melbourne to rural Victoria with very urban expectations. E.g. that someone will come and deal with a fire on their behalf.

- Inconsistent development in inappropriate areas that are more at risk. Sub-division is often approved based on what people have experienced in the past 10-20 years. E.g. the area has not flooded in living memory, so it is OK to develop the area. This may not hold true in the future."
- Expectations of landholders. "Farmers are adapting and at the same time putting a hold on other things. In ten years the pasture is likely to be all bent grass and we will see more summer cropping. This is because white weed is a big problem in crops."
- "Loss of whole swathes of vegetation. "Seed won't germinate and we will lose key components of the ecosystem."
- "Salinity is no longer a threat."
- 'Pest plants' is a value-laden term. The UN definition of biodiversity does not make mention of the term 'native'. We need to change our perspective on how we view 'pest plants' before we start making decisions on landscape purity."
- "Bushfire frequency and intensity. May be little regeneration. Without a build-up in humus there will be a huge impact on biodiversity."
- "Erosion. Particularly if a big wet is followed by a big dry. We need to capture as much water as possible and also ensure the aquifers are recharged."
- "Increased pressure on roadsides. These areas will be doubly hard to manage but are important for biodiversity."
- "Less late frosts will make horticulture more competitive."
- "We need to change the way we practice. A benefit of climate change may be more opportunity for pasture cropping. We also need to better understand or soils as a community and a living ecosystem. This has huge potential for agriculture."
- "Fuel, fertiliser etc., has become too expensive. Climate change is just another challenge. "

Opportunities

- "Climate change will drive more innovation."
- "Volatility will change the way we look at the land and how we work with nature."
- "Hobby farmers provide an opportunity. A lot of the farming experience in the area is new. People are coming in and doing things differently on a small scale. Climate change is part of their thinking."
- "Something is happening to the climate. We can do something about it. Large scale solar and wind power provide income opportunities for farmers in renewable energy."
- "The large-scale clearing that has occurred means we are responsible for causing some of the change."
- "Incentives are needed to plant native vegetation on at least 5% of the farm."
- "I don't think there are any opportunities at all."
- "Melbourne. Five million people will soon be seven million people in the world's most liveable city. Transport costs will be an issue. We have a huge stakeholder in Melbourne which will influence how land is used here."

Carbon

- How to measure it is an issue. Long-term Carbon. Volatile Carbon.
- "Don't put a price on carbon. Show farmers how increasing carbon levels benefits productivity."
- "Carbon has hijacked the debate. The discussion should be about sustainable soils."
- "Carbon must not be seen as another burden on farmers."
- "If the soil is red it is dead – completely oxidised."
- "Any green matter will help boost soil carbon."
- "There is not the area available to grow the trees needed to sink enough carbon. So we need to be able to harvest the carbon as agrichar, biochar etc."
- "We need an economic driver on farm (e.g. bioenergy). Organic farming provides a biological and economic framework for building soil carbon without the need for government carbon farming programs. Organic farming provides both a system and an outlet for carbon."
- "The true cost of inputs needs to be accounted for. It is a complex field and there needs to be drivers."
- "In New England the shelter belts have been proven to provide excellent protection for stock."
- "Scandanavia is powering towns with populations of 150,000 people using wood.
- "Trees are not just biodiversity they are an investment in the future or building materials and firewood."
- "We need to tie the conversation in with local experience."
- "The CMA could model different scenarios for the region - the organic farming model, 100% tree planting on cleared land, and various levels of improved soil carbon, and the vulnerability scenarios. The results would be great for the conversation."
- "The CMA leadership and advocacy role with local government is vital because the CMA operates on catchment boundaries."
- "CMAs need to build on their work into sustainable soils (as per Auditor General's report)."
- "We need healthy waterways and healthy water within the waterways, so landscapes that filter the water are required. Ongoing river restoration will be even more important in the face of climate change."
- The CMA is doing really well in the education space. We need to educate the people and empower them to make the right decisions. Knowledge is power when it is held by all the people in the community."
- "The Carbon Action Plan needs to highlight the importance of a coordinated approach to adaptation and mitigation across all levels of government."

Raywood workshop notes

Participants:; Lindsay Falls; Andy Hay; Dennis Demeo; Dean Collins; Ian Hocking; Vern Wilson; Paul Haw; Andrew Wall; James Williams; Rohan Hogan; Geoff Park; Mal Brown.

Observations about climate change/climate variability/historic climate

"I collect rainfall records for the BoM at Tandara and have access to rainfall data from 1887. There has been a distinct 25-30 year cycle with a flood every 5 to 10 years."

"Every 12-15 years we seem to have a wet period followed by a dry period."

"1870 was the worst flood ever."

"In the late 1800s the flooding was so severe that the Loddon and the Campaspe joined."

"The seasons now are unreliable. The rain is inconsistent and we seem to be moving into an earlier dry."

"The 1960s and 1970s we had consistent spring rains. The last 15 years we have had very little spring rain. 2014 was normal until August and then it only broke in some areas. It depended if you got a storm. It was not a general rain the way it used to be."

"My grandfather grew 3 bags/acre in 1902. My parents missed five out seven harvests from 1938 to 1944. The 1940s was the worst drought ever in living memory in this area. We did not see another drought until 1982; even 1967 was very good in this area."

"I remember 1955-56, there was water everywhere and it was green until Christmas."

"Clearing 11 million acres in the Mallee must have had some effect on climate."

I remember we got four and a half inches of rain in late January one year about the time we started back at school. I also remember the flooding on Christmas Day in the early 1990s. We seem to be seeing more summer flooding."

"The years that end in '2' seem to be dry years. And years that end in '7' seem to bet wet. I have a spring lamb operation and this year I have been caught out with no chicory and no lucerne."

"In 1973-75 the big floods came in winter and we had long seasons. The 1980 were drier and the 1990s we started to see the shortening of the seasons. Even NSW and Queensland are noticing a change where predominantly winter rainfall is moving back to summer rainfall."

"When I was at school my father said the average annual rainfall was about 18 inches, now it is a 10-12 inch rainfall."

"The localised weather differences are incredible. We are doing OK but within 20 kilometres there are blokes going broke."

"Powlett Plains is disastrous this year and they will only harvest seed, whereas at Mitiamo farmers are talking about the best crop ever."

"At Buckrabanyule they have had 150 mm of rain this year compared to 200 mm at Boort. 70 mm makes a big difference to the crops."

Farming systems need water to be resilient, particularly in terms of livestock.

"Direct drilling and modern varieties have had an enormous effect on the farming operations in this area."

"The Myers Creek has not run at all this year."

"Containment of livestock commenced in 2002 and during the drought it has assisted greatly."

"In Serpentine there are two farmers who have locked their sheep up already to protect ground cover."

"Red loam is not a good soil for a stock containment area. You need to select the right area to contain stock."

"The dry spell used to be January to March. Now summer rain and lucerne will carry you through to the winter. Lucerne has changed the whole scene. In the Serpentine area they got into growing lucerne early and we are seeing good stands around here again this year."

"Green feed is vital. The rainfall season is not long enough any more. It is a two edged sword. I am having to rethink my whole operation and find a system that will work for livestock in failed cropping seasons."

"In past years the recent day where we had high winds would have seen a lot of paddock blow. There would have been dust storms across Bendigo. We no longer see dust storms because farmers have changed their practices. There is little exposed soil during the summer any more."

"My dad used to put ripper lines across the paddock to catch some of the soil being blown away."

"It can be quite variable. I had a paddock where the gravel even blew. Whereas next door where I had sheep on canola stubble it did not blow."

"The heat is no more intense in recent times than it was in the 1960s. We had a poultry operation and I can remember a week of 115 degrees Fahrenheit or more."

"The heat waves don't seem to last as long as they used to. They used to last for up to a fortnight. Now we always seem to get a cool change."

"It seems that we are getting hotter days earlier in the year than we used to. This is harsh when you are trying to finish off crops."

I think we need to see the data rather than rely on hearsay. 2014 has had some of the hottest months on record."

Issues and risks associated with the climate projections

"Our farming systems need water to be resilient, particularly in terms of livestock. Prograze and other pasture programs are almost inapplicable in this area. One farmer said he can only grow feed now by sowing it. It is very hard to manage pasture. People are lambing earlier and as a result the market is dropping."

"I have been grazing crops such as wheat and barley. It reduces the biomass and can lead to better crop yields. In 2013 I grazed a wheat crop which delayed flowering and the crop never got frosted. Whereas the crop that was not grazed did suffer frost damage. Reducing biomass reduces transpiration. The again some farmers who have grazed crops have had the season peter out and the crops failed. We need help. We need to train the cropping agronomists in becoming more knowledgeable about livestock management."

"I have not grazed any crops in the last three years. There is also the issue of when is it too late to graze? July is too late if you don't get the rains in August."

"When I was young wheat finished off better than barley in a tough end to a season. Now barley finishes better than wheat."

"I grazed a wheat crop in June that went 6.2 T/ha even after 500 ewes had mowed it down. So it can work."

"In 2014 we got the best start to the season ever so I grazed an oat crop. That turned out to be a mistake because the finishing rains just did not come."

"If we get summer rain we can consider sowing millet."

"Unless the summer rain is excessive you can't get a summer crop around here. Most of the water evaporates and the crop struggles to germinate."

"You need an inch and a half of rain in summer and you need to have machinery ready to sow straight away."

"We have been adapting to all the predictions, especially with lucerne."

"Plant breeders are not done yet. They will develop plants and cereals that will cope with drier times."

"Climate change is gradual and we are evolving with it."

"Yes we have been adapting with our cropping systems but we are not doing so well with grazing."

"More lucerne means less runoff. The dams have been empty the last two years."

"We are now more reliant on outside (off-farm) sources of water."

"People who have given up their water right are regretting it big time. Water is the big issue around here."

The region is seeing increasing uptake of low input grazing systems based on native pasture.

"The best thing government could do is to install a piped system."

"The Kamarooka water scheme went in after the 1982 drought and it has been a wonderful investment in drought proofing our farms."

"Plans have been drawn up for a scheme that supplies from Dingee to Kow Swamp, but it is still only a concept. There is no money to build the scheme."

"A piped water supply is a fantastic investment."

"We have planted a lot of trees. Whereas we used to plant in Spring, we now have moved to autumn planting."

"I have planted thousands of trees and used to think I had a green thumb. They all took. But in the last three years I have direct seeded and planted trees spring and got nothing."

"This year the natural native vegetation has never looked healthier. Since 2011 the natural regeneration has been amazing. Black Box trees are coming up and they only germinate two to three times in a century."

"In the area around Yando there are some great crops but no run off. There is no need drainage. As a result the wetlands are changing back to what they used to be like."

"The price of water has had a lot to do with efficiency and the loss of run off. I don't mind if it is a little dry at the bottom of the bay. I'd rather that than see the water end up in the drain."

Thunder Swamp has been fenced so that it can be strategically grazed. A cool fire might benefit the swamp. The area managed by Parks Victoria (PV) is weed infested. Where there has been a fire through the area there are less weeds. Pattersons Curse is rife throughout the PV managed land. There are lots of tracks which suggest the foxes are very active."

"PV management has caused the deterioration of Thunder Swamp. PV locked it up and took the grazing off it. Now it is a mat of grass that is way too thick and there are no wild flowers. Compared to the area Roger Lowery has fenced so he can strategically graze it, there is a mass of wild flowers."

"Farmers are better land managers than PV."

"Tang Tang was also strategically grazed until about 25 years ago. Now it is a fire risk and needs a cool burn."

"The bull rushes grow where the water enters Tang Tang. They grow and die and grow and die until they become a thick mat of understorey. They are an enormous fire risk."

"Tang Tang has water in it two years in five, and probably fills one year in five."

"Thunder Swamp is similar and gets its water from the Myers Creek."

"Local land managers should be allowed to manage the swamps and the surrounding areas."

"We need to have management of the swamps taken away from PV. Even though there is no money and no people we need to change and fix the management problem."

"We need more fox baiting on the swamps to protect the Brolgas."

"I have observed two sightings of Brolgas at East Loddon this year."

"I see Brolgas every year and nine pairs this year. One year they nested on a check bank and I only discovered them during harvesting. I steered away but they abandoned the nest."

"I see Brolgas every day."

"Electric fencing is a great deterrent for foxes."

"People should be trained in the use of fox traps also."

"We used to fox drives but we are not allowed to drive them and shoot them on public land. We need a 'Game Stamp' At Thunder Swamp we are allowed to drive them through the fence and shoot them on private land."

Opportunities

- "Hay market might be more viable in the longer term. This is the fourth season in a row that has been good for hay making."
- "Regeneration in hot summers may be beneficial to the environment."
- "Grain genetics. E.g Molloy Barley finished going to head 8 weeks ago. We may be harvesting in September in the future."
- "Soil moisture probes are a good management tool. They tell you how much water is in the profile and help you decide when to apply fertiliser etc."
- "We have a vineyard and we watered the vines for the first time ever in early September. The probes were telling us the soil was too dry even though the vines were not showing any signs of stress."

Carbon

- "There are many limitations for Carbon. The cost of establishing vegetation is just one."
- "Growing crops soaks up heaps of carbon."
- "The whole carbon issue is awfully complicated."
- "Deep rooted plants like lucerne and canola may be taking carbon down to depth."
- "There is no financial benefit at the moment. Does it apply to planted trees or native vegetation."
- "Woolshed Swamp has 200 hectares of natural regeneration."
- "Healthy ecosystems lock up carbon, including ants etc. It is not just about plants."
- "A local dairy farmer has planted a lot of trees which provide shelter for his cows. 10% of the farm is treed. The benefit shows up in the quality of the milk and the increased returns he gets for his milk."
- "My son lives seven kilometres away and has more vegetation on his farm than I do. He gets about two inches more rainfall each year."
- "We need practical information on carbon farming. The North Central CMA has a role as the honest knowledge broker."
- "At the Speed Field Days there was a map of the soils moisture probes across Victoria. Raywood had one of the highest readings across the state."

Appendix 7 – Stakeholder Workshop report

Participants:	
Name	**Organisation**
Dale Tomkinson	Hepburn Shire Council
Damian Wells	North Central CMA
Derek de Vrieze	bankmecu
Geoff Caine	Department of Environment and Primary Industries (now DELWP)
James Williams	North Central CMA (Board)
Joel Spry	North Central CMA
Keith Reynard	Bendigo Sustainability Group
Mark Costello	Department of Environment and Primary Industries (now ecodev)
Martin Hamilton	Department of Environment and Primary Industries (now ecodev)
Martin Szakal	Central Victorian Agribusiness Forum
Nick Layne	North Central CMA
Peter Wilcock	Federal Department of the Environment
Phil Dyson	North Central CMA
Robyn Major	CoGB
Rohan Hogan	North Central CMA
Shane O'Loughlin	North Central CMA (NRMC)
Sonny Neale	Central Victorian Greenhouse Alliance
Sophie Bickford	Central Victorian Biolinks
Steve Jackson	Dja Dja Wurrung Aboriginal Corporation

Climate change issues

"The Riverine Zone under threat."

"The system as a whole will all get whacked by climate change."

