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Australian Government

Local Strategic Plan 2016-2021

Climate Change Addendum

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Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing December 2016. However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of Local Land Services or the user's independent adviser.

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Local Land Services Western Region

The Local Land Services Western Region is the largest in NSW, covering about 40 per cent of the state or 314,500km^2 (Figure 1). It is larger than Victoria and Tasmania combined. Despite its size, population densities are quite low with approximately 42,873 people living in the region, 18500 of whom live in the city of Broken Hill.

The region is unique in NSW as 95 per cent of the area consists of semi-arid rangelands characterized by relatively intact native vegetation communities and a highly variable rainfall regime. Grazing (sheep, cattle, and goats), dryland and irrigated cropping, mining and nature conservation are key activities across the region. The southern and eastern margins are also used for intensive horticulture and viticulture enterprises.

To address issues of scale and diversity, Local Land Services Western Region has taken a local "community" approach to meeting the needs of the population and separated the region into three community service delivery areas. These are presented in Figure 2. Each community has its own Local Community Advisory Group to provide advice to the Western Local Board on the effectiveness of the organisation's activities, programs and community engagement.

Within the Western Region, Aboriginal people make up approximately 13 per cent of the population and there are 16 current Aboriginal language groups identified. There are many sites of cultural significance and Aboriginal people in the region are passionate about environmental health. Local Land Services Western Region works closely with Aboriginal landholders and communities and has three Aboriginal Community Advisory Groups across the three community service delivery areas that communicate directly with the Western Local Board.

Figure1: Map of Local Land Services Western Region

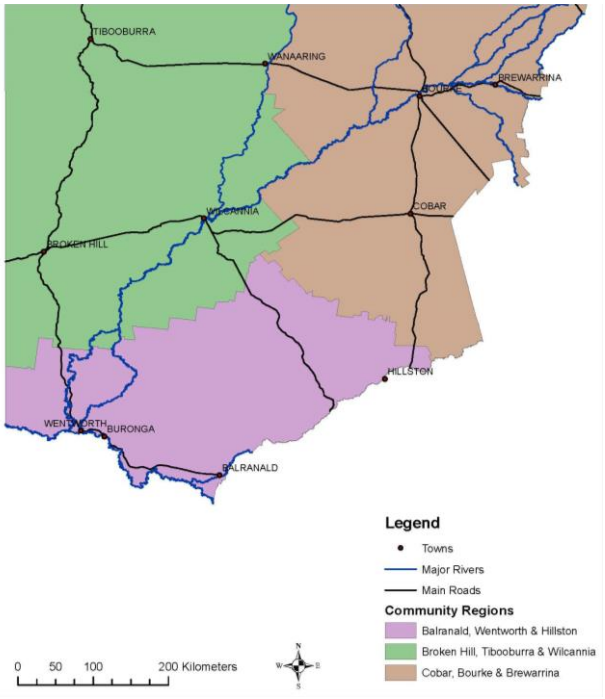


Figure 2: Map of Local Land Services Western Region communities

Developing a plan to address climate change in the Western Region

In 2012 the Australian Government established the Regional Natural Resource Management Planning for Climate Change Fund with the aim of improving the capacity of regional NRM organisations to plan for climate change. The fund included planning support (Stream 1) and a series of research projects (Stream 2) to provide regional-level climate change projections, tools and resources for NRM adaptation planning. The climate change projections aspect of Stream 2 has been delivered via the National Projections Project and eight regional cluster projects.

The aim of the regional approach for Local Land Services Western Region was to update the local strategic plan to provide clear guidance on the impacts of climate change and implementation of climate change adaptation and mitigation strategies. Additionally, the intent was to ensure that the regional community was well-placed to gain positive natural resource management benefits from the carbon economy by guiding the development of well-targeted, appropriately-designed carbon abatement projects.

There were various elements to the project which helped inform the updates and the approach to climate change and carbon farming in the Western Region. On a national level these included:

- Information shared through the Stream 2 Cluster Project, including hard copy publications and the Climate Change in Australia website, outlining the climate change projections and impacts for our region
- Information shared through the Stream 2 Adapt NRM project team and website, providing climate change adaptation tools for NRM planners.

As part of the regional approach a number of sub-projects were implemented to provide data and strategic direction to inform approaches to carbon projects, climate mitigation and adaptation as well as building landscape integrity in the region. These were designed to ensure that updates to the Strategic Plan were based on the best possible information. The sub-projects included:

- A spatial analysis of Landsat imagery project to provide (Appendix F):
    - Spatial documentation of the extent and changes in woody vegetation in the region since 1986 to inform assessments of carbon potential
    - Identification and mapping of potential biodiversity refugia in Western NSW
- A literature review of the impact of fire regimes on carbon balance in the Western Region
- The development of a carbon economy strategy for the region.

In addition to information from Stream 2 projects and the local sub-projects outlined above, various other approaches were taken to ensure that proposed additions to the Western Local Strategic Plan reflected the aspirations of local communities and landholders and took into account the most current information about policies, strategies and scientific knowledge. Some of these approaches were:

- Community consultation on updating the Western Local Strategic Plan to incorporate information about climate change impacts and adaptation approaches
- Community consultation on the carbon economy and the development of regionally appropriate carbon projects
- A comprehensive review of current climate and carbon literature

This addendum supports the Western Local Strategic Plan with the aim of informing climate change adaptation priorities and guiding the implementation of carbon sequestration activities in the region. Knowledge and understanding gained from all sub-projects has informed this document to ensure our region is well-prepared for climate change and the emerging carbon economy. At the same time this addendum recognises that a regional approach to climate change operates within the context of international, national and state policies regarding climate change.

A planning framework

Since the inception of this project in 2012 approaches to climate change have undergone a number of transformations at international, national and state levels. Although it is beyond the scope of this addendum to address the international context, planners have drawn on existing and emerging frameworks for climate change and carbon accounting at the national and state scales in an attempt to take a comprehensive approach to understanding and addressing issues of climate change projections, impacts, mitigation and adaptation in Western NSW.

Understanding Climate Change – four key concepts

Projections

Climate change projections show how Australia's climate may change in the future using a range of global and regional climate models to help predict how our future climate may look.

Impacts

Whilst climate change projections provide an understanding of how the future climate might look, climate change impacts explain the current and future ***effects*** that this changing climate will have on our landscapes, health, infrastructure, biodiversity and coastlines.

Adaptation

Adaptation means taking appropriate action to prevent or minimise the damage of climate change impacts and/or take advantage of opportunities that may arise.

Mitigation

Climate change mitigation refers to efforts to reduce or prevent emission of greenhouse gases. Carbon farming involves ways of accounting for activities that achieve emissions avoidance or carbon sequestration aimed at climate change mitigation.

A National approach

This project was initiated as part of a national approach to ensuring that all Australian NRM organisations updated their strategic plans to address climate change and help prepare communities for the emerging carbon economy. Stream 1 of the *Regional Natural Resource Management Planning for Climate Change Fund* directly supported NRM bodies to update their plans while Stream 2 of this program funded the development of accurate climate change projections and national support for climate change adaptation.

Climate change projections and impacts - the regional cluster approach

Stream 2 of the *Regional Natural Resource Management Planning for Climate Change Fund* grouped together NRM regions with broad-scale climate and biophysical similarities to form eight clusters (see Figure 3). The cluster approach enabled the CSIRO and Australian Bureau of Meteorology to prepare tailored climate projection reports and guidance on the changes in climate that need to be considered for planning in those cluster regions.

Throughout the three years of the project, planners from NRM regions in each cluster had regular opportunities to collaborate starting right from the initial planning stage of the project, meaning all NRM regions were involved in identifying the priorities and direction of the project. Local Land Services Western Region is part of two clusters; Rangelands and Murray Basin. Regional projections will be explored in more detail in the section "Future Climate" (see page 12).

Local Land Services Western Region is part of two clusters: Rangelands and Murray Basin.