"Climate change will impact on wildlife."

"2014 is a model year for where things are going to go."

"The productive landscape will be drier/warmer, so are we being sustainable?"

"The increased fire risk is a challenge for policy makers."

"The Basin Plan water reform is positive. I am optimistic about the future of the Murray Corridor and its resilient wetland ecosystems. But there are so many moving parts in agricultural systems, especially if governments keep promoting the concept of 'feeding the world'."

"We need a regional food production budget."

"The small plants in the forest have not come up this year. It has been too dry."

"Governance and local government administrative issues concern me. What organisational structures are needed to deal with the issue of climate change?"

"How do we get multiple organisations working together?"

"Population growth and water quality are important issues. The increased pressure on run-off and streams is likely to lead to an increase in Blue Green Algal outbreaks."

"BSG has an urban and peri-urban focus. We facilitate and advocate for community-based groups and medium sized businesses who want to reduce their carbon emissions. We want to move Bendigo to a carbon neutral city. We work with partners including bankmecu, local government, local community, solar suppliers and the Biodiversity Nature Group."

"The City of Greater Bendigo has a huge asset maintenance program and works across a range of areas that are best described as community productivity, emergency management, energy security (taking a wholistic approach) food security and accessibility, community vulnerability and support and advocacy."

"Hepburn Shire Council has an asset management role (with some assets over 100 years old); bushfire and flood; energy and food security.

"It is important to provide the right signals to nature (such as cuing native fish by dropping the water level 30cm in Gunbower Forest. I also see connectivity as vital."

"Legislation was needed in the 1980s to deal with the proliferation of dams in the upper catchment. Appropriate legislation may be required to deal with the issue of climate change."

Central Victorian Biolinks is focussed on the increasing pressure climate change puts on the natural environment, as well as the social and economic dimensions. Biolinks are a primary response for biodiversity to respond to climate change and adapt to a more suitable climate."

"We are supporting 12 Landcare networks and CMNs and planning to contextualise their local work and to get access

to large scale planning, such as a link between the Grampians and the Pyrenees. We are working to determine the best ecological functioning links for connectivity."

"From an agricultural perspective DEPI is interested in increasing productivity and maintaining access to markets and trade. We are focused on better decision making regarding climate change. We work where people are already organised, such as the FSS groups. We are also supporting incremental change through the Connections Program. When looking at agricultural lands such as the Mallee we acknowledge that we can grow crops there, but how viable is it? We are doing some work with BCG and the Mallee Sustainable Farming Group to try and determine if we are speeding up or slowing down adaptation."

"Many farmers are moving to lower input systems. As Bill Twigg calls it, 'working in sympathy with nature.' People have been really hurt by high input costs and failed seasons. They want access to new information."

"The Central Victorian Agribusiness Forum (CVAF) is a ten year old group with a growing list of stakeholders. CVAF supports agribusinesses and creates opportunities for them. Landcare has the potential to add value to markets. Maintaining access to a sustainable market is critical. E.g. we can lose market share due to bushfire smoke taint in agricultural product, or heavy metals in different soils. Diversification is happening in agriculture and we are seeing a lot of reverse marketing. Instead of saying we produce this particular product and you buy it, farmers are now asking 'what do you want to buy and we'll grow it'."

"Land health and sustainable productivity are best achieved through one-on-one conversations with farmers. Group processes, such as whole farm planning also have their place."

"In a climate change context, environmental water is a threat to individual species. No one wants to make the call about which species get funding and which species do we let go. DEPI is working with local government on planning, particularly in terms of managing crown land tenure in the future for biodiverse linkages. We are also involved in forest management, particularly in terms of fire management and firewood coupes."

"The Victorian Adaptation and Sustainability Partnership (VAS Partnership) is an established, successful partnership between the State Government and Victoria's 79 councils. The VAS Partnership helps the State Government and councils work together on climate adaptation and environmental sustainability issues that affect all Victorians. It builds on the achievements of the former Victorian Local Sustainability Accord by raising the priority of climate change and sustainability within councils, supporting councils to work with their communities to become more sustainable and resilient to climate change, and prompting on-ground local action."

"Farming for Sustainable Soils is a collaborative program with other partners, including DEPI. It is a program that is proving successful because it is the group that identifies the need. Over 800 farmers have been directly involved in the program to date."

"The North Central CMA has its strategic Regional Catchment Strategy (RCS). The development of the RCS was essentially an instructive process involving the trading off of competing project priorities. In terms of water the CMA has its fingers in many pies including Basin water reform, carry over, and groundwater management plans where we have been involved in determining the rules around allocation and extraction. At the whole-of-system level (Basin Plan) we are involved in scenario planning for environmental flows."

"The Federal Department of the Environment (DoE) has an interest in environmental flows, and risks to both biodiversity and systems. Building resilience back into stressed systems is a social responsibility. Empowering local communities to do the work and make the difference. The DoE has a regulatory role in avoiding adverse outcomes and provides funding that will increase knowledge. DoE also has a role in Direct Action and the Emissions Reduction Fund which will provide incentives for emissions reduction activities across the Australian economy. The future of the Carbon Farming Initiative is unclear. Climate change and carbon has a profile in this space."

Postscript note [The Carbon Farming Initiative Amendment Bill, passed by the Senate on 31 October 2014, establishes the Emissions Reduction Fund to replace the carbon tax and provide a transition for the Carbon Farming Initiative by amending the: Carbon Credits (Carbon Farming Initiative) Act 2011 to: provide for the Clean Energy Regulator to conduct auctions and enter into contracts to purchase emissions reductions; enable a broader range of emissions reduction projects to be approved; and amend the project eligibility criteria and processes for approving projects and crediting carbon credit units; and Australian National Registry of Emissions Units Act 2011, Clean Energy Regulator Act 2011 and National Greenhouse Energy and Reporting Act 2007 to make consequential amendments. It also provides for transitional arrangements in relation to: the Register of Offsets Projects, which will be renamed the Emissions Reduction Fund Register and will include information about contracts to purchase emissions reductions; and existing Carbon Farming Initiative projects and methodologies and applications for new projects.]

"Vegetation is a key issue. Where it is well managed that's great. The recent natural regeneration across the landscape is terrific. Farmers and agencies hold an incredible body of knowledge about the natural environment. Native vegetation, particularly perennial vegetation, is the key that holds everything together."

"There is a risk in pulling the trigger too early on species that may eventually help change our ecosystem."

Opportunities:

"BSG is a sustainability group. There is potential for landholders to benefit from solar and wind energy generation."

"bankmecu partners with different groups and encourages seven star rated green homes, and lower emission vehicles. I am optimistic about the future."

"Climate change is precipitating a whole-of-landscape approach that will benefit both biodiversity and agricultural productivity. An important question is 'how can private landholders contribute to biodiversity conservation?' We need a lot more information on what the potential is for the soil to store carbon. Is water the limiting factor? What species are we putting back and what constitutes a carbon planting?"

"Conservation cropping is an opportunity. Farms need to be functioning ecosystems."

"Land use planning. For example the location of intensive animal industries and the need for labour. An element of courage is needed to do land use planning in advance. We are not looking far enough ahead. In the longer-term if we are going to feed Asia we need to get the land use planning right."

"Where in the climate change space is the most important part of the picture."

"We are now much more aware of what our individual impacts are from our reliance on the big institutions. Climate change has made us step up and challenge what we need to do differently. And that is more an individual response. There is a huge opportunity for clarity around climate change. For example, should Australia be banking on the export of coal to India when that country is clearly going down the path of Renewable Energy Technology?"

"Regarding the big institutions, we need to promote local resilience, local experimentation and the need to allow people to develop different pathways."

"Energy from waste is an opportunity."

"Clean technology focused around sustainability is an opportunity."

"Acknowledge the Emissions Reduction legislation in the plan. The Palmer United Party made sure the legislation references the importance of these regional plans."

Biodynamic farming at Powlett Plains is showing a measurable improvement in soil health.

Dryland lucerne underpins many farming systems in the region.

Table A7.1 *Priority Actions identified by Stakeholders*

DEPI 1	Clear areas of governance identified in the Climate Action Plan. DEPI to lead with threatened species and state policy for native vegetation removal.
	One pager visual representation of the key pillars to the success for the Action Plan showing what government bodies/agencies are responsible for, or are doing work on.
	Identifying what is being covered in the plan vs what is out.
DEPI 2	Information, science, methods (adaptation opportunities) – anything to increase awareness.
	It will just be another plan if it sits on the shelf. Let's get it out there. People/farmers are still looking for ideas.
DEPI 3	Very clear scope of the plan. Intended impact and delivery.
	Clear links with existing plans and strategies.
	Roles and responsibilities – lead accountability and support roles.
	To see how implementation of plan will contribute to organisation's goals.
NCCMA 1	Key land use planning priorities as they relate to climate change.
	Key agricultural opportunities in key landscapes across the region.
NCCMA 2	Low input farming
	Education programs
	Transformational change
NRMC	Population growth and water quality. Less water – more people in the run-off areas of the region.
CVGA	Facilitating collaboration should be recognised in the plan as a distinct function that needs to be specifically funded.
	Projects that deal with complex problems require multiple stakeholders to develop and deliver. These projects need a centralised secretariat that is supported and empowered to manage direct engagement.
Central Victorian Biolinks	Provide access to climate prediction surfaces and other relevant outputs (threatened assets etc).
	Biodiversity – adaptation strategies including broad-scale connectivity and refugia are given due attention.
	Support for community environment groups to better incorporate climate adaptation and mitigation objectives into their activities.
CVAF	To consider agribusiness objectives in the plan with the principle of 'doing no harm' in limiting opportunity and growth in agribusiness and profitability.
Bendigo Sustainability Group	Target for region for carbon neutrality
	Promotion of renewable energy generated locally, including agri-systems.
bankmecu	Impact on community
	Population shift
	Shift in thinking of climate change
Hepburn Shire Council	Facilitation of new land management structure (e.g. land banks, cooperatives) that will more easily allow efficient bioenergy, soil carbon management, market responsive crops.
	Improved use friendly carbon documentation processes
CoGB 1	Roles and responsibilities. Show that the plan does understand the difference between the role of local government and that of state government.
CoGB 2	Put actions assigned to local government in correct context: Lead, support, advocate.
CoGB 3	Need more conversation regarding the content of the plan, including possible content. What local government could do and what we need to include in our own plans.
X1	Integrated farming system approach to trees
X1	Integrated cross industry approach to carbon management
X2	Link between what is in the plan and how it will contribute to practical change.

Appendix 8 – Adaptation Pathways workshop report

A8.1 Introduction

The North Central Catchment Management Authority has engaged Natural Decisions and Scarlet Consulting to undertake a series of tasks to inform the development of the North Central Climate Change Adaptation and Mitigation Plan.

Given the uncertainty around the climate and other socio-economic variables in the future, keeping as many management options open as possible is vital. The consultants have adopted the concept of 'adaptation pathways' as one approach to deal with the uncertainty of planning for climate change. This concept is still in its early stages of development and there has been little practical application in natural resource management (NRM) planning in Australia.

The adaptation pathways approach enables decision makers to consider a range of possible management actions and how they will perform under a range of potential futures. The approach is shaped by the consideration of thresholds and tipping points of certain outcomes and management options. Thereby considering if and when a management option might cease to be effective, and what might be the tell-tale signs of the threshold or tipping point being approached or exceeded.

A working definition developed by Southern Slopes Climate Change Adaptation Research Partnership (SCARP) is *"A pathway approach allows us to move forward in the face of uncertainty by considering a range of adaptation actions and sequences as new information and data become available."*

SCARP's pathways planning approach accords with recognised principles for adaptation: Consider multiple possible futures; plan to learn; be explicit about values and knowledge; and action does not require complete knowledge or consensus.

The principles of an adaptation pathways approach are being applied in developing the Draft North Central Climate Change Adaptation and Mitigation Plan (the Draft Plan) and will provide for:

- A strategic rather than reactive planning process
- A flexible strategy, by committing to short-term, incremental actions within existing governance arrangements, while monitoring how 'robust' possible options remain across a multitude of possible futures
- Shift planning from vulnerability assessments to strategies that may address the underlying drivers of those vulnerabilities over the longer term
- Provide a means for salient and credible dialogue
- Support synergies with best-practice regional NRM and use existing data, information and planning processes such as risk and vulnerability assessments.

The approach has been modified to include considerations of technical feasibility, landholder adoption, socio-political risk, cost to government and potential for adverse impacts, to ensure that the adaptation options identified have been scrutinised and evaluated in the light of current understandings.

To inform the development of the Plan four 'Adaptation Options' workshops were held in early 2015. Each workshop focused on a selected priority asset in The North Central Regional Catchment Strategy (RCS). While the principles of adaptation pathways underpinned the approach used in these workshops it may not be possible to fully develop pathways for the final Plan due to lack of knowledge, complexity and issues of scale.

This report details the findings of each workshop.

The four high value asset/case studies explored in the workshops were:

1. Bunguluke – Native vegetation, wetlands and productive soils (Charlton workshop)
2. Upper Coliban River – Waterway, water resources, habitat and soils (Trentham workshop)
3. Goldfields Bioregion – Box-Ironbark habitat (Castlemaine workshop)
4. Kamarooka wetlands – Wetlands, habitat and productive soils (Epsom workshop).

Each workshop sought to identify a range of adaptation options that would reduce the vulnerability of these high value assets under a drying, warming and more variable climate. Consideration was given to:

- Business as usual
- Business in a changing climate
- A 2050 Timeframe.

A8.2 Policy Context

A Regional Catchment Strategy (RCS) is required under the Catchment and Land Protection Act (1994). It is the primary planning framework for land, water and biodiversity management in the North Central CMA region. The current 2013-19 North Central RCS integrates regional priorities with relevant state and federal legislation and policies regarding NRM. It strives to achieve regional outcomes that will contribute to national NRM targets.

The 2013-19 North Central RCS provides the long-term vision for natural resource management (NRM) within the North Central Catchment Management Authority (CMA) region. The RCS sets regional priorities for the management of natural assets, sets overall direction for investment and coordination of effort by landholders, partner organisations and the wider community. It provides a framework that supports and encourages participation in protecting and enhancing our environment.

The North Central CMA is taking a responsible course of action in preparing a complementary climate change adaption and mitigation plan that sits alongside the RCS and considers how best to protect the region's high priority natural assets in the face of the current modelled climate futures. These predictions include:

- Increased temperature across all seasons
- More hot days and less very cold days
- Decrease in winter rainfall
- Increase in summer rainfall - possible
- Increase intensity of extreme rainfall
- Continued rainfall variability
- Increased frequency and severity of bushfire & flood events.

The following strategic documents were referred to during the workshops and will be referenced in the final plan.

- North Central CMA is developing a Regional Sustainable Agriculture Strategy.
- Trust for Nature is undertaking Conservation Action Planning relevant to the native vegetation across the region.
- The City of Greater Bendigo Council is developing an Environment and Sustainability Strategy that covers Goldfields native vegetation.
- Coliban Water has a 50 year water supply demand strategy (Waterplan 2055).