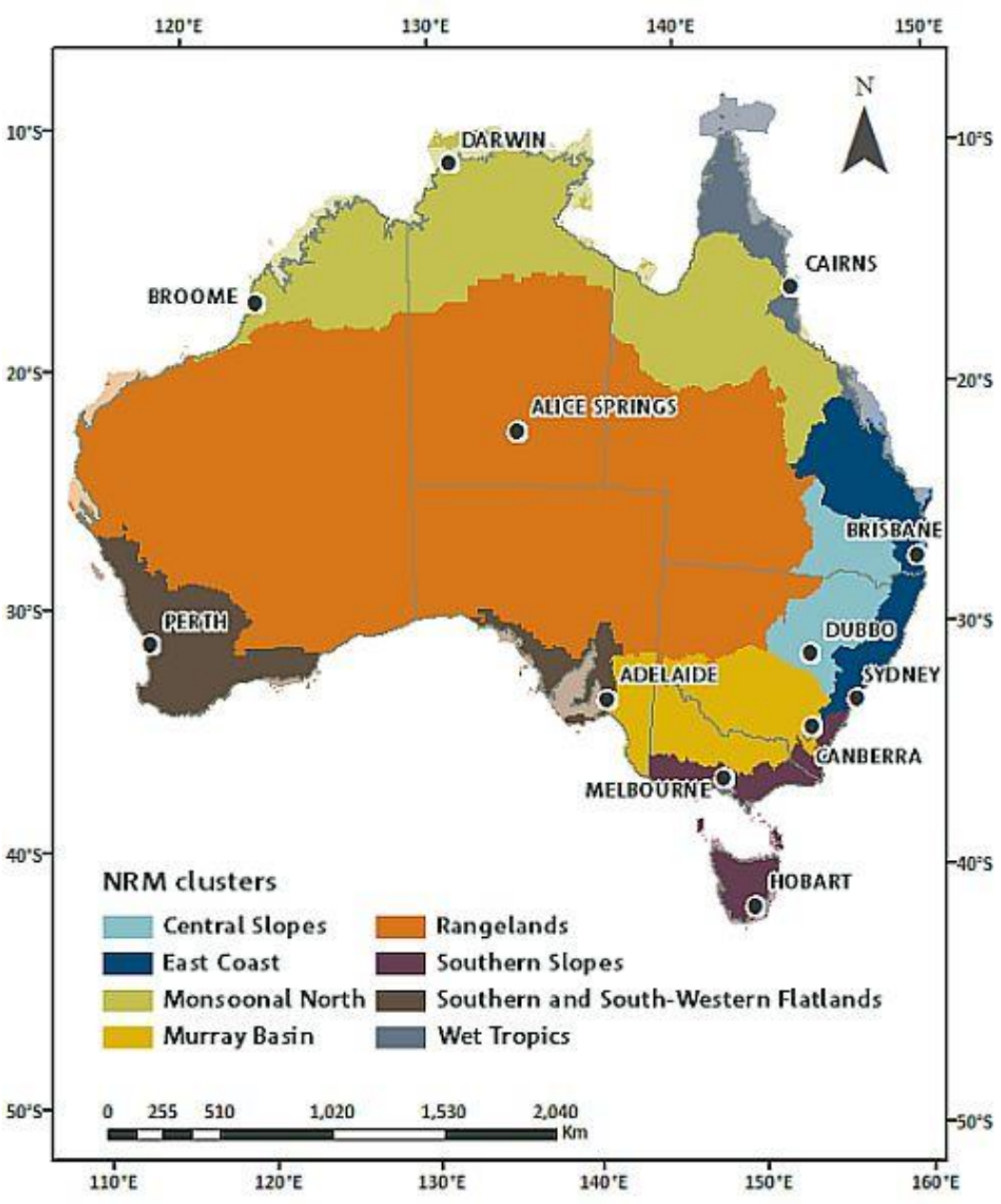


Figure 3: Australian regionalisation scheme

The Australian Government's action on climate change – adaptation and mitigation

Plan for a cleaner environment

The Australian Government has a vision for meeting emissions targets and protecting and improving our environment for future generations based on four pillars: Clean Air, Clean Land, Clean Water and Heritage Protection. This overarching plan includes a range of different programs and some of the most significant that have contributed to our regional planning process are:

National Landcare Programme

Based on three simple principles – simple, local and long-term, the National Landcare Programme (NLP) puts Landcare back at the centre of caring for our land and informs the way that Local Land Services operates in our region. This program goes beyond biodiversity conservation and environmental rehabilitation to promoting sustainable agriculture as well as tackling feral animals and weeds.

Emissions Reduction Fund

The Emissions Reduction Fund and the Safeguard mechanism are at the core of the Australian Government's approach to climate change mitigation. The fund supports businesses, communities and landholders to undertake activities which reduce or avoid greenhouse gas emissions. The Emissions Reduction Fund (ERF) has provided significant opportunities for landholders in the Western Region of NSW which will be explored in the mitigation section of this document (see page 44-53).

National Climate Resilience and Adaptation Strategy

The Australian Government developed this strategy to articulate how Australia is managing the risks of a changing climate and to provide a set of principles to guide effective adaptation practice and resilience building. This climate change addendum draws on the principles of this national adaptation strategy in developing a regional approach to assisting land managers and communities prepare for and adapt to the impacts of a changing climate.

Figure 4: Photo acknowledgement image taken from Australian Government's Plan for a cleaner environment

Policy and approach to climate change in NSW

Local Land Services

Whilst the national *Regional Natural Resource Management Planning for Climate Change* national project provided the original impetus for developing this climate change plan, Local Land Services Western Region exists within a state-wide framework of eleven Local Land Services Regions. Organisational prioritisation, visions and goals for Local Land Services regions are defined at a state level with each region taking a local approach to implementation and achieving goals.

Figure 5: Local Land Services regions in NSW

The four goals of the State Strategic Plan are:

1. resilient, self-reliant and prepared local communities
2. biosecure, profitable, productive and sustainable primary industries
3. healthy, diverse and connected natural environments
4. board members and staff who are collaborative, innovative and commercially-focused.

While the intent of this state plan is to guide local strategic plans, it does not specifically address actions for climate change mitigation or adaptation.

New South Wales – State strategies for climate change

As well as aligning with Local Land Services state objectives this addendum is guided by other state policies with regard to climate change. The New South Wales Government has taken a proactive approach to climate chently released a NSW Climate Change Policy Framework to strengthen their position as a state dedicated to support climate change mitigation and adaptation.

Key elements of this framework include:

- A Draft Plan to Save NSW Energy and Money.
- Climate Change Fund: Draft Strategic Plan

The Climate Change Fund was established in 2007 to address the impacts of climate change, encourage energy and water saving activities and increase public awareness and acceptance of climate change. The new strategic plans are underpinned by aspirational objectives aimed at both mitigation and adaptation:

- Achieve net-zero emissions by 2050
- Ensuring NSW is more resilient to a changing climate

There are seven policy directions that will guide NSW government action to achieve these objectives:

- Create a certain investment environment by working with the Commonwealth to manage transition
- Boost energy productivity, put downward pressure on household and business energy bills
- Capture co-benefits and manage unintended impacts of external policies
- Take advantage of opportunities to grow new industries in NSW
- Reduce risks and damage to public and private assets in NSW arising from climate change
- Reduce climate change impacts on health and wellbeing
- Manage impacts on natural resources, ecosystems and communities

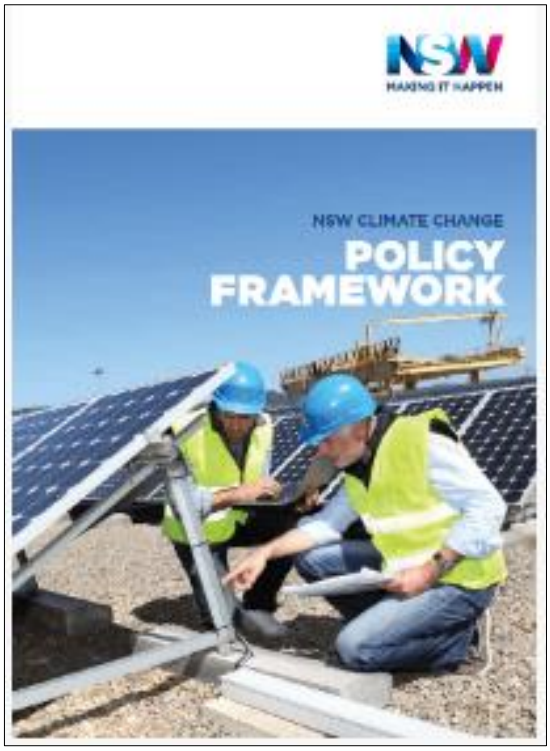


Figure 6: Taken from NSW Climate Change Policy Framework

NARClim and AdaptNSW

Since 2011 the NSW Government has also been delivering information on climate projections and impacts in an effort to assist local government, business and communities build resilience to, and minimise the impacts of, climate change. The NSW and ACT Regional Climate Modelling (NARClim) Project is a multiagency research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW.

Results of the NARClim research project have been shared with the public through the AdaptNSW website which provides climate change projections and impacts and adaptation approaches relevant to NSW and the ACT. During the course of developing this regional approach to climate change the project officer liaised closely with the NARClim team, and information from this collaboration has contributed greatly to the development of this climate change addendum, in addition to the information drawn from the national cluster project.