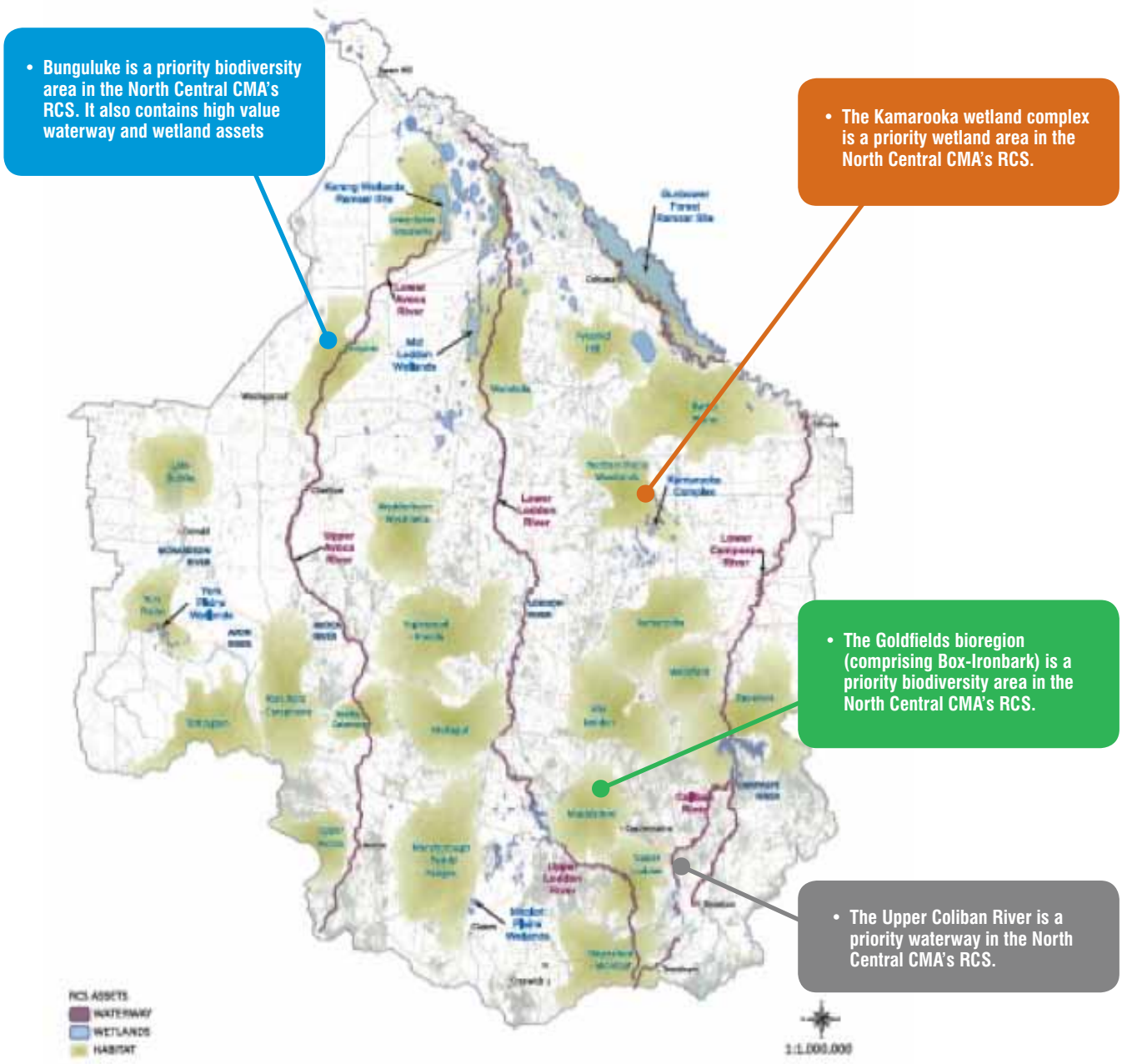


Figure A8.1 *Regional Catchment Strategy priority natural assets in the North Central CMA region.*

A8.3 Charlton Adaptive Pathways Workshop 30 January 2015 – Bunguluke

Present: Ken Coates (North Central CMA's NRMC and Project Steering Committee), Craig Cossar (Landholder and FSS Coordinator), Brad Drust (North Central CMA), Nathan Wong (Trust for Nature), Ruth Raleigh (DELWP), Joel Spry (North Central CMA), Rohan Hogan (North Central CMA), Geoff Park (Natural Decisions), Mal Brown (Scarlet Consulting).

Values:

Significant grasslands, grassy woodlands, threatened flora and fauna

Threats:

Habitat destruction, overgrazing, pest plants and animals

Aspirational goal:

To improve the condition and extent of grassland and grassy woodland habitat to support viable populations of significant species characteristic of this landscape.

Key Actions

Fencing and grazing management, pest plant and animal control.

About the asset

The Bunguluke priority habitat area is approximately 20,000 ha in size and extends from Charlton in the south to Quambatook in the North. It includes the ephemeral wetland and the surrounding agricultural area.

It predominantly consists of floodplain grasslands with isolated patches of semi-arid grassy woodland. It contains the lower branches of the Avoca River, including the Tyrrell, Lalbert and Back creeks, as well as extensive wooded drainage lines.

A 2012 assessment determined that 5,624 total ha of grasslands and 4,235 ha of grassy woodlands remained within the asset area. This included 2,600 ha of grassland in 'excellent' condition (~46%), 3,024 ha of grassland in 'average to good' condition (~54 %), 2,678 ha of grassy woodland in 'excellent' condition (~63%) and 1,556 ha of grassy woodlands in 'average to good' condition (~37%).

The area contains the highly threatened Kangaroo oat grass (Themeda avenacea). While this species is extensive in central and northern NSW, there are only four known populations in Victoria of which two are in the Bunguluke area, with one of these being the largest in the state.

The area also contains Buloke woodlands, a nationally listed Endangered Ecological Community that is also Flora Fauna Guarantee (FFG) listed. Buloke woodlands occur within the semi-arid woodlands EVC within the Bunguluke area. They provide important habitat for woodland bird communities.

The area supports important fauna species such as the Carpet Python, the Plains Wanderer, the Golden Sun Moth, and populations of Grey-crowned Babblers. Bunguluke contains more highly connected Grey crowned Babbler habitat than any other area of Victoria.

Current situation (based on workshop participant's experience)

Hydrology

- The average annual rainfall of the area today is approximately 400 mm.
- The Bunguluke wetlands are quite different to other wetlands in that the soils are still forming. The soils are fertile enough for an irrigation area!

Native vegetation

- The tributaries in the area are not getting a drink as often as they used to and the associated riparian vegetation is looking stressed.
- Red Gum health has generally declined since late 1970s. There has been a lot of protection of the Red Gum country in the last 15 years. There has been a good response to the 2010-11 flooding.
- Big Eumongs (Acacia stenophylla) have died because of the flood, however regeneration is good.
- Big Native Pines (Callitris) and Black Box have got wet and died. There is good regeneration where there are no rabbits.
- The top end of the Bunguluke area is where Red Gum transitions to Black Box.
- The vulnerability mapping shows that the Lalbert Creek is highly vulnerable (2050)
- 80% of the River between Quambatook and Charlton fenced off. Grazing has been removed and generally not touched. As a result the banks have stabilised.
- Cabbage Bush is not regenerating.
- Shrubs are getting into woodlands.
- Grasslands are hit hard by flooding and variability. They continue to decline. Drought is the best thing for grasslands.
- Plains Wanderers crash in the wet due to a decline the availability of preferred habitat (widely spaced grass tussocks)
- The demand is there to protect natural assets:
  - Patho has 2,000 ha of grassland ready to be protected
  - Lower Avoca has 2,000 ha of grassland ready to be protected
  - No high quality native vegetation 'on the table' for protection in Bunguluke
  - Louise Todd's property has cropping + grazing + conservation.

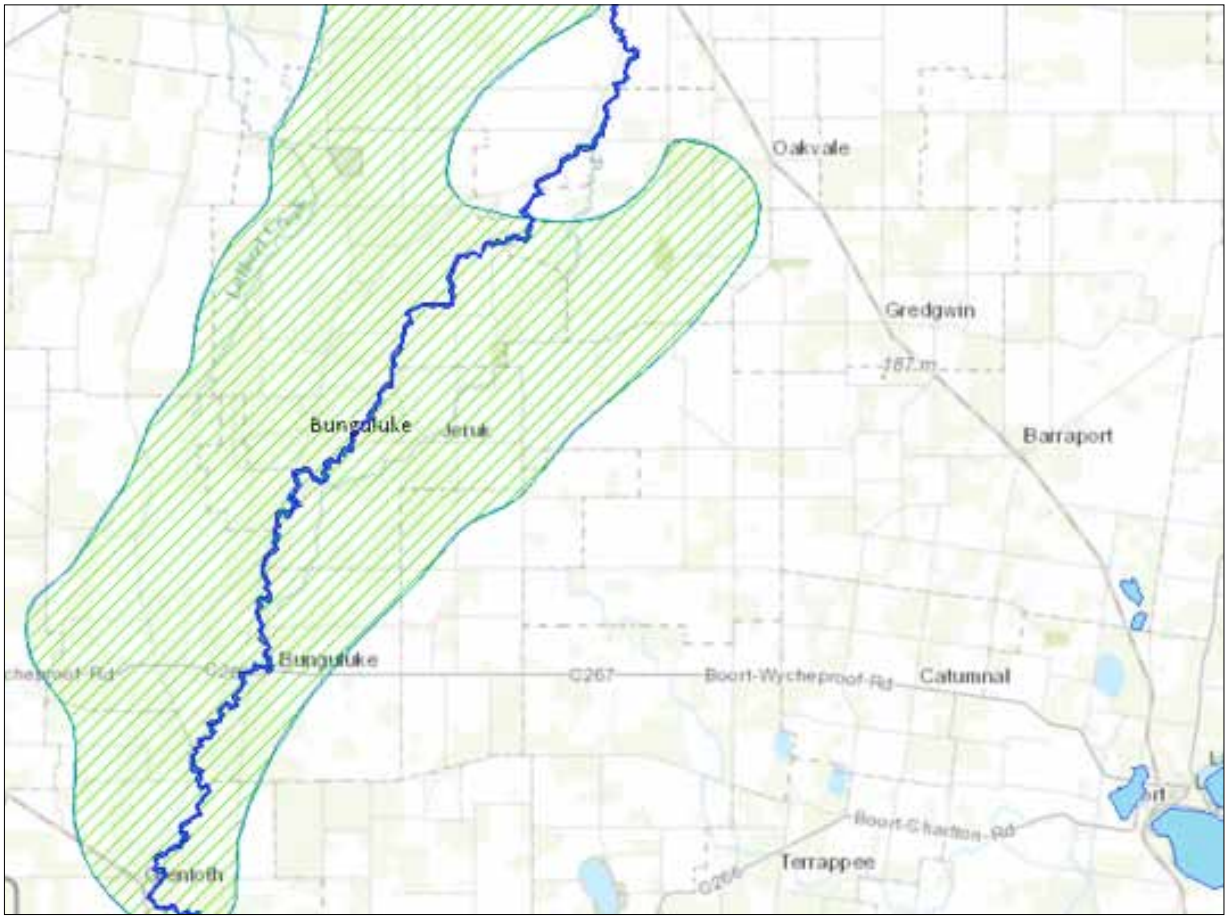


Figure A8.2 *The Bunguluke area straddles the Avoca River between Charlton and Quambatook*

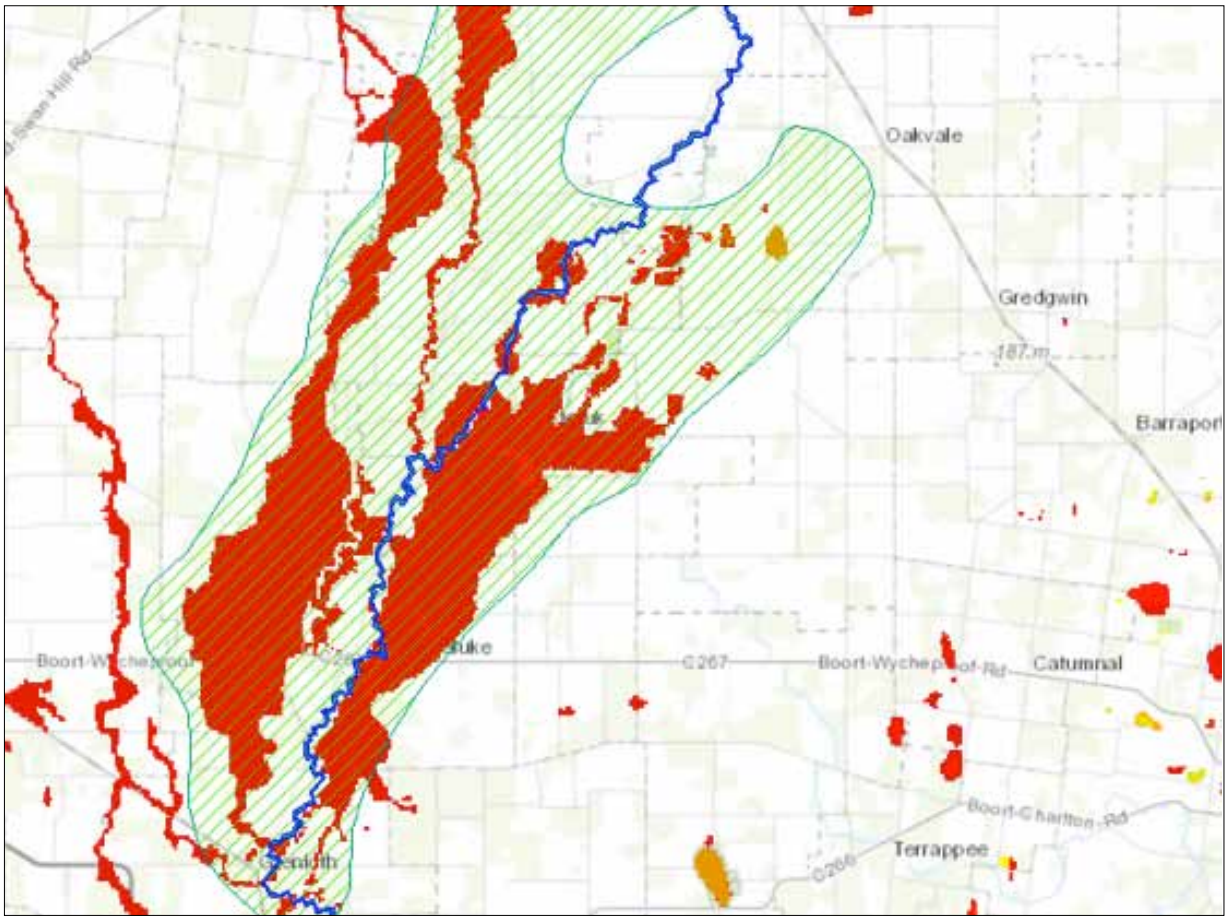


Figure A8.3 *A sample of the climate change vulnerability assessment for the Bunguluke area*

Socio-economic drivers

- Originally the area was covered by two large stations, one comprising 60,000 acres and the other 50,000 acres. The land managers delved the river and banked it up to push the water east and west. They ran cattle on the higher ground.
- Soldier settlement was followed by some very wet years and more banks were put in.
- The growth and profitability of cropping saw a lot of clearing of trees on both the floodplain and in Buloke country. Nevertheless, Doug and Liz Todd, who farm and own land in the Bunguluke area, have the largest Buloke woodland in Victoria on their property.
- Wycheproof community is largely ignorant of the Bunguluke wetlands.
- 20-25 landholders own the Bunguluke asset. The average age of landholders is 65+
- There have been big environmental changes in the area, especially the Wimmera Mallee pipeline.
- There is a lack of active management in the area.
- Farms are fewer and bigger. 80% of the farm area is cropping. 20% is grazing.