Regional approach to climate change

Western Local Strategic Plan

Underpinning the Local Land Services State Strategic Plan, each of the 11 Local Land Services regions has developed a local strategic plan. This addendum sits below and supports the five year Western Local Strategic Plan 2016-2021 which outlines the strategies and actions that will be implemented over the next five years to achieve the vision of strong communities, resilient landscapes and competitive agriculture in the Western Region. The Western Local Strategic Plan is tailored to address the issues, risks and opportunities that characterize the communities, industries and landscapes of this region. While it has a strong local focus, it also aligns with the statewide strategy and mission of resilient communities in productive, healthy landscapes.

Information and priorities drawn from both local consultation and the Regional NRM Planning for Climate Change project were built in to the Western Local Strategic Plan during the consultation period ensuring that an understanding of climate change impacts, adaptation and mitigation were embedded in the regional plan.

The Western Local Strategic Plan 2016-2021 has the following goals:

Self-reliant, adaptive and prepared communities

Productive, bio-secure and sustainable primary industries operating in resilient landscapes

Effective, efficient and integrated service delivery underpinned by collaboration, adaptive management and local decision making

These goals provide a sturdy framework for preparing communities in Western NSW for climate change.

As well as being shaped by the Western Local Strategic Plan, regional adaptation strategies draw on the data from Stream 2 of the NRM Planning for Climate Change Fund projects and the tools and resources for NRM adaptation planning as provided through the AdaptNRM website.

Collaboration with other NRM regions

Local Land Services Western Region understands the importance of collaborating with adjacent regions to reduce duplication of service and ensure that the benefits of knowledge, training and programs are shared. In addition to collaboration through the regional cluster project, Local Land Services staff communicate regularly with neighbouring NRM organisations and actively seek opportunities for cross-regional collaboration such as:

- Working with Central West Local Land Services to produce a quarterly "Western Newsletter' including information about climate change and carbon workshops, forums and planning
- Inviting representatives from adjacent NRM organisations (e.g. Riverina and Central West Local Land Services and South West NRM) to events with potential for cross-regional collaboration
- Local Land Services Western Region is a member of the 14 member Rangelands Alliance which provides regular opportunities for sharing information and developing collaborative approaches pertinent to rangelands regions.
- Local Land Services Western Region is currently working with NRM organisations in South Australia and Queensland to initiate a tri-state alliance for the rangelands

Local Consultation on climate change and carbon

Importantly, strategies to help our region adapt and become climate resilient also address the concerns of local stakeholders. While the Western Local Plan was being developed, Local Land Services Western Region undertook a public consultation process over six weeks from 12 October to 22 November 2015, to ensure that the strategies and actions in the plan met the needs of the region. As part of this consultation regional land managers and communities were asked about their priorities for coping with the impacts of climate change and carbon farming. The main issues they identified were:

- Groundcover
- Water availability and infrastructure
- Animal welfare

When asked specifically what they needed from Local Land Services Western Region to help cope with the impacts of climate change they mainly requested:

- Training and education
- Specialist advice
- On ground support
- Financial support (grants and funding)
- Advocacy, research and innovation.

Collaboration with other agencies

Local Land Services Western Region understands the importance or working collaboaratively with a range of government and non-government organisations to ensure that our region has access to up to date information and improved service delivery. Some of our key partners and fellow collaborators include:

- NSW Department of Primary Industries
- NSW Office of Environment & Heritage
- Western Landcare
- Western Lands Advisory Council
- Regional Development Australia (both Far West and Orana).

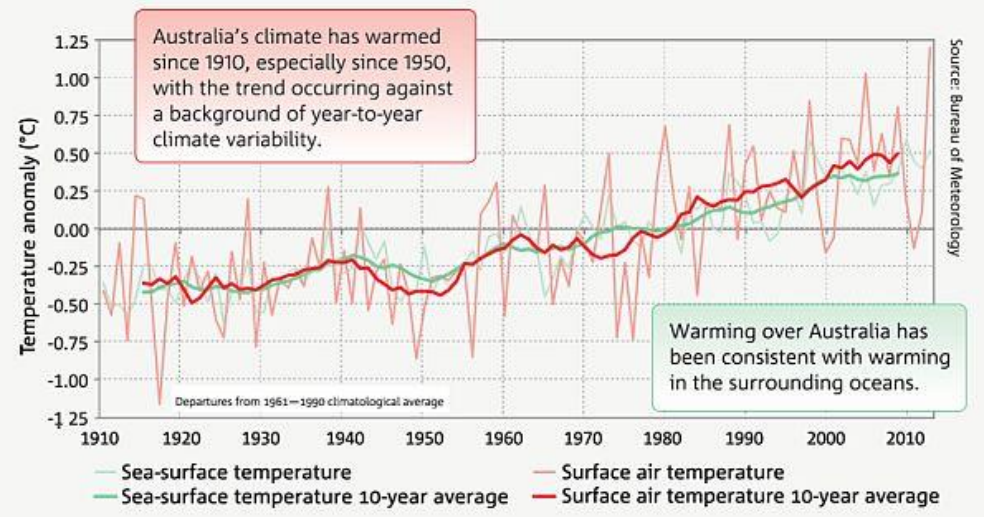
Local Land Services Western Region is committed to working with communities, landholders and other stakeholders to support the prosperity and wellbeing of our communities, economy and environment by encouraging improved choices through understanding our future vulnerabilities to climate change and helping to manage those risks.

Future climate in the Western Region

Australia's climate is changing

Australia's climate has already changed, with temperature increasing by 0.9°C since national records began in 1910. Warming has increased even more significantly since 1950 as seen in Figure 7.

More change is unavoidable as it is locked in to the climate system from past emissions.



Time series of anomalies in sea-surface temperature and temperature over land in the Australian region. Anomalies are the departures from the 1961–1990 average climatological period. Sea-surface temperature values are provided for a region around Australia (from 4°S to 46°S and from 9 4° E to 174°E). (Bureau of Meteorology)

(Gill, Horn, & Gibson, 2016)

Figure 7: Mean temperature rise in Australia from 1910 to 2010

Climate variability and climate change are different facets of climate

Weather can be highly variable on a daily, weekly or even yearly basis. The weather is what you experience each day. Climate is the average weather pattern in a place over at least 30 years.

Australia's climate is famously variable and this is particularly true of rangelands environments. ***Climate variability*** refers to the year-to-year variations around the average conditions, meaning that consecutive summers will not all be the same, with some cooler and some warmer than the long-term average. ***Climate change*** refers to any long-term trends or shifts in climate over many decades, around which climate variability is evident year to year.

Hence, a single warmer or cooler decade on its own is not sufficient evidence to assert climate change is or isn't occurring. However, statistically significant changes in average conditions over many decades do provide evidence of a changing climate.

Australians have learned to live with climate variability such as droughts and flooding rains, or hot and cold years, but our coping capacity is limited.

We are vulnerable to extreme events, as shown by the economic, social and environmental costs of recent fires, floods, heatwaves, droughts and cyclones.

Climate change represents a raft of new challenges for this generation and those to come, through increases in extreme weather events and other changes.

Climate change will be superimposed on natural climate variability, leading to a change in the frequency, intensity and duration of extreme events. Climate risk profiles will be altered and adaptation will be necessary to manage these new risks. Adaptation includes new management practices, engineering solutions, improved technologies and behavioural change. (Bureau of Meteorology)

What will the future climate look like for Local Land Services Western Region?

The National Projections Project, funded through the Stream 2 Regional Natural Resource Management Planning *for Climate Change Fund* project developed climate projections for natural resource management regions (or clusters) as seen in the map in Figure 8. The cluster approach was developed to align with NRM boundaries and preserve details of existing climatic zones.

In addition to producing a range of reports detailing the regional climate change projections, the project developed a comprehensive website, Climate Change in Australia, which provides a full suite of reports, data and projections for all the different clusters. The scientific research and assessment was carried about by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Bureau of Meteorology (BoM) taking a cooperative approach working with regional project stakeholders in each cluster. In addition to the detailed projections this comprehensive website provides a range of tools for determining precise information about particular places with information about past trends and future scenarios.

In terms of the natural resource management regions, Local Land Services Western Region is situated across the *Rangelands Cluster* in the North and the *Murray Basin Cluster* in the South as per figure 4. Although climate change projections for these regions are similar, impacts and adaptation pathways are quite different due to both climatic zone differences as well as different types of dominant regional agriculture and natural resource management.

Note: At the inception of the NRM Regional Planning for Climate Change project the Western Catchment Management Authority (Western CMA) region fit entirely within the Rangelands Cluster but when Local Land Services regions were launched in January 2014, the boundaries were changed and Local Land Services Western Region expanded to include parts of the Murray Basin cluster.

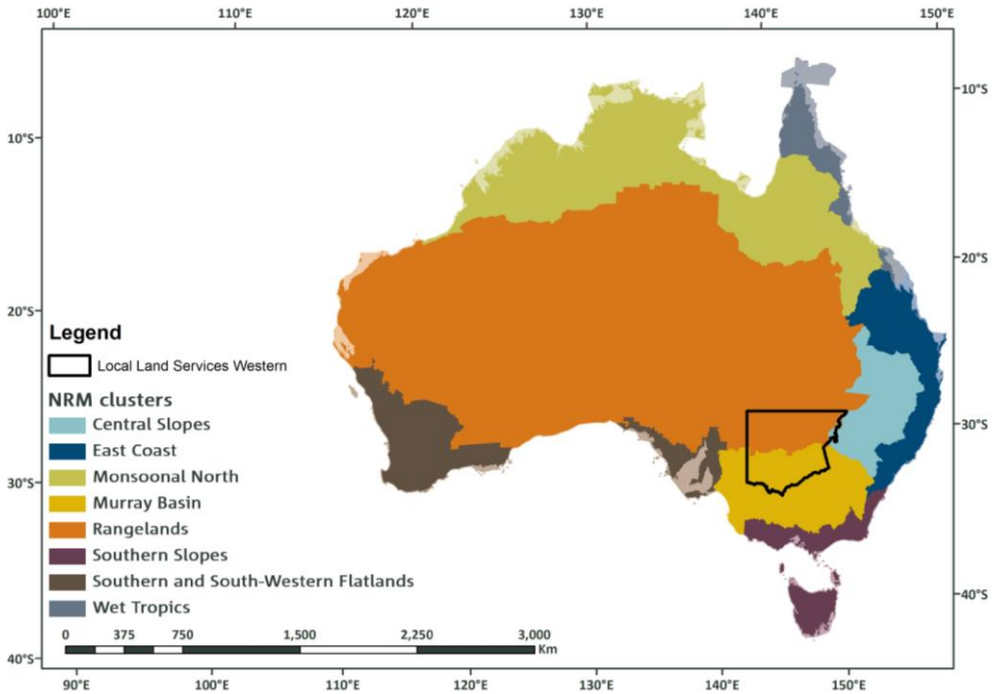


Figure 8: Local Land Services Western Region – black line superimposed on the cluster map of Australia

Climate Projections – Rangelands Cluster

Much of the Local Land Service Western Region is situated within the Rangelands Cluster which was by far the largest cluster in the national project. Comprising NRM regions in four States and the Northern Territory, this vast region contains many varied landscapes, including the Flinders Ranges, the ranges of the Pilbara and "The Centre"; hence much of the iconic "Outback". Cattle and sheep grazing are the dominant agricultural activities.

The climate of the rangelands has always been highly variable. Rainfall is low and highly variable, being summer dominant in the north and winter dominant in the south. Drought is a major part of the climatic cycle in the rangelands of Western NSW.

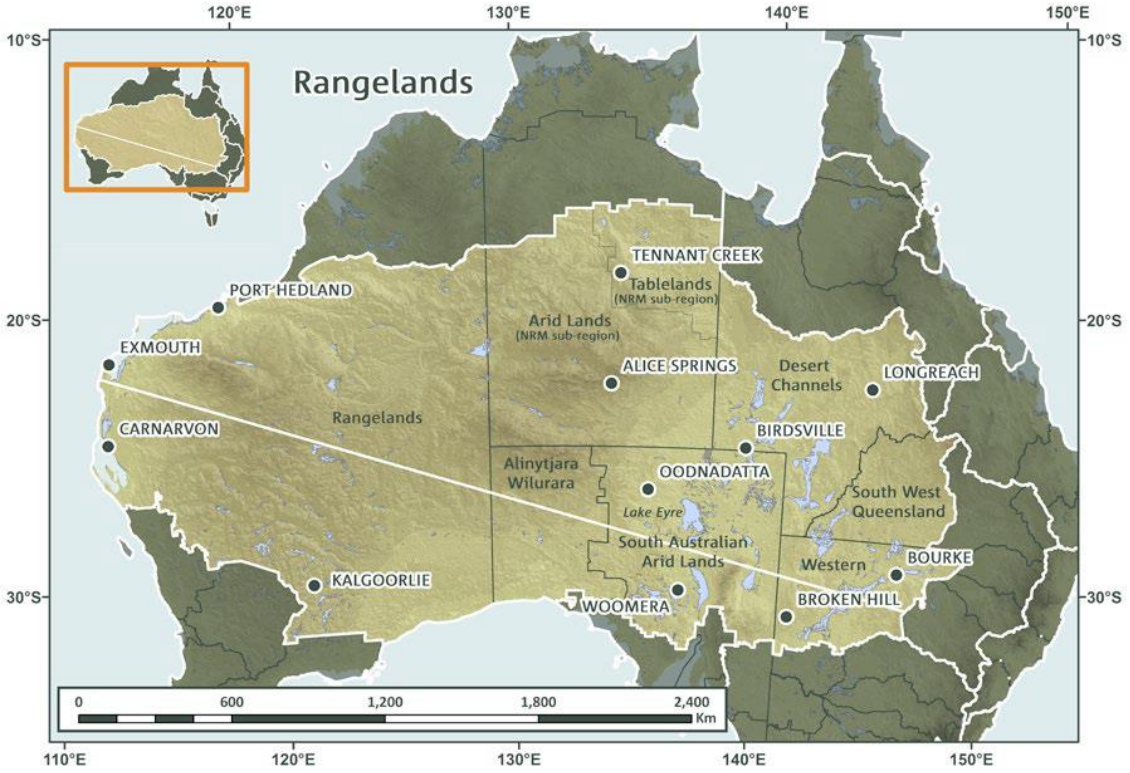


Figure 9: The Rangelands Cluster showing NRM regions, towns and water features with respect to the Australian continent. The diagonal white line defines the partition between the North and South sub-clusters of the Rangelands

Key messages – Rangelands Cluster

- Average temperatures will continue to increase in all seasons *(very high confidence)*
- More hot days and heatwaves *(very high confidence)*
- Increased rainfall variability and decreased winter rainfall *(high confidence)*
- Increased intensity of extreme rainfall events *(high confidence)*
- Increased evaporation *(high confidence)*
- Increased risk of drought *(medium confidence)*

Temperatures

Temperatures have already increased over the past century, with the rate of warming higher since 1960. In the rangelands of Australia mean temperatures increased between 1910 and 2013 by around 0.9°C in the North and 1°C in the South. (Watterson, et al)

Continued substantial increases for mean, maximum and minimum temperatures are projected with very high confidence.

For the near future (2030), the mean warming is around 0.6 to 1.4°C above the climate of 1986 – 2005.

By late in the century (2090), for a high emission scenario the projected range of warming is 2.9 to 5.3°C. Under an intermediate scenario the projected warming is 1.5 to 2.9°C. (Watterson, et al)

Hotter and more frequent hot days, less frost

In addition to the overall warming trends mentioned above it is predicted with very high confidence that there will be a substantial increase in the temperature of hottest days, the frequency of hot days and the duration of warm spells.

Where frosts (minimum temperatures under 2°C) occur in the cluster, these are projected to decrease.

Rainfall

There has been a long-term increase in summer rainfall in the northwest of the Rangelands but a small decline in winter rainfall in the south. However, natural variability is high and will continue to dominate into the near future.

By 2090, decreases in winter rainfall are projected for the South with *high confidence*. The magnitude of the change in winter rainfall in the South ranges from -20 per cent to +10 per cent for 2030: and from -45 per cent to 0 per cent for 2090.

Decreases are also projected for spring in both North and South, but with medium confidence only.

Changes to rainfall in other seasons, and annually, by 2090 are possible, but the direction of change cannot be reliably projected given the spread of model results. Such contrasts highlight the need to consider the risk of both a drier and wetter climate in impact assessment.

It is also predicted that there will be an increased intensity of extreme rainfall events.

Increased intensity of heavy rainfall events

It is predicted with high confidence that the intensity of heavy rainfall events will increase, although there is low confidence of the magnitude of change and the time when any changes may be evident against natural variability.

Drought

It is projected, with medium confidence that time spent in drought will increase over the course of the century.

There is *low confidence* in projecting how the frequency and duration of extreme meteorological drought will change, although there is *medium confidence* that time spent in drought will increase by 2090.

Increased evaporation rates, and reduced soil moisture.

Projections for potential evapotranspiration indicate increases in all seasons.

Soil moisture projections suggest overall seasonal decreases which will be strongly influenced by changes in rainfall but also increased evapotranspiration. For similar reasons, runoff is projected to decrease.