Soils and agricultural issues

- Cropping is already borderline. 80% of farm practice is now direct drilling. The wheat-oats-barley system is still the most popular.
- A 'Farming for Sustainable Soils' Group is active in the area. The group has a high level of confidence in its knowledge of the local soils.
- The area contains red hard-setting soils that compact naturally and are proving difficult to manage. Up to 130 mm of the top 250 mm of the soil is compacted. These soils have saline sub-soils and are also associated with native grasslands. Rye grass is best able to penetrate these soils.
- Nitre goosefoot is a wetland plant that is suitable for grazing.

Additional Threats

- Buffel grass (first incursions into Victoria have been detected around Sea Lake)
  - Wards weed (small areas already on the Avoca). A Brassica also known as Donald Duck weed (terrible for grazing)
- Lightning strikes and fire
- Crop diseases could move south
- Less people with less resources to deal with threats.

Pine Vale farmer Ken Sims and grandson Hunter in a lush cover crop.

Adaptation and Mitigation options

Adaptation and Mitigation options put forward for each asset by workshop participants are summarised in tables that follow. When reading the tables please note:

1. Feasibility – How technical feasible is the application of the option?
2. Adoption – What is the likelihood of landholder adoption/participation?
3. Risk – What is the risk of failure due to socio-political or administrative factors?
4. Cost – What is the magnitude of the cost to government in implementing the option (additional to business as usual)?
5. What is the potential for adverse impacts (e.g. reduced water yield, increased bushfire risk) from implementing the option?

Timeline symbols:

Preparatory work required before option could be adopted (grey indicating preparatory work)

Option may not be robust across the planning timeframe (solid line fades indicating lower confidence)

Option appears to be robust across the planning timeframe (solid line).

Options identified for Bunguluke	Benefit to:			2015	2030	2040	2050	Feasibility	Adoption	Risk	Cost	Adverse impacts
	Wetland	Waterway	Habitat									
Business as usual	L	L	L					H	H	M	L	H
Identify and adopt existing crop varieties suited to drier conditions.	L	L	L					H	M	L	L	M
Work with R&D sector to develop improved crop varieties for use in this area. Participate in trials.	L	L	L					M	M	M	L	M
Adopt low input and low risk grazing systems for both productivity and conservation.	H	L	H					M/H	L/H	M	L	L
Increase the summer dominance of the grasslands by strategic grazing	H	L	H					M/H	L/M	M	L	L
Modify floodplain infrastructure to reinstate more natural hydrology	H	H	M					L	M	H	H	M
Convert current cropland to grazing systems based on native perennials	M	L	H					H	L	M	L	L
Introduce drier country species into the existing Red Gum system (e.g. Black Box, Eumong)	H	H	M					M	H	H	M	M
Establish farm forestry plantations for firewood, carbon storage, bioenergy etc	L	L	H					H	L	M	L	M
Actively put environmental water from the Waranga Channel into the wetlands (through John Scarce's property)	H	H	M					M	M	M	M	M
Use water from the Wimmera Mallee pipeline for intensive agriculture	L	L	L					H	L	M	L	L
Strategically purchase properties or management rights for conservation benefits (and use local management)	H	L	H					H	N/A	H	H	L
Allow large-scale natural regeneration on the floodplain for carbon storage	L	L	M					H	L	M	L	L
Identify and protect areas suitable for cropping that contain high value remnant vegetation	M	L	H					H	L	L	M	L
Increase the extent and quality of the existing woodlands	M	L	H					M	L	L	M	L
Diversify into ecotourism (fence Bunguluke to be the next Scotia)	L	L	L					M	L	L	M	M

Table A8.1 *Adaptation Options for the Bunguluke wetland complex*

A8.4 Trentham Adaptive Pathways Workshop Wednesday 4 February 2015 – Upper Coliban River

Participants: Geoff Caine (DELWP), Rohan Hogan (North Central CMA), John Cable (local landholder and North Central CMA's NRMC), Brendan Smith (Tylden Landcare), Nick Lane (North Central CMA), Francine Noble (Land and Catchment Coordinator, Coliban Water), Aleksy Bogusiak (Water Resources Manager, Coliban Water), Geoff Park (Natural Decisions), Mal Brown (Scarlet Consulting).

About the asset – Upper Coliban River

The Upper Coliban River is an inland perennial river of north central Victoria. The river rises below Little Hampton near Lyonville in the Great Dividing Range and flows generally north, descending 33 metres over the Trentham Falls, and continuing to flow northward to the Upper Coliban, Lauriston and Malmsbury reservoirs. The Coliban River below these reservoirs continues north and enters the Campaspe River at Lake Eppalock.

Gold was found in the river in 1858, and water from the river was used to supply the goldfields cities of Bendigo and Castlemaine. As the population of those cities grew a water supply system consisting of 70 kilometres of tunnels and aqueducts were constructed. Over time, the water supply was extended to Kyneton, as well as many other smaller towns in the region. Today the system supplies drinking water to a population exceeding 130,000 and also supplies water for irrigation and stock and domestic purposes to customers off the channels system. Coliban Water manages the three major water supply reservoirs, which are part of the Eppalock Proclaimed Water Supply Catchment.

Values:

The river has an intact overstorey and contains many threatened flora and fauna species. It is home to the platypus as well as eight native fish species including the Macquarie Perch.

Threats:

Altered flow regimes, overgrazing (including uncontrolled stock access), farm dams, weeds, cultural values (such as a preference for European landscapes vs indigenous vegetation), and landholder knowledge.

Aspirational objective:

'To improve the condition of the Upper Coliban River from moderate to good (based on ISC) by 2050.'

Key actions:

Fencing and grazing management, weed control.

Current situation (based on workshop participant's experience)

Socio-economic drivers

- Whilst a few large farmers with properties greater than 600 acres are found in the catchment, farms are generally getting smaller not bigger as land prices and proximity to Melbourne and regional centres make sub-division attractive.
- Tree changers, life stylers and hobby farmers now dominate the landscape.
- On average today's property sizes range from 10-20 acres up to 200 acres.

Land use

- The catchment contains some large blue gum plantations and equine developments.
- Potato farming occurs on the red country and a few vineyards also occur.
- Cattle numbers have increased over the years and they dominate the grazing land in the catchment.
- Enterprise viability is declining and a lot of properties survive on off-farm income.
- A Kyabram dairy farmer bought a block in the catchment and developed it. It is now an out-paddock for a Mortlake dairy farmer. The extent of such land purchases in the catchment is unknown.

Vegetation

- Exotic species are highly valued by the community and cultural change is needed for native vegetation to be valued to the same degree.
- There was active discussion as to whether greater legislative protection is needed or whether ensuring compliance /enforcement of already existing legislation would provide the greatest benefit.
- There is high interest in riparian protection. Tylden Landcare held a planting day that attracted 20 landcare members and 40 non-landcare members.
- Riparian vegetation is improving. 20% of Little Coliban River fenced.
- Huge natural regeneration has taken place since the 2010-11 floods. There has been an extraordinary change.
- Weeds are a massive issue - they are uncontrollable in the catchment (particularly Gorse, Blackberry, Broom and Hawthorn). Nevertheless the weeds have provided for incredible structural stability.

Water quality

- There are many potential risks to water quality and they are increasing - more people, more septic systems, more cows, more waste, more contamination. These risks create more human health, taste and odour issues.
- Livestock pose a higher risk to human health as the pathogens in their faecal matter carry species that are infectious to humans. The risk increases again with young livestock (calves and lambs) as they shed these potentially human infectious pathogens in higher quantities than their parents.
- Whilst there was an impact on water quality following the floods, having the three storages and access to water from the Goulburn System allowed Coliban Water to buffer these impacts to some extent. Additionally the very sophisticated treatment systems Coliban Water has in place for Bendigo and at other offtakes is an important component of managing water quality risks so that water can be treated to the appropriate standard.
- Crown land grazing needs to be managed using sustainable practices (information is available from Ag Extension officers).
- The higher concentration of grazers in the catchment will increase the need to have more productive paddocks to supply feed. One side effect of this may be increased use of superphosphate to enhance productivity and protect soil. Extra 'super sediments' may be picked up in runoff and carried to creeks. Appropriate application methodology can be given by retailers and agricultural extension leaflets as a way of mitigating this impact.

Water quantity

- Water yield is subject to variable inflows. In terms of the water resource it is important where and when the rain falls. Summer rainfall is of reduced value to Coliban Water due to limited runoff. The large January 2015 rainfall event delivered only 500ML to storages (insignificant in context) because the catchment was dry.

Figure A8.4 *The Upper Coliban River*

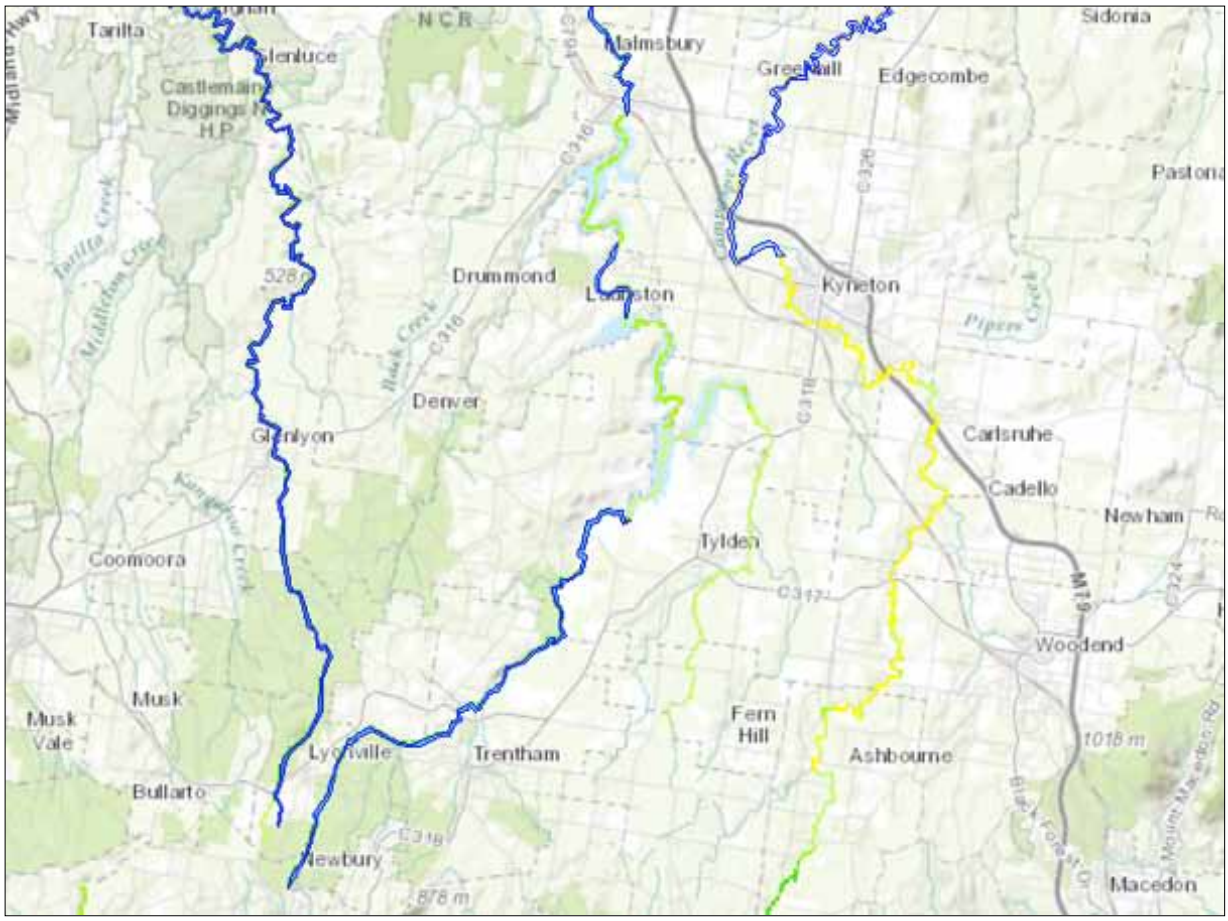


Figure A8.5 *sample of the climate change vulnerability assessment for the Upper Coliban River area*

Options identified for Upper Coliban River	Benefit to:			2015	2030	2040	2050	Feasibility	Adoption	Risk	Cost	Adverse impacts
	Wetland	Waterway	Habitat									
Business as usual	L	L	L					H	H	M	L	H
Implement an incentive program on agricultural land that will stabilise soils.	H	M/H	L					H	M	L	H	L
Introduce codes of practice that reduce demand for water and support self-sufficient water use (both agricultural and semi-urban properties). Drive down the demand for water.	M	M	M					M	M	L	M	L/M
Establish large-scale carbon sequestration by planting biodiverse plantations/trees on poorer soils or along the riparian zone. Examine drier country species for inclusion in the plantings.	H	L	M					M	L	M	L	H
Protect existing biodiversity hotspots (refugia).	H	L	H					H	H	L	M	L
Continue to explore water surface polymers (or other substances) that could reduce evaporation from storages.	L	H	L					L	N/A	N/A	M/H	M
Examine the groundwater resources available to secure a future water supply.	L	H	L					H	H	M	L	L
Introduce legislation for no new farm dams and an incentive program to decommission existing farm dams.	H	H	L					M	L	H	L	L
Increase water harvesting from hard surfaces.	L	L	L					H	M	L	M	L
Preserve groundwater as a resource. Peg back extraction from the status quo. Explore a possible buy back scheme.	M	M	L					H	L	M	M	L
Increase the use of recycled water.	M	L	L					H	M	L	H	L
Ensure better linkages and integration across agencies who manage the natural assets to achieve on-ground outcomes and outputs.	M	M	M					H	M	L	L	L
Introduce a local community citizen science program to collect data on catchment health	M	L	M					H	M	L	L	L

Table A8.2 *Adaptation Options for the Upper Coliban River*

A8.5 Castlemaine Adaptive Pathways Workshop Thursday 5 February 2015 - Goldfields bioregion

Participants: Rohan Hogan (North Central CMA), Robyn Major (CoGB), Ian Higgins (North Central CMA), Tanya Loos (Connecting Country), Jarrod Coote (Connecting Country), Shane O'Loughlin (North Central CMA's NRMC and Project Steering Committee), Ruth Raleigh (DELWP), Geoff Park (Natural Decisions), Mal Brown (Scarlet Consulting).