Climate projections – Murray Darling Basin cluster

The Murray Basin cluster comprises NRM regions across New South Wales, Victoria and South Australia. The cluster extends from the flatlands of inland New South Wales to the Great Dividing Range along the southern and eastern boundaries. 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.

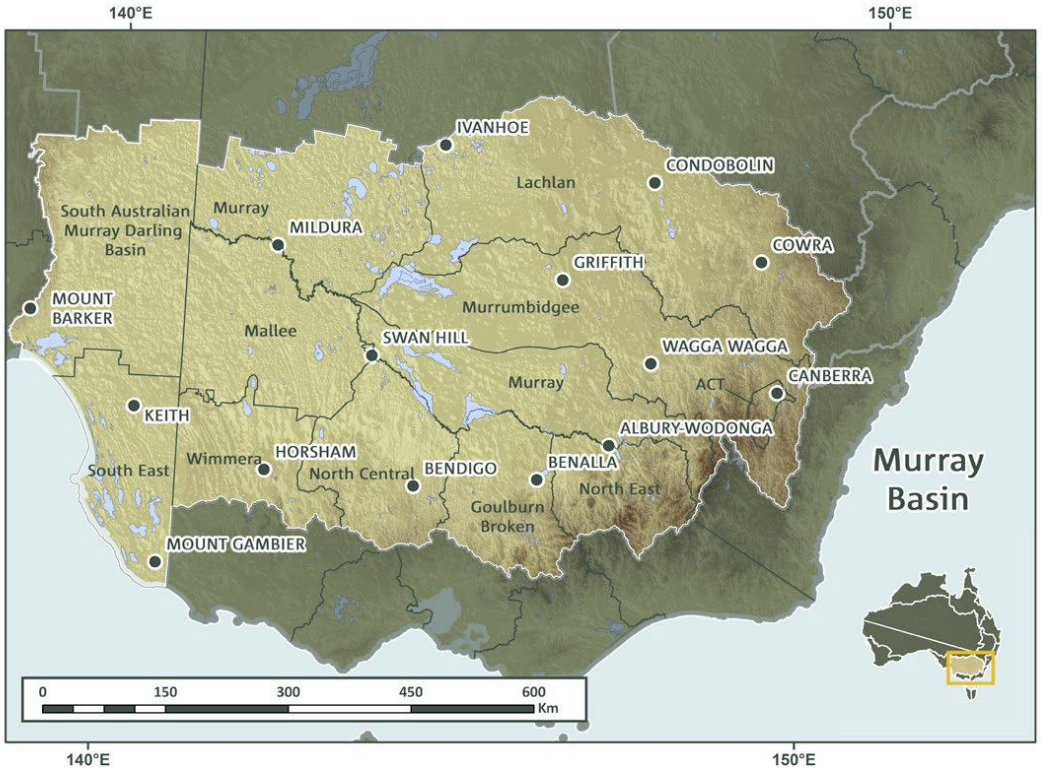


Figure 10: The Murray Basin Cluster and main localities with respect to the Australian continent

Key messages – Murray Basin Cluster

- Average temperatures will continue to increase in all seasons *(very high confidence)*
- More hot days and warm spells and fewer frosts *(high confidence)*
- By late in the century, less rainfall is projected during the cool season *(high confidence)*
- There is *medium confidence* that rainfall will remain unchanged in the warm season
- Even though mean annual rainfall is projected to decline, heavy rainfall intensity is projected to increase *(high confidence)*
- A harsher fire-weather climate in the future *(high confidence)*

Temperature

Temperatures have increased by around 0.8°C over the past century with daily minimum temperatures warming more than daily maximum temperatures.

It is projected that there will be substantial increases in projected mean, maximum and minimum temperatures.

For the near future (2030), the annually averaged warming across all emission scenarios is projected to be around 0.6 to 1.3°C above the climate of 1986 – 2005.

By late in the century under a high emission scenario it could mean temperature increases of 2.7 to 4.5°C or 1.3 to 2.4°C under an intermediate scenario.

Extreme Temperature

There will be more hot days and warm spells and fewer frosts.

Frost risk days are projected to decrease and could halve by late in the century.

Rainfall

By late in the century (2090), less rainfall is projected during the cool season, with high confidence. There is medium confidence that rainfall will remain unchanged in the warm season. For the near future natural variability is projected to dominate any projected changes.

Extreme rainfall/ and drought

Even though mean annual rainfall is projected to decline, heavy rainfall intensity is projected to increase, with high confidence.

Time spent in drought is projected, with medium confidence, to increase over the course of the century.

Fire weather

There is high confidence that climate change will result in a harsher fire-weather climate in the future. However, there is low confidence on the magnitude of the change to fire weather. This depends on seasonal variations in rainfall. Enhanced summer rainfall could moderate the number of severe fire weather days.

Evaporation

Potential evapotranspiration is projected to increase in all seasons as warming progresses (high confidence).

Humidity and solar radiation

Small changes are projected for solar radiation and relative humidity for the near future (2030). Later in the century (2090), there is high confidence in projected increased winter and spring radiation (related to decreases in cloudiness associated with reduced rainfall) along with a projected decrease for relative humidity.

How will this impact on regional agriculture and environments?

The Western Region is predominantly semi-arid rangeland. The climate is already highly variable, property scale is large in comparison to higher rainfall areas and the landscape can respond in seemingly unpredictable ways. As grazing of livestock is the most extensive land use in this region, changes in climate will impact the future ways in which pastoralism occurs. Maintaining native pasture, or groundcover, is a priority for both the environment and primary production in rangelands environments. Groundcover includes pastures, dead plant material such as pasture residue or tree leaf fall and gibber, and biological soil crusts.

Rangelands

In rangelands environments groundcover plays an essential role in minimising erosion, promoting moisture infiltration and providing conditions for pasture establishment as well as biodiversity.

Rangelands have distinct ecologies and social systems, such that conventional approaches to climate adaptation applicable in other regions may not always work in these remote areas. A successful approach draws on the existing capacity of rangelands residents who already tend to think in the long term. (Healy, 2015) The approach involves:

- Vulnerability reduction
- Enhancing resilience

Synergy between production and environment in rangelands environments

Most rangelands land managers already have a keen understanding of the importance of groundcover as their livelihood depends on it. Improving native perennial grasses means both better production and improving the natural resource base. The poor condition of rangeland vegetation is often a result of heavy grazing pressure from feral and native herbivores as well as domestic stock. The control of total grazing pressure, including feral goat impact, is a critical first step to improving groundcover and implementing sustainable management practices.

"Your true wealth lies in your grass not your animals." Angus Whyte, grazier.

Elevated CO_2

While research has shown that a rise in carbon dioxide tends to promote pasture growth, this could be counteracted by reduced rainfall. In conjunction with the likelihood of reduced pasture growth, there is potential for increased variability of pasture production. The nutritional quality of pastures is also likely to decline, through a reduction in foliar nitrogen concentration due to elevated CO_2, reflected in the impact on crude protein and water soluble carbohydrates. Plants may differ in their ability to acclimatize to gradual increases in temperature leading to changes to the botanical composition of pastures. A shift towards C4 species (many of which have lower digestibility than C3 species) is likely. It is not, however inevitable; a shift towards C3 species with increased CO2 may be equally likely, and has been suggested as an underlying mechanism of the worldwide encroachment of C3 "woody weeds" in semi-arid rangelands. (Cowie & Martin, 2009)

Weeds

Increases in temperatures, heatwaves and rainfall variability will impact on humans, stock and wildlife as well as native plant communities. Distribution and management of weeds and invasive plants will become a priority for adaptation management. Local Land Services Western Region is currently finalising a *Regional Weeds Plan* and further information about Weeds of National Significance (WoNS) and the Australian Weeds Strategy is available at the Weeds Australia website. (Australian Weeds Committee) Increasing concentrations of CO_2 in the atmosphere will also impact on the proliferation of invasive plants such as buffel grass.

Buffel grass (Cenchrus ciliaris) is one of the most widespread alien grasses in Australia. It is both a desirable pasture species and an invasive weed driving altered fire regimes in nature conservation areas. Buffel grass disperses readily by wind and has been shown to acclimate to higher temperatures and to maintain competitiveness and response to fire under increased CO2, conditions expected under climate change. It is predicted that buffel grass will spread further South under a changing climate. There is a risk that many native plant species will not survive in a future climate that is hotter and dryer. If buffel grass proves to have greater resilience than other plant species it might form the basis of a novel ecosystem. However containment strategies for buffel grass are required for high value environmental assets as control and containment are likely to be difficult, if not impossible. (CSIRO, 2014)

Figure 11: Buffel grass (Cenchrus cilaris) Photo Mark Marathon http://en.wikipedia.org/wiki/File:Cenchrus cilaris jpg.

Heat Stress

Impacts of increased heat stress in cattle include reduced grazing time (partly as a result of animals seeking shade), reduced feed intake, increased body temperature, increased respiration rate, and weight loss. (Cowie & Martin, 2009)

Basing decisions on past experiences will become increasingly risky.

Understanding vulnerabilities and enhancing resilience

Appropriate transformational change to adapt to future climates will probably require a fundamental shift in management towards a more conservative risk-based approach to the use of natural resources. It is unlikely that current best management practices will remain so under projected climate change. (Healy, 2015) An important first step in the adaptation pathway for rangeland communities is the understanding of vulnerabilities, especially enhancing the resilience of groundcover, water availability, animal welfare, infrastructure and biodiversity in the face of a changing climate.

Local Land Services Western Region already offers a range of services and support such as providing expertise and funding to assist with improving groundcover, biodiversity outcomes, animal nutrition and horticulture as well as controlling weeds and the management of invasive animals. In the face of a changing climate we will be taking an adaptive approach by reviewing service provision to ensure that future funding and training remain appropriate and are aimed at both vulnerability reduction and building the capacity and resilience of communities.

Climate change will add to existing threats and pressures

Factors such as invasive pests and diseases and vegetation degradation have already impacted on biodiversity in the region. Climate change adds a new dimension to what is already happening by directly affecting native species and by changing the ways other threats interact with them. Almost all biodiversity will be affected by climate change but some areas will be more affected than others.

Agricultural industries in the Southern part of the region, such as viticulture, horticulture and cropping, are already being impacted by changes to seasonal conditions and issues with water availability. Climate change presents further challenges and opportunities and identifying these can help landholders prepare, adapt and potentially take advantage of opportunities as they arise. Local Land Services Western Region has a key role to play in assisting landholders identify the issues and impacts and providing advice and services aimed at improving adaptation and enterprise viability in a changing climate.

Water

Water availability, usage and efficiency will become a major driver for adaptation to the changing climate in coming years. Increasing temperatures and hot spells combined with greater variability in rainfall will increase competition for water between the needs of various agricultural industries and the natural environment as well as increase pressure on water resources from domestic, pest and unmanaged animals. Improving water efficiency, capture and storage will play a major factor in ensuring the ongoing success of agriculture under climate change conditions.

Water is factored into all the impacts and adaptation approaches for the Western Region.

Valuing social capital

Local Land Services Western Region is well placed to support regional adaptation processes by recognising the importance of people and social capital, and committing to help develop the capacity of communities to understand and prepare for climate change. It is the people living in, and managing, the landscape who are the key to maintaining the viability of industries and the environment in the face of an uncertain future. It is also important to understand the priorities of those people and focus on things they are able to address rather than things that are beyond their control, as people can often become overwhelmed by the enormity of the issues surrounding climate change.

Local Land Services Western Region's approach will focus on enhancing resilience and reducing vulnerability. This approach focuses on increasing adaptive capacity through support, improved messaging and communication. A strategic and inclusive approach to engagement can help increase community preparedness, create ownership of and buy-in for adaptation options, improve social cohesion, and increase confidence in governance processes.

In primary production systems, adaptation will largely be driven by the private sector; however, government still has a key role to play in helping set the right policy conditions and providing appropriate incentives.

Figure 12: Participants at a rangeland rehabilitation workshop

Adaptation in the Western Region of NSW

What is adaptation?

Adaptation is the principal way to deal with the impacts of a changing climate. It involves taking practical actions to manage risks from climate impacts, protect communities and strengthen the resilience of the economy.

Adaptation is a shared responsibility. Governments at all levels, businesses and households each have complementary roles to play although individuals and businesses will often be best placed to make adaptation decisions that reduce climate risks to their assets and livelihoods. (Department of the Environment)

What is the Australian Government's approach to adaptation?

In 2015 the Australian Government released the *National Climate Resilience and Adaptation Strategy*. The vision of this strategy is:

We act together to support prosperity and wellbeing in Australia and beyond by building the resilience of communities, the economy and the environment to a variable and changing climate.

Some of the key messages of the strategy are:

The choices we make today will affect our future vulnerability to climate change

We all have a role to play in understanding and managing the risks

Taking an adaptive and flexible approach to planning

Incorporating climate adaptation into regional planning processes presents several challenges:

- the need to plan for multiple possible futures
- employing flexible planning processes
- identifying and preparing for likely future decisions
- strengthening the adaptive capacity of people and organisations

Through the Stream 2 aspect of the NRM Planning for Climate Change fund AdaptNRM has developed a *climate change checklist* which reflects an iterative approach and includes five general components of planning.

This is the most appropriate approach to adaptation planning because the most effective responses to climate change risks have not necessarily been defined yet.

The best outcomes may only be achieved after trying a range of options, assessing the responses, and adjusting those responses.

Figure 13: The five components of adaptation planning (CSIRO, 2014)

How does Local Land Services Western Region incorporate an adaptive and flexible approach to planning?

Western Local Strategic Plan – Learning and development

Local Land Services Western Region already fosters adaptive management and continual improvement across the organisation. In its simplest form, adaptive management is about a three step continuous improvement cycle: "plan to learn". This is achieved through strategic planning, implementation and knowledge management and then adapting plans based on key learnings. Each step in the adaptive management cycle is linked, to ensure continuous improvement over time.

A triple loop learning approach is applied to evaluate for adaptive management and drive continuous improvement at different scales of planning: annual plans, business implementation plans, strategic plans and governance.

The first loop of evaluation and learning occurs frequently, at least annually, and involves regular monitoring, auditing, evaluation and report of actions. This level of leaning leads to incremental changes in projects and actions.

The second loop of learning focuses on challenging, and potentially reframing, strategies and objectives, as well as examining evidence and assumptions that underpin our strategic approaches, regional objectives and the projects that underpin them.

The third loop of evaluation and learning focuses on challenging, and potentially transforming governance arrangements, value systems, vision and mission, and other high level processes. This level of learning can lead to changes in direction and goals (e.g. transforming our business to accommodate climate change adaptation needs). (Local Land Services Western Region, 2016)

Local Land Services Western Region has three levels of adaptive management built into its planning processes:

- The **Western Local Western Local Strategic Plan 2016-2021** represents the highest level of adaptive planning and is revisited every 5 years.
- The **Business Plan** (under construction) is reviewed annually and represents the implementation of programs and strategies
- The **Project Review Team (PRT)** process takes place every 4-6 weeks at an operational level. It involves reviewing all proposed and ongoing projects and ensuring they have evidence-based outcomes and comply with regional strategies, objectives and funding criteria

General adaptation approaches

The key to the success of Local Land Services Western Region's approach to adaptation in the region relies on incorporating adaptation thinking across the full range of service delivery, and monitoring the effectiveness of different approaches.

Local Land Services Western Region has developed adaptation strategies which have relevance across the whole region as well as specific adaptation strategies for biodiversity, livestock and different types of agriculture.

General adaptation strategies

- Increased collaboration across industry sectors to develop long term resilience adaptation plans that address:
    - *Human health and safety including mental health through:*
        - Continuing and expanding upon partnership approaches with the NSW DPI Rural Resilience Program
        - Ongoing participation in cross-sectoral collaborations such as recent Enabling Regional Adaptation Workshops hosted by NSW OEH
        - Further development of cross-sectoral collaboration approaches with local government
        - Developing cross-sectoral approaches with regional health providers
    - *Resilience of communities and infrastructure*
        - Collaborating with health and local government sectors
        - Collaborating with Regional Development Australia
    - *Resilience of agricultural industries*
        - Continuing and increasing collaboration with NSW Department of Primary Industries
        - Continuing and increasing collaboration with industry organisations like Meat & Livestock Australia (MLA) and Australian Wool Innovation (AWI)
        - Continuing and increasing collaboration with NSW Farmers
        - Continuing and improving collaboration with Regional Development Australia
        - Development of a Regional Weeds Plan
    - *Resilience of natural resources*
        - Continued collaboration with Landcare
        - Continued collaboration with NSW Office of Environment & Heritage
        - Development of a Regional Weeds Plan
- Developing the capacity of land managers and communities through ongoing education about:
    - *impacts of climate change on the landscape, animal welfare, productivity and human health*
    - *adaptation approaches*
    - *innovation in agriculture*
    - *weed management*
    - *protecting biodiversity*
- Encouraging investment in sturdy and innovative infrastructure that will function efficiently in extreme temperatures and withstand extreme weather events
- Encouraging innovation and the use of technology to improve resilience and enterprise viability.