About the asset

The Goldfields bioregion was dominated by Box-Ironbark Forest but also had large areas of Dry Foothill Forest Complexes, Inland Slopes Woodland Complexes, Plains Grassy Woodland Complexes and Herb-rich Woodland Complexes. Endemic flora species of the Goldfields bioregion include several orchids, Narrow Goodenia, Whorled Zieria and Goldfields Grevillea.

Fragmented but considerable remnants of Box-Ironbark Forest remain within the Goldfields bioregion, whilst the surrounding areas have been cleared for agriculture and urban development. Threatened fauna species in the area include the Powerful Owl, Brush-tailed Phascogale and Common Dunnart. The area also provides important habitat for a wide array of woodland birds.

Values:

- High quality Box-Ironbark remnants, drought refuge for fauna, woodland birds.

Threats:

- Habitat fragmentation, total grazing pressure, inappropriate fire regimes, fire and prescribed burning (threat to woodland birds)

Aspirational objective:

- 'By 2050 improve condition and extent.'

Key actions:

- Fencing, direct seeding and grazing management for natural regeneration, pest plant and animal control. Ecological thinning in a drying climate.

Current situation (based on workshop participant's experience)

Land use change

- The landscape is a product of the last 50-100 years
- Land use change continues to occur as land values rise. There is strong demand for rural retreats. The land is too expensive for farmers to farm.
- The Muckleford Valley is transitioning out of farming (only two full-time farmers left).
- Sutton Grange is at a tipping point. One lawyer has a 1500 acre hobby farm where he is running a beef cattle operation. His operation is supplemented by off-farm income.
- Large farms are being sub-divided into smaller farms. So where we had two landholders we now have 10-15 landholders managing the same area.
- Novice farmers are replacing experienced farmers. The new land managers are good at pest plant and animal control but not at producing the high quality food and fibre.

Socio-economic drivers

- The proximity to Bendigo and Melbourne is important.
- Lifestylers moving in change the land management issues (weeds, rabbits, CFA volunteers, fire risk). Lifestylers need continual education.
- The Landcare community has asked the City of Greater Bendigo to write action plans and facilitate the change.
- Connecting Country has secured 300 ha of land for a project aimed at protecting habitat for woodland birds. The properties are in Clydesdale, Blue Hills, Sutton Grange, Muckleford, and Green Valley. 16 landholders are involved. Only one is a full-time farmer.
  - Most participating landholders only want the bush, not grazing animals.
  - They are mostly long-term residents. Many are young families.
- People moving into the area value native vegetation.
- People already living in the area don't necessarily value the asset they have.
- The area comprises people who are among the most nature loving, enthusiastic and landcare-oriented individuals in Australia. There is an unprecedented number of Landcare groups and an almost full-time Landcare Facilitator. Campbell's Creek provides the opportunity to create the water from urban Castlemaine that will keep the creek wet continuously.
- CoGB offers a rate rebate to land managers who undertake environmental management.
- At the same time there is low-level interest in environmental issues.
- There's currently a large extension gap. (Agencies are not active in the community). Agronomists are also leaving for the private sector and as a consequence they are not giving advice on carbon.
- It is business as usual at the moment and the adaptive management that is happening is inadequate to meet the challenges of climate change.
- There is high awareness in the community about fire. The CFA volunteers are exhausted. There are vastly different attitudes to fire preparedness. Buffers around houses, tree density and species are important issues.
- Surface water is disappearing. Farm dams are drying up in summer.
- There is an increasing fear of fire. People with less than two hectares are clearing everything.
- People who are into nature don't appreciate the importance of soil.
- There is a local philosophical approach to natural farming systems (biodynamics). People are trying to have a vegie patch on a paddock scale.
- Land managers on lifestyle properties who participate in revegetation eventually sell out and give way to new owners with motorbikes and/or horses. This undoes the good work of the previous owners.
- New residents don't understand what a river looks like in its natural state. The riparian zone is a great opportunity for revegetation and future corridors.
- There has been good uptake of incentives along the Barkers Creek.
- The Blackberry Taskforce model is supported by government. Government provides funding for community groups to coordinate and do the work.

Native Vegetation

- Natural Red Gum regeneration has been amazing since 2011. A lack of grazing has impacted on the density of seedlings. Some strategic thinning is needed.
- The native regeneration is excellent nesting and feeding habitat for birds using the adjoining Box-Ironbark.
- It is unfortunate that Vic Forests now manages State Forests for utilisation rather than conservation. Logging and free firewood collection is impacting negatively on the forests.
- Habitat is generally going backwards. Sheep are murder on native vegetation. Vegetation bounces back once sheep are removed. We are losing diversity of ground flora.
- Prescribed burning is not helping ground cover.
- During the extended dry the Box Ironbark forest lost a lot of the palatable species (mainly due to kangaroos, wallabies and rabbits).

Fauna

- The Victorian Temperate Woodland bird community dropped off during the Millenium Drought.
- 200 surveys by Connecting Country across 50 sites have found that certain areas are doing really well. These are refuge areas for threatened species, such as Diamond Firetails and Hooded Robbins (e.g. Clydesdale).
- An increase in woodland birds has been observed at Porcupine Ridge (near Mt. Franklin), even though this area is not woodland.
- Creeks and tributaries provide excellent opportunities for corridors. Wattles impact on birdlife.

Wattle. (courtesy Robyn McKay NCCMA)

Spotted Pardalote. (courtesy Adrian Martins)

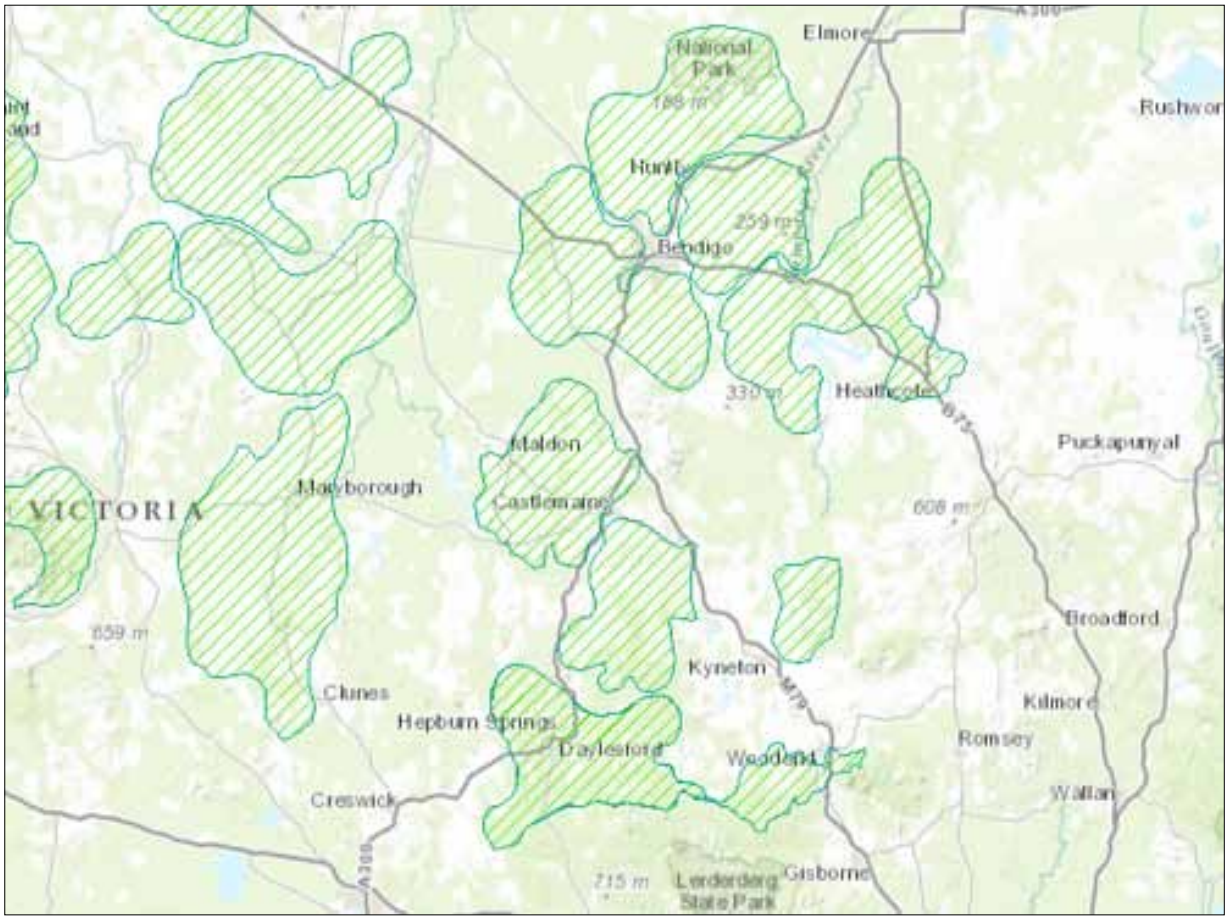


Figure A8.6 *The Goldfields Bioregion and the high priority native vegetation asset areas*

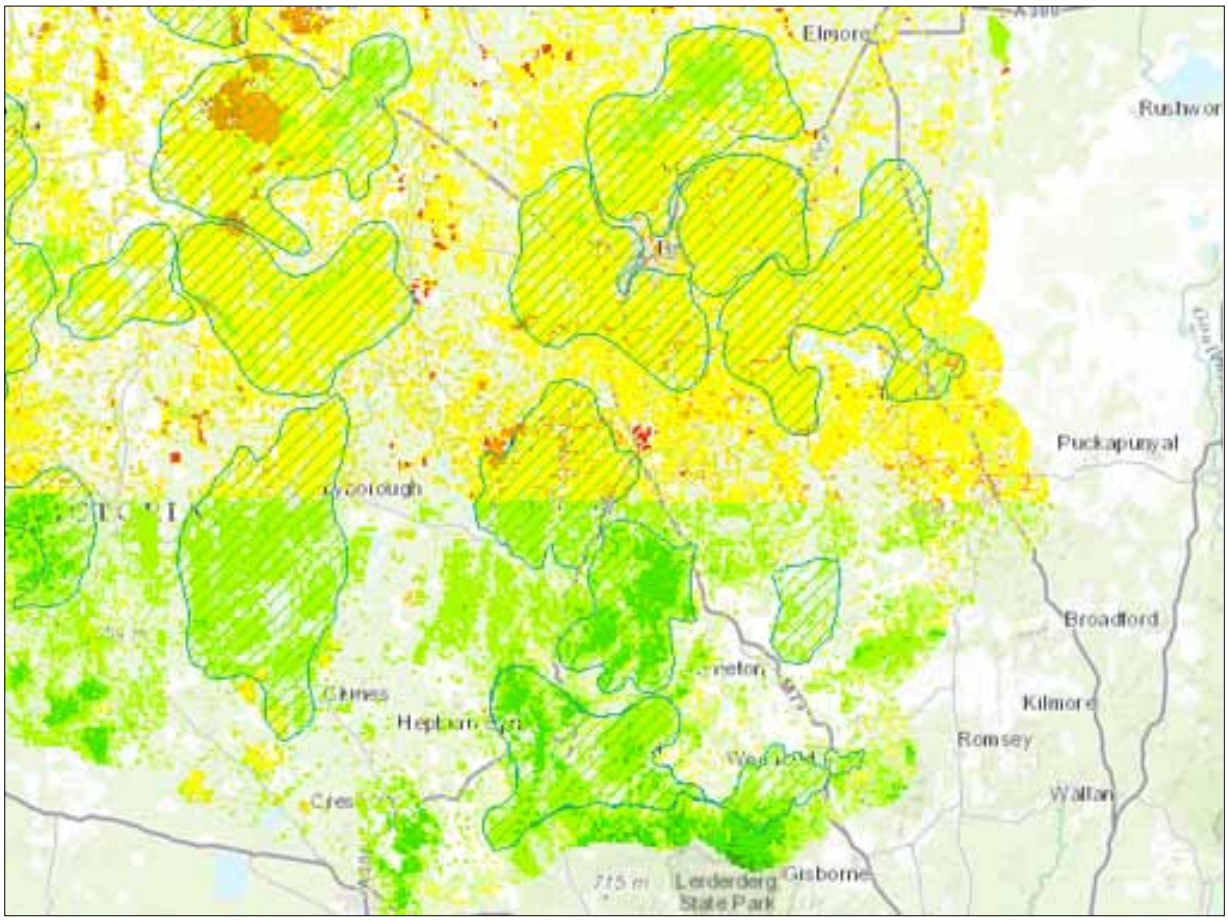


Figure A8.7 *A sample of the climate change vulnerability assessment for the Goldfields area*

Options identified for Goldfields native vegetation	Benefit to:				2015	2030	2040	2050	Feasibility	Adoption	Risk	Cost	Adverse impacts
	Waterway	Habitat	Soil	Fauna									
Business as usual	L	L	L	L					H	H	H	L	H
Implement a well-resourced Whole Farm Planning and education program (with a sustainability focus) for land managers.	H	H	M	M					H	M	L	L	L
Enable an ecological thinning program on both public and private land.	L	H	L	M					M	M	L	M	L/M
Implement a well-funded, scientifically rigorous, biodiversity monitoring program using woodland birds as a key indicator of ecosystem health.	N/A	N/A	N/A	N/A					H	M	H	M	L/M
Implement a monitoring program in crown land forests to inform stocking density and species tolerance.	N/A	N/A	N/A	N/A					H	H	L	L	L
Introduce new legislation to ensure company directors take responsibility for both profit and environmental protection.	H	H	H	M					H	H	L	L	L
Implement an on-ground restoration program that achieves connectivity and increases the extent of native vegetation from 30% of the landscape to 50%.	H	H	M	H					H	N/A	L	L	L
Include some drier climate species and wider genetic material of existing species in revegetation programs.	H	H	L	L					H	N/A	L	L	L
Put stricter controls on development in bushland areas or adjacent to public land	H	M	M	M					H	M	L	L	L
Achieve a significant reduction in prescribed burning.	M	H	M	H					H	H	L	M	L
Implement a reward system for land managers who provide ecosystem services.	M	M	M	H					M	M	L	H	L
Reduce livestock damage, revegetate and manage the riparian zone along waterways in the asset area.	H	M	M	M					H	M	L	M	L
Amend the Victorian Planning Provisions to include the ability to identify areas for future biolinks or landscape connectivity.	L	H	L	M					M	N/A	M	M	L
Implement large-scale carbon sequestration across landscape for biodiversity outcomes.	L	L	H	M					H	H	L	L	L
Implement large-scale carbon sequestration across landscape for soil benefits.	M	H	H	M					H	H	L	L	L

Table A8.3 *Adaptation Options for the Goldfields vegetation*

A8.6 Epsom Adaptive Pathways Workshop Friday 6 February 2015 – Kamarooka Wetlands

Participants: Brad Drust (North Central CMA), Adrian Martins (North Central CMA), Bree Bissett (North Central CMA), Phil Dyson (North Central CMA), Ted Gretgrix (North Central CMA's NRMC and Project Steering Committee) , Dean Collins (local landholder), Geoff Park (Natural Decisions), Mal Brown (Scarlet Consulting), Rohan Hogan (North Central CMA).