- Encouraging the appropriate uptake of programs that allow for more precise land management decisions such as:
    - NRM Spatial Hub
    - Precision pastoralism
    - Precision agriculture
- Encouraging the appropriate use of technology that allows for remote management such as:
    - Drones
    - Telemetry
    - Remote fence management
- Encouraging and educating about the use of technology in adaptation planning
    - NRM Spatial Hub
    - Climate Change in Australia website
    - Adapt NSW
    - BoM
    - Spatial identification for improved management

Improvements in technology over recent years allow modern land managers to take a more sophisticated approach to managing their enterprises. Australian farmers have remained competitive in the global food market despite having low levels of subsidies relative to other countries. The ability to adapt and innovate is a major factor in ensuring a strong, prosperous and sustainable agricultural industry in an uncertain future. Today's land managers are increasingly turning to digital technologies including apps and remote sensing tools to enable better monitoring, better decision making and more precise management of their resources and production. As part of the adaptation strategy, Local Land Services Western Region will be increasing collaboration with researchers and industry to ensure that land managers and communities have up to date information about innovations in agriculture that can improve decision making, management and enterprise viability.

Incorporating traditional ecological knowledge

Figure 14: Dennis King, Damion Kennedy and Ernest Mitchell at Stepping up to Manage country workshop.

Aboriginal people make up 15 per cent of the population of the Western Region and are a critical sector of the community for engagement by Local Land Services and its partners. There is growing recognition of the value of traditional cultural knowledge and traditional management techniques as a way of building on existing sustainable natural resource management practices.

The Aboriginal community of the Western Region has been described as highly resilient. Upon European settlement, Aboriginal people were exposed to extreme disturbances and shocks that resulted in the degradation of their land, culture, language and way of life. Over time, the highly developed skills, knowledge and intimate relationship they had with their traditional lands was eroded. Despite these changes, the Aboriginal community is passionate about maintaining connection to traditional country, recording and sharing knowledge and looking after the land, water, plants and animals that sustained its people for tens of thousands of years. (Western Catchment Management Authority, 2013)

Understanding Aboriginal Community Values

In recent years Aboriginal people have been involved in regular and extensive consultation processes in Western NSW and have identified the following values as the most important to them:

- Education of children and passing down traditional ecological knowledge
- Establishing partnerships with other land managers
- Employment opportunities for Aboriginal people on the land
- The health of aquatic systems
- The ability to own and access country to undertake traditional practices

Local Land Services Western Region recognises that Aboriginal people retain a holistic relationship with the land and have important ecological knowledge about country to share. Local Land Services Western Region has Aboriginal staff and Aboriginal Community Advisory Groups in each of the three communities to ensure ongoing consultation and inclusion in the adaptive management process.

The following strategy is part of the Western Local Strategic Plan 2016- 2021:

Create opportunities for Aboriginal people to connect to Country and share traditional land management knowledge. Actions to achieve this will include:

- Implement and expand the Western Local Land Services Aboriginal Cultural Knowledge System.
- Promote opportunities for Aboriginal people to connect to Country for the purpose of practicing traditional culture, transferring knowledge and implementing sustainable land management practices.
- Promote positive relationships, trust and respect between Aboriginal people and non-Aboriginal land managers and organisations.
- Increase training opportunities for Aboriginal people in land management and primary industries with a view to long term employment.
- Strengthen and communicate duty of care for Aboriginal cultural landscapes.
- Increase youth awareness and knowledge of sustainable land management and Aboriginal culture.

Figure 15: Participants at an Aboriginal plant identification workshop

Biodiversity: A regional approach to helping natural systems adapt to climate change

An uncertain future for Biodiversity

The National Climate Change Adaptation Research Facility (NCCARF) has conducted extensive reviews of available research on the impacts of climate change on biodiversity. However for most species, little is known about their thermal and physiological tolerances, natural resilience and adaptive capacity. The ability of individual species and ecosystems to cope with and recover from extreme events is uncertain.

There is already evidence for many species that changes in the timing of life history processes such as breeding and migration will impact on survival, reproduction and interaction with other species. These changed interactions may have cascading effects such as plants flowering in the absence of their usual pollinators or disrupted predator/prey relationships.

At the landscape level, refugia are seen to be vital but the management of these areas will require new thinking. Rising carbon dioxide levels will make plants more water efficient, but may change the palatability of leaves and grasses with unknown impact on native herbivores (and livestock). The balance of native pastures may change but there is conflicting evidence as to which plants will be favoured, e.g. there is evidence that plants using the C4 photosynthesis pathway will have a competitive advantage. Fire regimes will change and this will potentially affect local species composition and interactions with invasive species.

Adaptation in species is an evolutionary response to change. However, the rate of change expected under climate projections will be too fast for evolutionary processes for many or most species. Therefore, adaptive management of biodiversity will be needed to avoid serious loss of species and landscape function.

Biodiversity management in a changing climate

Projected climate change will challenge current management of biodiversity. CSIRO has developed guiding principles for future management. They flag a shift from a focus on preserving current or restoring past species composition to a less easily defined objective, described by the following four principles:

Optimise ecological processes

This is quite pragmatic and aims to maintain diverse ecological communities that continue to deliver ecosystem services for natural systems and human benefit. This accepts that there may be loss of some species at the local level.

Currently regional landscapes are under significant pressure from stressors including a high population of unmanaged goats. The future management of these stressors is a key to the ongoing delivery of ecosystem services.

Maintain the evolutionary character of the Australian biota

This principle focuses on the value of biodiversity i.e. the value of the Australian flora and fauna at a global level, and the values that many Australians place on our unique flora and fauna and its contribution to national identity. This aims to support processes that will allow ecosystems to re-assemble from endemic Australian species by managing exotic species and other threatening processes. This does accept that the species composition is likely to change through natural processes and may include intentional translocation of plants or animals to maintain ecosystem function. Additionally, factors such as low soil nutrients and marsupial grazing that have driven the evolution of Australian biota need to be understood and maintained.

Maintain unique regional character

Australian biodiversity is characterised by a high degree of regional endemism and biodiversity hotspots. This principle recognises that in managing the re-assembly of ecological communities, the focus should be on proximate species rather than distant species. This will support regions with distinct biodiversity characteristics to maintain much of their unique character.

A unique regional character provides a "sense of place" for the community by linking them to their environment. Such has been the impact of human activity, except for major reserves and wilderness areas, regional landscapes are "constructed", being the product of decisions to conserve or utilise particular areas. Maintaining a "unique regional character" under climate change will require an intensive conversation between the community and the institutions that must make decisions on future landscape management. An informed community is essential for both influencing management on public lands and for commitment to support conservation on private lands.

Minimise species loss nationally

This will be achieved by managing the full range of Australian environments including refugia and may depend on species specific actions such as assisted dispersal of vulnerable species in the future.

Promote cross-sectoral adaptation planning

Helping to ensure that adaptation in other sectors, like agriculture and urban development, does not inadvertently reduce the ability of biodiversity to adapt and persist.

No Regrets management

Having access to climate projections allows proactive management to reduce future impacts. Until impacts become more evident, this will largely consist of "no regret" options, i.e. using management that produces tangible benefits, even in the absence of climate change. Examples include managing non-climate impacts to increase the resilience of natural systems and increasing landscape scale connectivity. These practices are consistent with current management.

Example: It is vital to get control of existing stressors like those from the grazing of unmanaged goats in the Local Land Services Western Region in order to manage biodiversity in the region sustainably under *current* climate conditions, let alone those projected for the future. Controlling existing pressures will produce a raft of tangible benefits and improve landscape resilience in the face of a changing climate.

The importance of managing biodiversity at a landscape scale

While major reserves such as national parks will continue to play an important role in biodiversity conservation and in-situ evolutionary processes, they will be vulnerable to latitudinal and altitudinal climatic shifts. The resulting floral and faunal biodiversity will depend on the ability of individual species to respond to the changes in local climate or to persist in refugia.

There is little information on the ability of individual species to adapt to variation in climate. It is inevitable that some species will not have the thermal and physiological tolerance to survive in projected future climates, reducing diversity and causing unpredictable impacts on ecosystem dynamics. Refugia may be present where the climatic impact is moderated by local factors such as aspect, hydrology and geology allowing some species to persist longer by retreating to these areas.