Values:

- Regionally valued wetland complex that support significant threatened flora and fauna species.

Threats:

- Altered flow regimes, inappropriate grazing pressure (including under-grazing), pest plants and animals.

Aspirational objective:

- To maintain and improve the ecological condition of the wetlands by 2050 as measured by the Index of Wetland Condition.

Key actions:

- Fencing, grazing management, pest plant and animal control. Ecological thinning in a drying climate, improved water availability and delivery for water-dependent vegetation, and an appropriate water regime for species such as the Brolga.

Brolga tending nest and Red Gums at Tang Tang Swamp. (courtesy Adrian Martins)

Current situation (based on workshop participant's experience)

Hydrology

- Water flow across the landscape is controlled by the drainage that was installed through the area in the 1980s.
- Man-made structures have made a huge difference during flooding.
- The Tandara Pondage was built in the 1970s. To the west of the pondage the majority of trees were killed within two years of its commissioning. Trees that were planted to intercept seepage were the wrong trees and they have suckered like mad. We also spoke a bit about the impacts of the pondage.
- Episodic rainfall is important in this area. (It is not included in the statewide dataset)
- Flooding in 2011 from the Neilborough Hills was good for the wetlands but not good for farming.
- You need a flood to get a feed off the country. Rainfall alone won't do it.
- Historic data at the Drummartin gauge will indicate if summer rainfall is increasing.
- In January 2015 when the Bendigo Creek was running the water did not get into Tang Tang. Water fanned out into paddocks just south east of Tang Tang (i.e. no man's land) but didn't make it all the way to the wetland. There is a difference between local catchment runoff entering Tang Tang (i.e. during winter last year when the brolgas utilised it for breeding) and flooding that enters from Bendigo Creek.
- The intense rainfall event before Christmas 2014 filled the Tang Tang pool.
- We are in a rich environment for environmental water with large volumes held in storages. This augers well for getting water into the Kamarooka wetlands.

Wetlands

- The wetlands health is not improving. There are quite stark differences between the health of the local wetlands. The annual incremental improvement is not happening.
- Thunder Swamp has deteriorated during the life of the local landholder.
- Landcare fencing on some wetlands ten years ago is still in very good condition.
- Dunns Swamp gets grazed occasionally and is cropped around it.

Fauna

- We don't know enough about the fauna in the wetlands. Too few resources and sporadic monitoring. Most of the monitoring at Tang Tang was undertaken in the 1980s and-1990s but not much has occurred since then. This makes it difficult to determine if any change in diversity, composition and abundance is occurring.
- Brolga may have gone from 70 breeding pairs down to around 10 breeding pairs.
- There is a radio tracking opportunity for Lace Monitor and Carpet Python (both the threatened species).
- There are up to 50 pelicans on Thunder Swamp when it rains.

Native vegetation

- 2014 IWC assessment for Tang Tang rated the swamp as good for tree health assessment. 20% of trees in poor health. 80% good to excellent health.
- Brolga chicks born in the spring of 2014 died because the water drew down too quickly. (Adrian Martins pers comm). The chicks are unable to fly for 3 months.
- Large Black Box trees in Dunns Swamp are all dead. They were ringbarked in the 1880s.
- A lot of trees have come up this year.
- A group of Black Box regeneration in the corner of the swamp was recently fenced by the Collins family to remove grazing access.

Land Use trends

- There is a residual population of farmers and a trend towards family corporations.
- The area has experienced 20-30 years of consolidation.
- The bigger family farms are the more successful farms.
- Some farmers would rather be in cropping but it is risky. There will be a trend towards mixed farming if it gets drier.
- It is a unique cropping area with sodic soils and sodic sub-soils. These alkaline soils lend themselves to lucerne.
- Wind erosion under lucerne has emerged as a problem.
- The Farming for Sustainable Soils group is concentrated on maintaining soil structure.
- Summer storms are driving the need to control summer weeds.

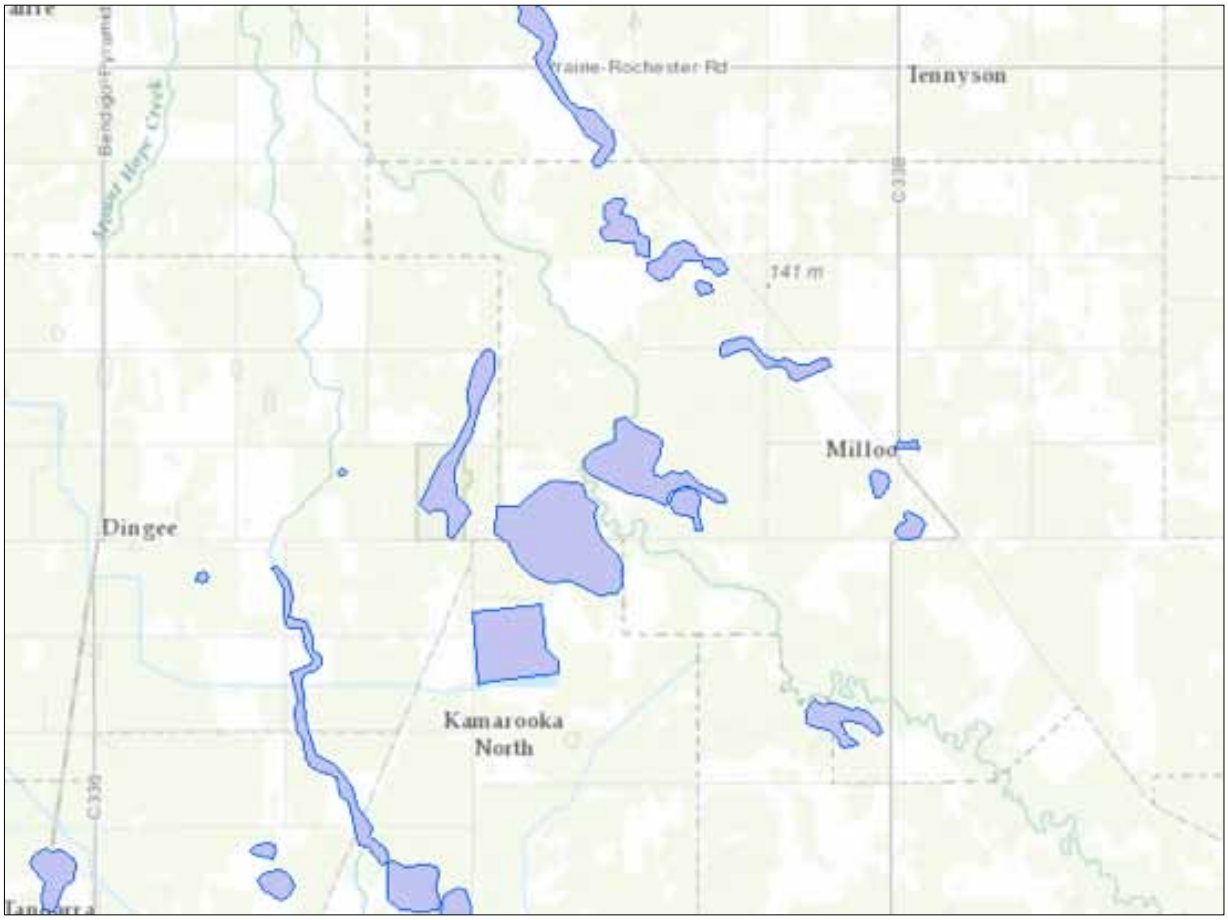


Figure A8.8 *The Kamarooka wetlands of northern Victoria*

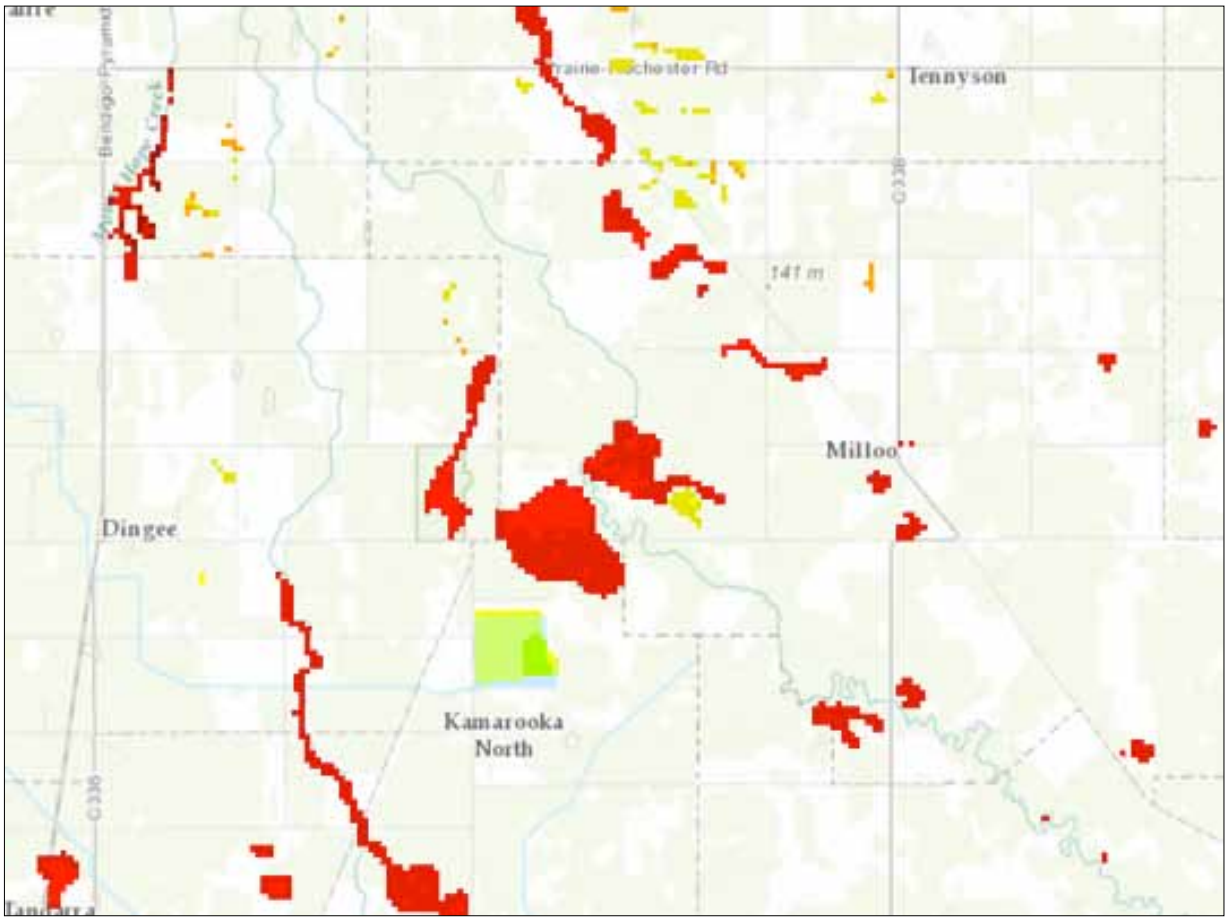


Figure A8.9 *A sample of the climate change vulnerability assessment for the Kamarooka wetland complex*

Options identified for Kamarooka Wetlands	Benefit to:			2015	2030	2040	2050	Feasibility	Adoption	Risk	Cost	Adverse impacts
	Wetland	Fauna	Soil									
Business as usual	L	L	L					H	H	H	L	H
Develop an Environmental Watering Management Plan for Tang Tang Swamp and other priority wetlands	H	M/H	N/A					H	M	L	L	L
Build or modify infrastructure to manage regulated or unregulated flows of water into the wetlands	H	M/H	N/A					M	M	L	M	L/M
Model the current flow of water across this landscape and also determine how to best modify wetland drainage	H	M/H	M/H					H	M	H	M	L/M
Implement a research and capacity building program focused on the positive and negative aspects of flooding	L	N/A	M					H	H	L	L	L
Implement a local citizen science community monitoring program focused on key local fauna species	H	H	L					H	H	L	L	L
Develop a set of protocols for how the wetlands may be adaptively managed, recognising that their values might change under a future climate	H	H	L					H	N/A	L	L	L
Implement a knowledge program focused on best practice grazing management of the wetlands (recognising stock need water)	H	H	L					H	N/A	L	L	L
Establish a local community management committee to oversee active management of the wetlands complex	H	M	M					H	M	M	L	L
Implement a sustainable funding program to facilitate better management of the wetlands (e.g. fencing, pest plant and animal control)	H	H	M					H	H	L	M	L
Implement a Farming Systems program for all farmers in the area based on preparedness for the predicted climate change scenario (e.g. new variety trials)	L	L	H					M	M	L	L	L
Implement a large-scale carbon sequestration and biofuel production program to achieve 30% tree cover across the landscape	M	H	M					M	L	M	M	M
Construct the proposed piped D&S supply from Dingee to Kow Swamp	M	L	H					H	H	M	H	M

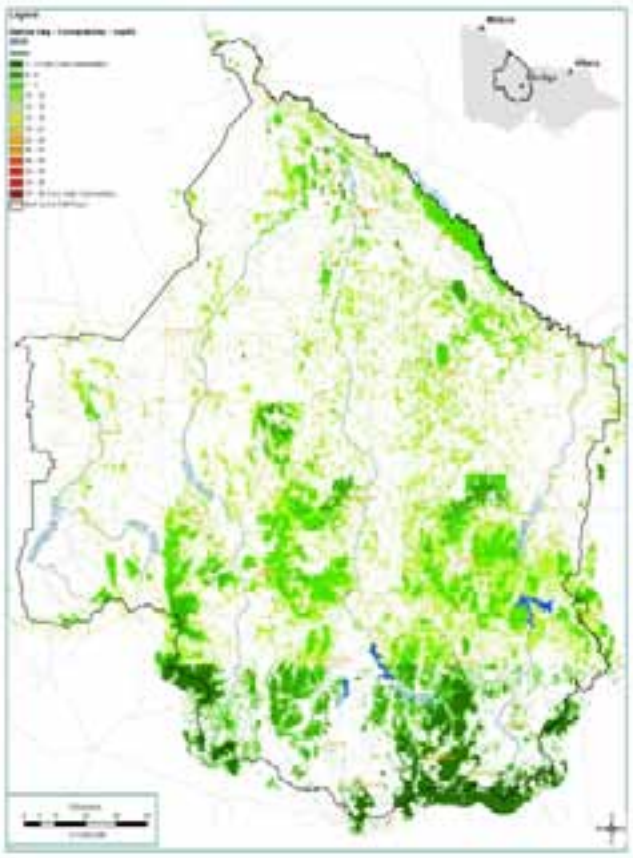
Table A8.4 *Adaptation Options for the Kamarooka Wetland complex*

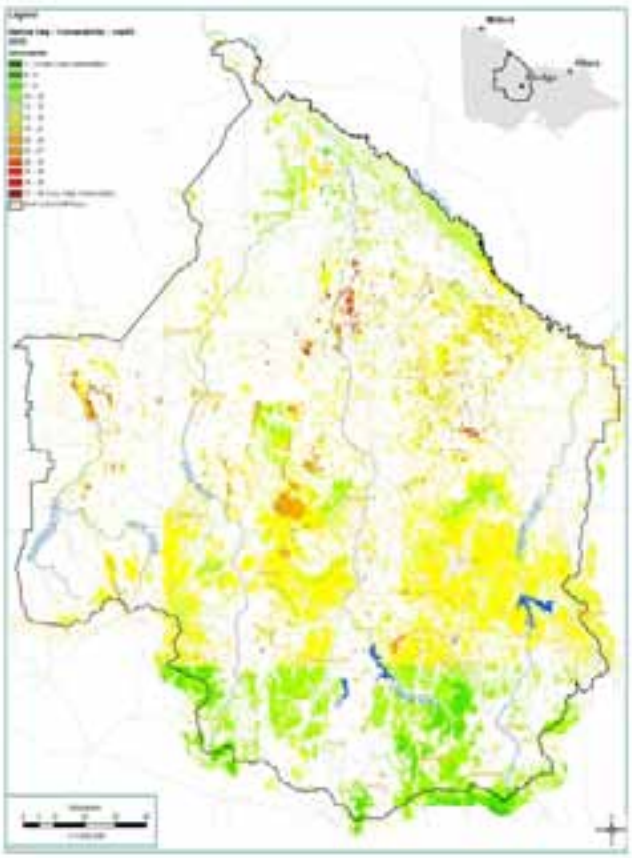
Appendix 9 – Carbon Farming Initiative approved methods

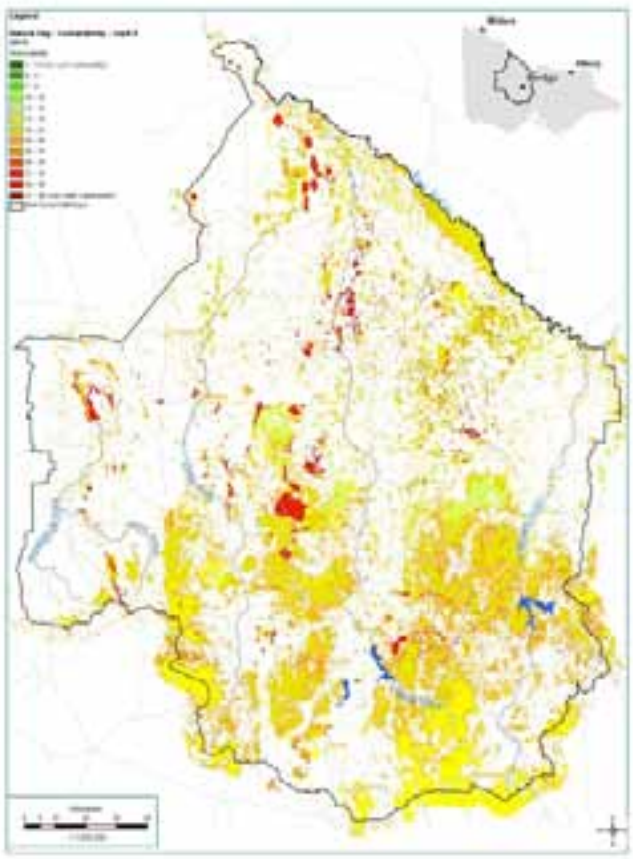
Relevant asset types	Approved method	Notes
Land/soils	Sequestering carbon in soils in grazing systems	Soil carbon can be stored in grazing systems by increasing the amount of organic matter in agricultural soils. This occurs when management practices either increase the amount of biomass (such as plant material) that is incorporated into the soil and/or reduce the amount of organic matter that is released from soils (for example, by reducing soil disturbance). Some activities, such as permanent destocking, are not eligible. Types of activities that could potentially be implemented include, but are not limited to, converting cropland to permanent pasture, rejuvenating pastures, or changing grazing patterns. Landholders must measure the soil carbon stocks at the project site at regular intervals during the project to estimate carbon sequestration. Emissions from other sources that have changed as a result of the project such as emissions from livestock, tillage events and applications of lime or synthetic fertiliser must be calculated to find the net abatement from the project. **http://www.environment.gov.au/climate-change/emissions-reduction-fund/cfi/methodologies/determinations/sequestering-carbon-in-soils**
Rivers, wetlands, native habitat	Environmental plantings	Under this method, planting or seeding native species on cleared land will allow a forest to grow and increase the carbon stored on the land. This method differs from other vegetation methodologies because it involves seeding or planting native trees rather than assisting natural forest regeneration. The method also uses a modelling approach to calculate the carbon stored, rather than directly measuring trees in sample plots. Environmental plantings are a carbon storage activity and the project area must be maintained permanently to ensure that any environmental benefit achieved is not reversed. The CFI permanence rules recognise the realities of Australia's natural environment and climatic conditions. Owners of environmental planting projects will not be penalised for losing carbon through no fault of their own. In the event of naturally occurring events such as bushfire or disease, the landholder must take reasonable action to re-establish carbon stores. The CFI permanence requirements mean that environmental planting projects should be viewed as complementary to existing land use and should only be considered in areas where they will deliver benefits for natural resource management or agricultural productivity. **http://www.environment.gov.au/climate-change/emissions-reduction-fund/cfi/methodologies/determinations/environmental-plantings**
Rivers, native habitat	Human-Induced regeneration of a permanent even-aged native forest	This method could be used by landholders who want to establish forests by promoting the regeneration of native forests which have been suppressed by agricultural land uses, such as grazing. For example, landholders may want to regenerate certain areas of their property to provide shelter for stock, minimise erosion, reduce salinity, improve water quality or provide a habitat for wildlife, while potentially boosting their income by generating credits under the CFI. Under this method, forests are established in areas that have been used for cropping or ongoing grazing for at least 10 years before the project starts. The method is based on the assumption that without a decision to change land management, the land would remain unforested. The change in land management must allow seed stores in the soil, remnant native plants or existing rootstock native to the site to sprout and germinate. Assisted regeneration can involve activities such as excluding livestock from the project area (not the whole property), managing the timing and extent of grazing, managing feral animals and non-native plants in the project area and stopping or suppressing activities such as mechanical clearing of natural regrowth. This method differs from other vegetation methodologies because it involves assisted natural forest regeneration rather than planting or direct seeding. **http://www.environment.gov.au/climate-change/emissions-reduction-fund/cfi/methodologies/determinations/human-induced-regeneration-native-forest**
Rivers, wetlands, native habitat	Native forest from managed regrowth	This method estimates greenhouse gas abatement achieved by human-induced native forest re-growth. The principal carbon pools estimated are in the tissues of woody plants, and include coarse woody debris on the forest floor. **http://www.environment.gov.au/climate-change/emissions-reduction-fund/cfi/methodologies/determinations/native-forest-managed-growth**
Rivers, wetlands, native habitat	Reforestation by Environmental or Mallee Plantings - FullCAM	The method generates abatement from the sequestration of carbon dioxide from the permanent plantings of native mixed species environmental plantings or mallee plantings. Abatement is calculated using output data from the Full Carbon Accounting Model (FullCAM). **http://www.environment.gov.au/climate-change/emissions-reduction-fund/cfi/methodologies/determinations/quantifiying-carbon-sequestration-permanent-native**

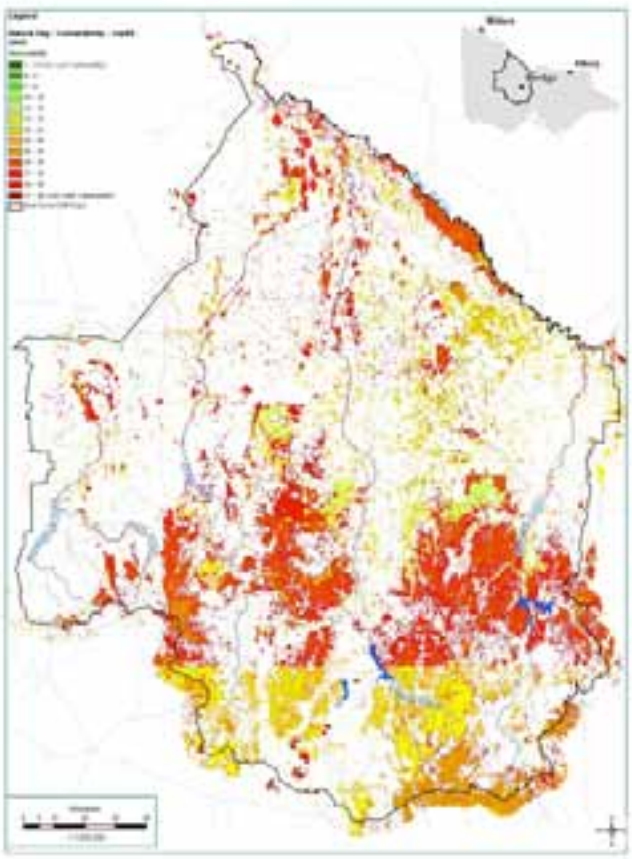
Table A9.1 *Carbon Farming Initiative approved methods*

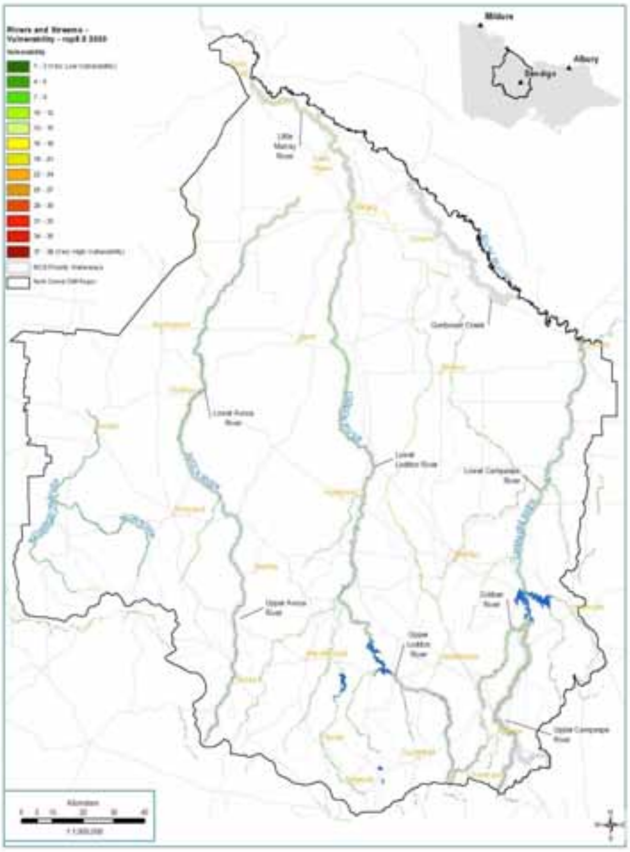
Appendix 10 – Time series maps for climate change impacts on biodiversity, rivers, wetlands and soils (2030-90)

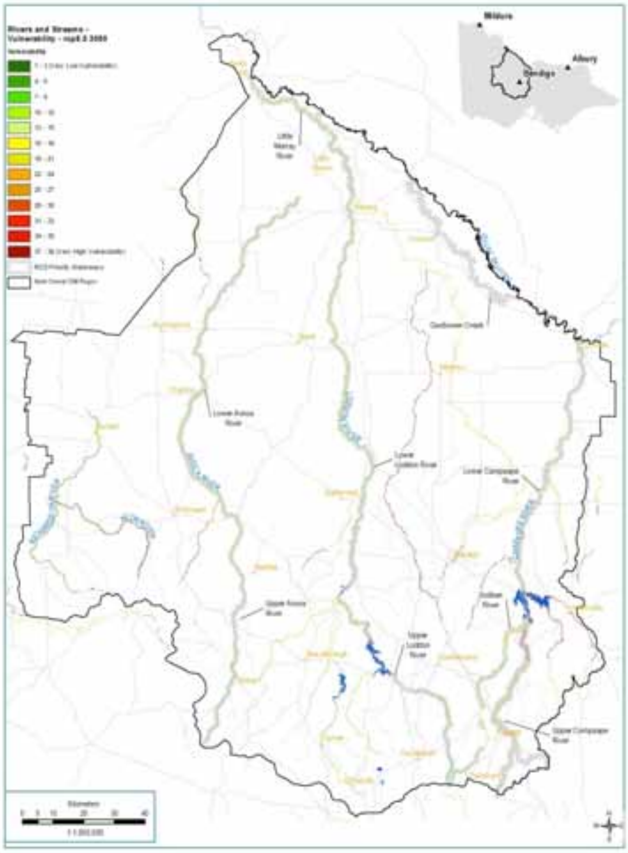


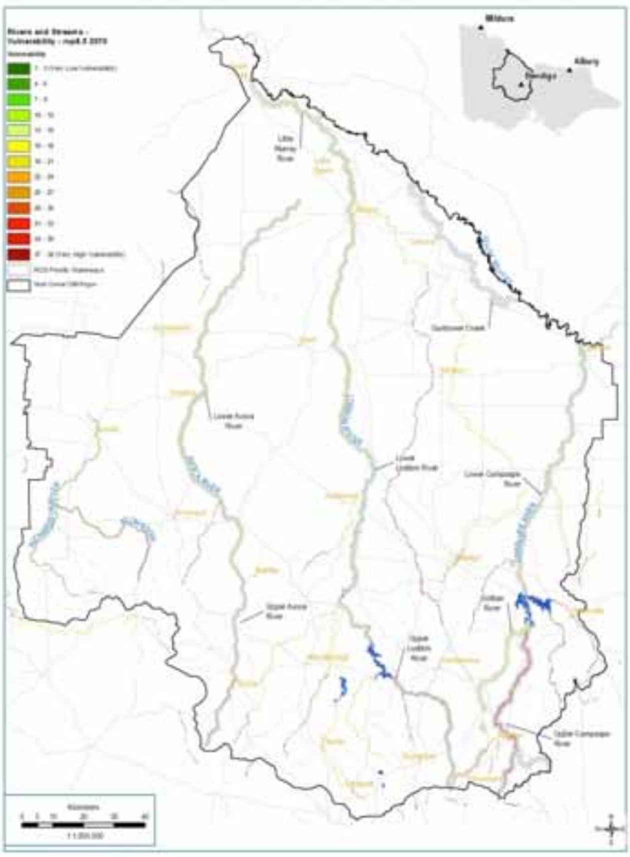


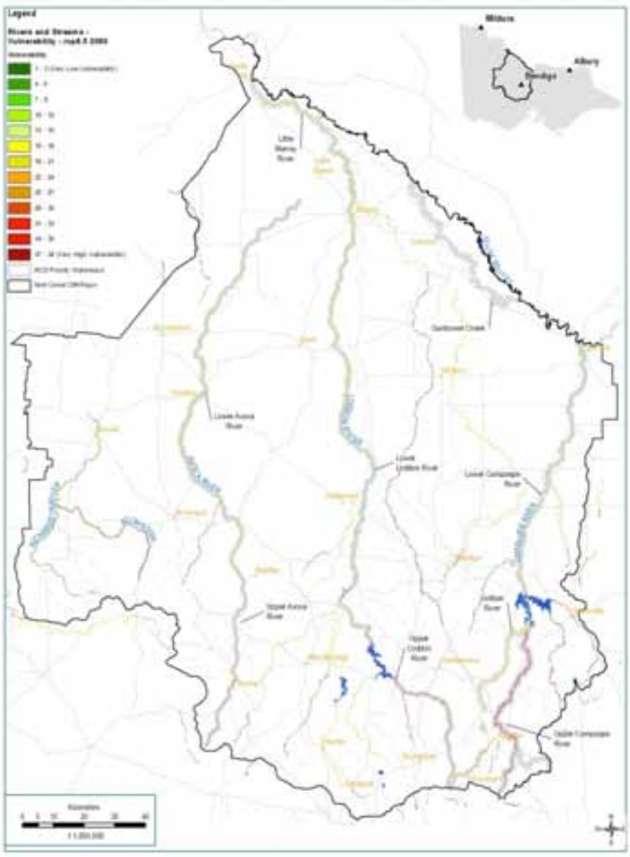


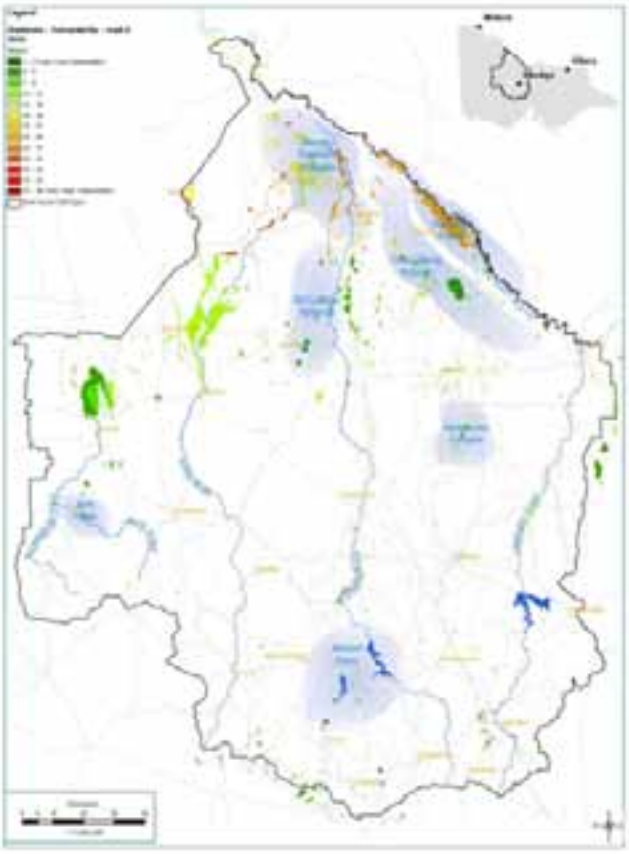


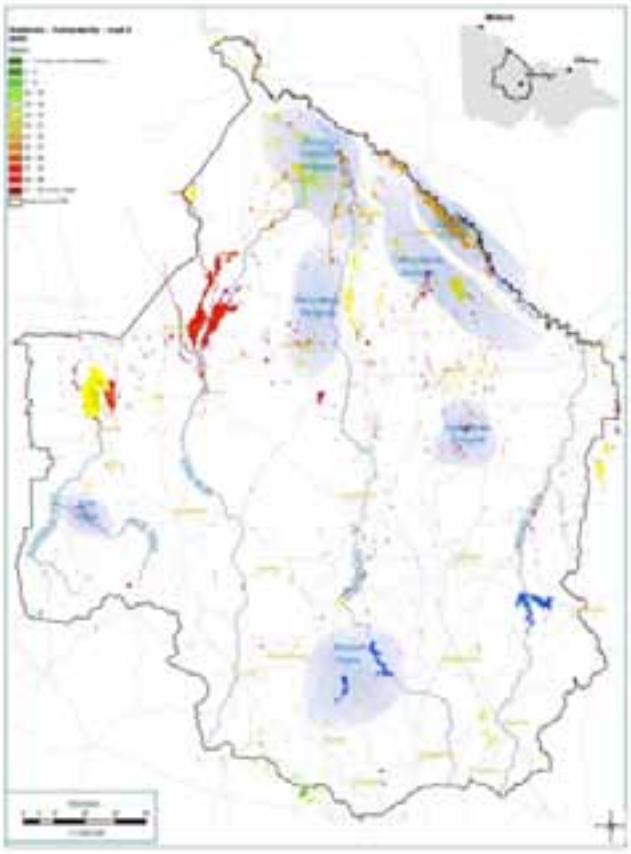

Mildura
Albury
Bendigo

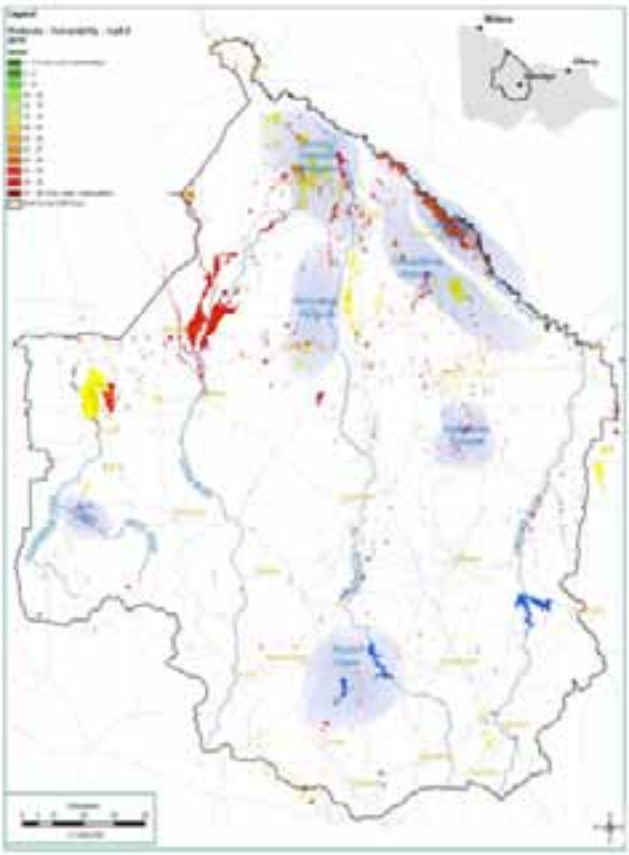

Mildura
Albury
Bendigo

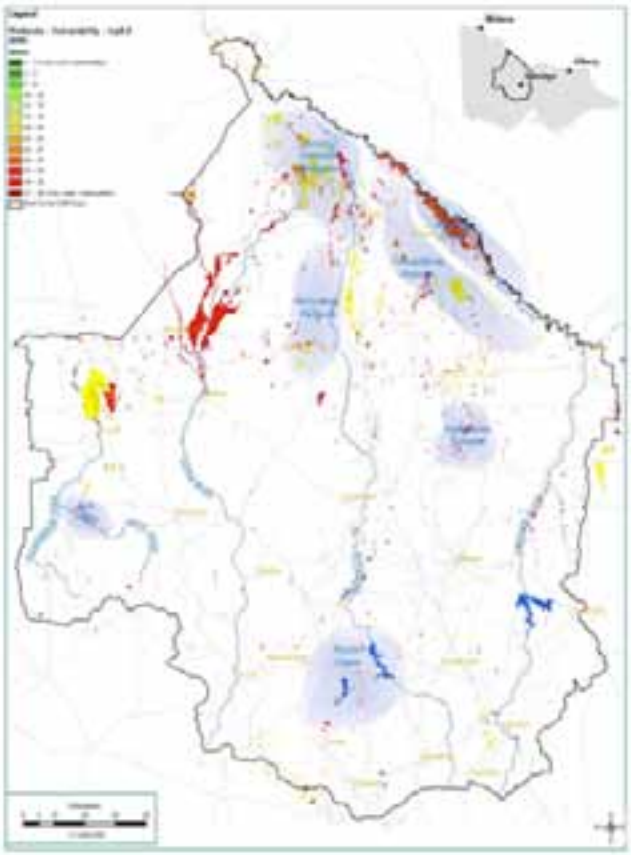

Mildura
Albury
Bendigo

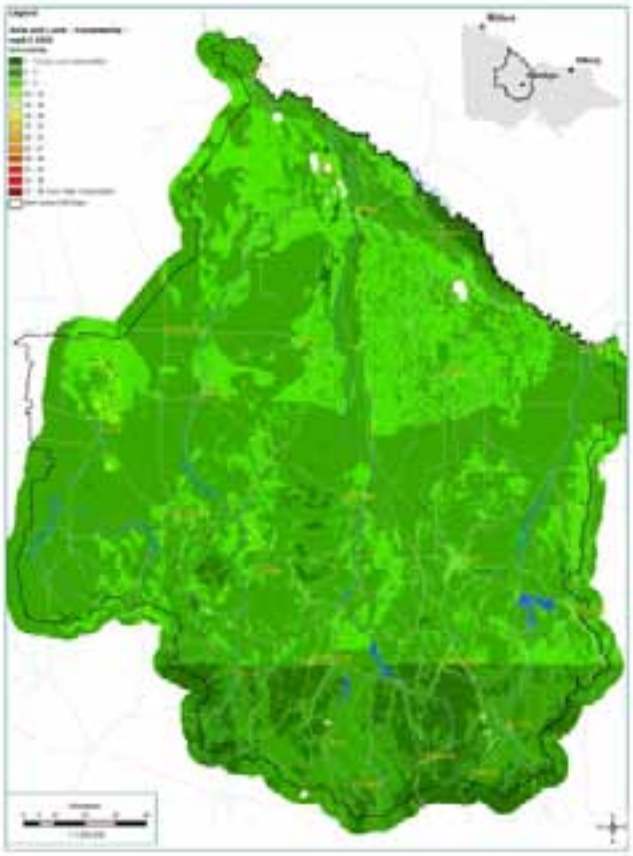

Mildura
Albury
Bendigo

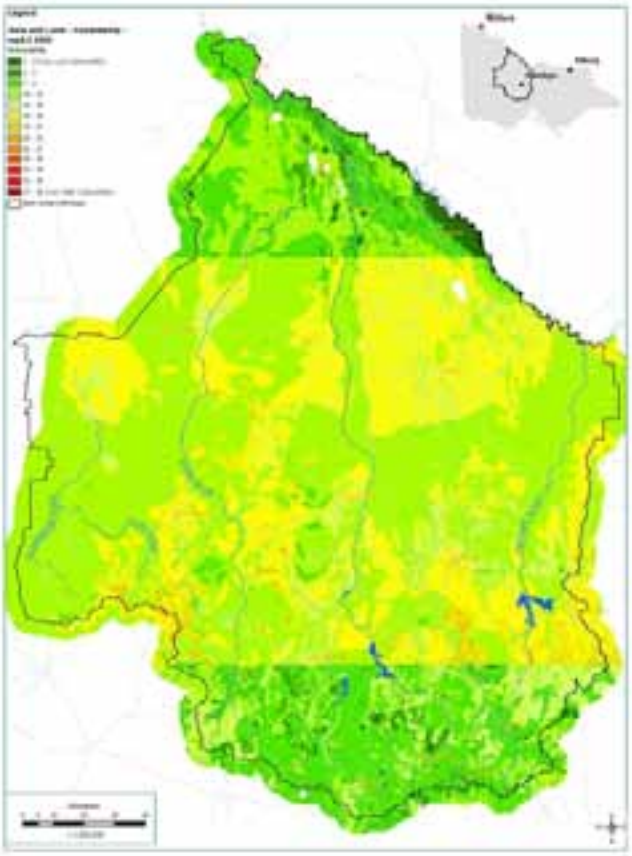


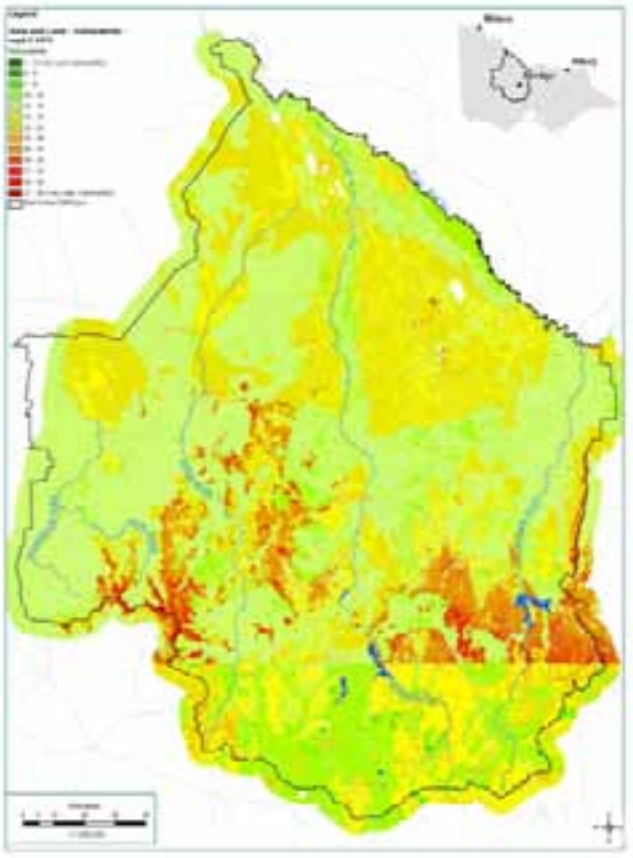


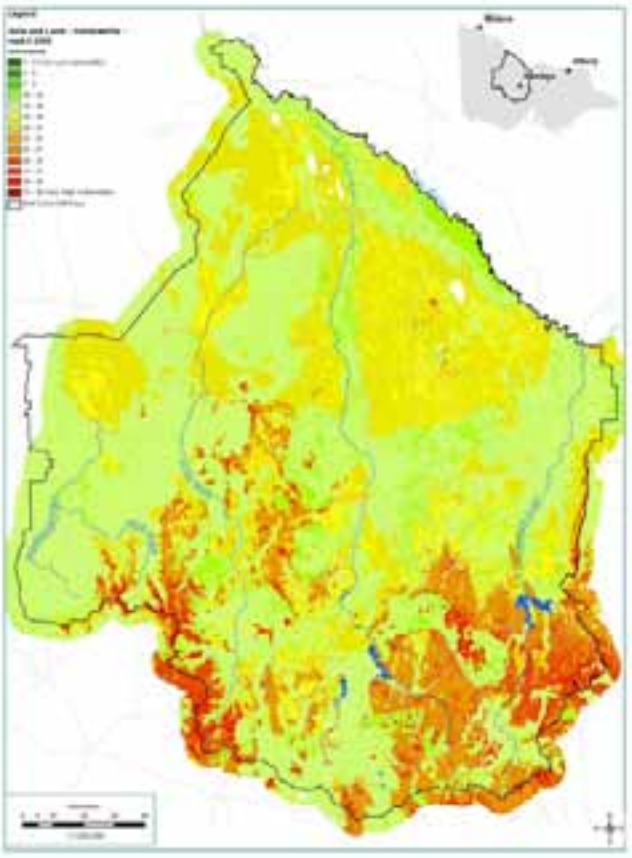












NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People