Priority areas for investment

The Western Region of NSW contains many sites of significant ecological value including priority areas for investment:

World Heritage Listed Area

- Willandra Lakes (including Lake Mungo)

OEH Priority Landscapes

- Barrier Ranges
- Barwon
- Bulloo Overflow and Caryapundi Swamp
- Culgoa
- Cuttaburra
- Darling
- Mutawintji
- Narran
- Neranghi Bogan
- Warrego
- Amphitheatre Lake
- Mt Arrowsmith
- Lake Mungo

Priority Fauna

- Malleefowl
- Southern Bell Frog
- Thick-billed Grass Wren
- Yellow footed Rock-wallaby
- Threatened fish

Ramsar wetlands

- Lake Pinaroo
- Lake Peery
- Paroo River Wetlands
- Narran Floodplain

63 x Nationally Important Wetlands

- See Appendix D for details

Threatened Ecological Communities

- Acacia melvillei
- Brigalow Gidgee Woodland
- Brigalow Woodland
- Coolibah Blackbox Woodland
- Myall Woodland
- Porcupine Grass Red Mallee
- Sandhill Pine Woodland
- Acacia loderi

Conservation projects that protect large representative samples of these landscapes and small sites of specific high conservation value are major priorities for Local Land Services project funding. Specific sites identified for threatened species conservation are also a priority as well as conservation of endangered ecological communities. Prioritised funding programs often focus on minimising the impacts of pests and weeds and fencing areas of refugia and riparian importance.
The prioritisation of high conservation value sites within the region has to some degree been compromised by data limitations based on field records. The extent of high conservation value areas and threatened species distributions are likely to be broader than currently mapped. However recent developments in remote sensing and other predictive approaches, as well as the implementation of citizen science programs, are helping to address historical data limitations.

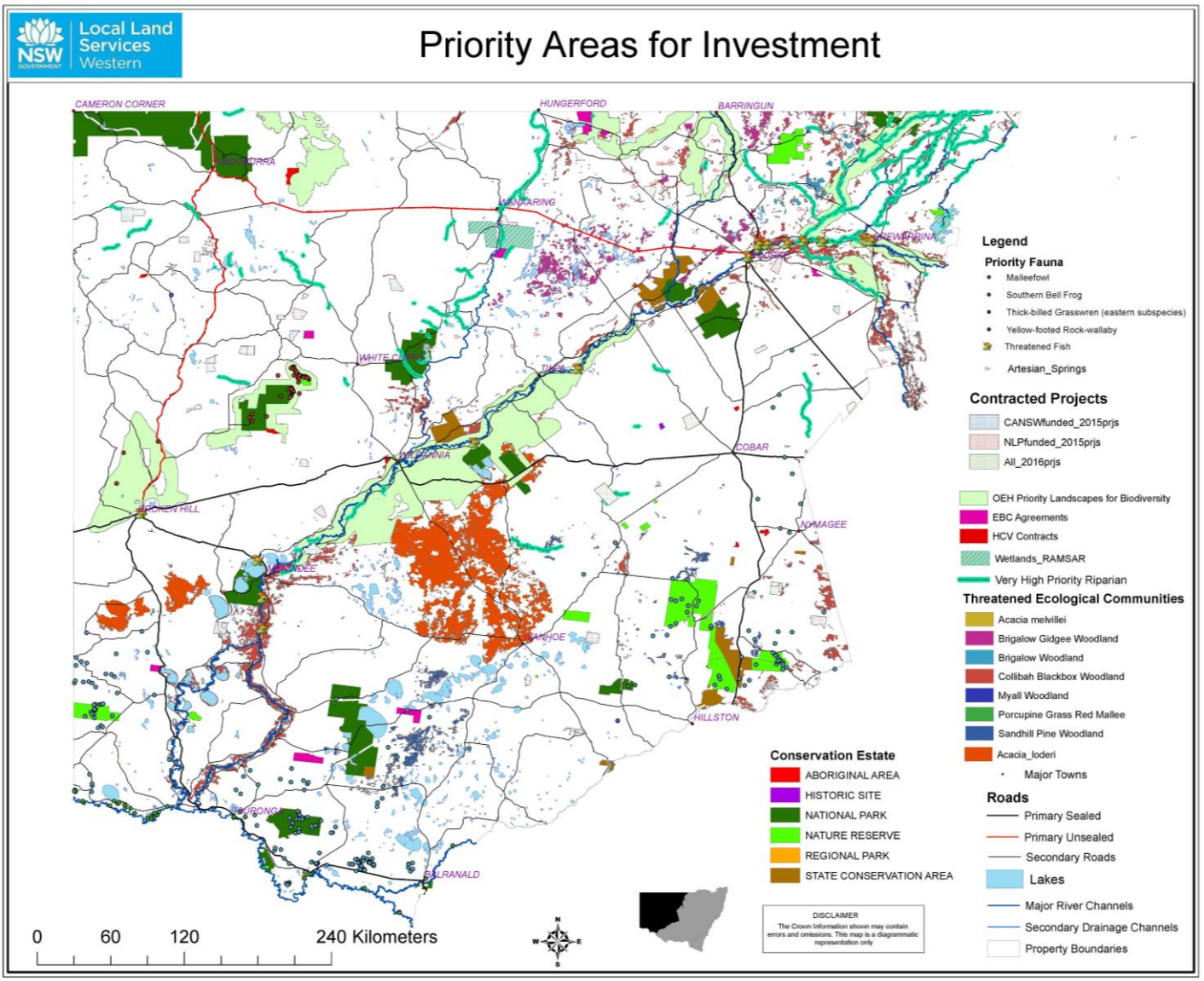


Figure 16: Regional map - priority areas for investment

Spatial Identification of areas of resilient habitat for high conservation area project funding

As part of a regional approach to climate change preparation and adaptation Local Land Services Western Region contracted NSW Office of Environment and Heritage (NSW OEH) to provide spatial identification of areas of potential biodiversity refuge in the region. As part of this project OEH developed spatial data products from remote sensing imagery that identify key landscape features indicating convergent areas where water and nutrients accumulate, terrain features that may moderate temperature and run on areas where species may be able to retreat and persist from the worst effects of climate change. These tools can be used in a variety of ways to illustrate water persistence and seasonal fractional cover. Figures 17-20 demonstrate how the tools can be used to generate maps identifying different aspects of the landscape – providing valuable information for identifying areas of high conservation value for future project funding as well as areas of productive significance for land managers.

"Change is inevitable and biodiversity management will require application of new paradigms as well as continuation of existing practices" (Alistair Hobday, CSIRO)

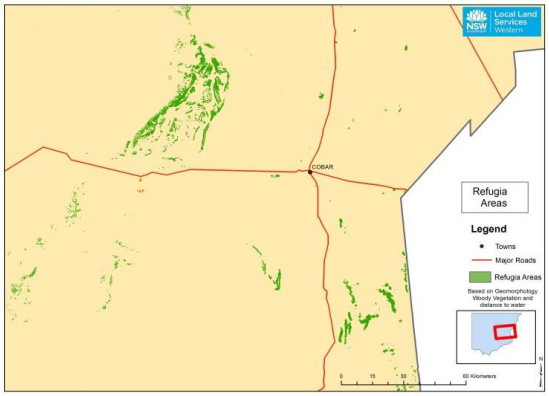


Figure 17: Run on areas in Cobar District

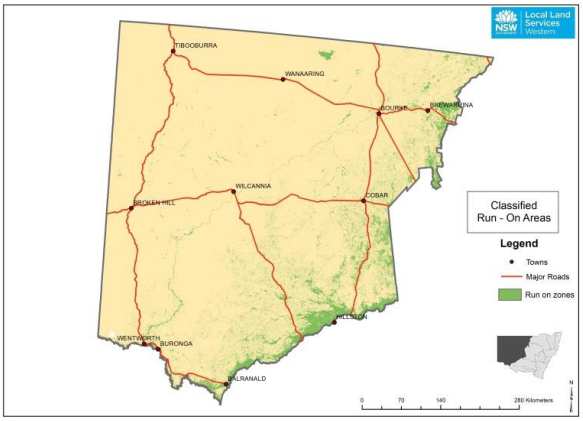


Figure 18: Run on areas

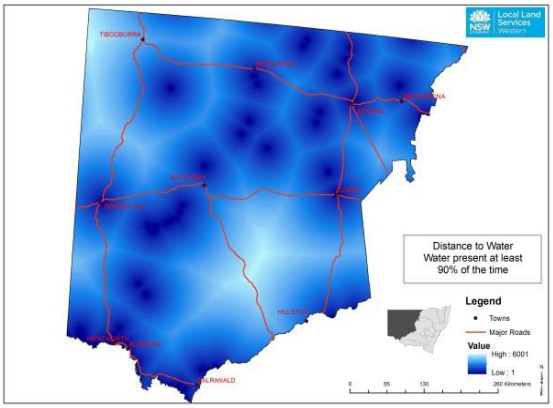


Figure 19: Water present 90 per cent of the time

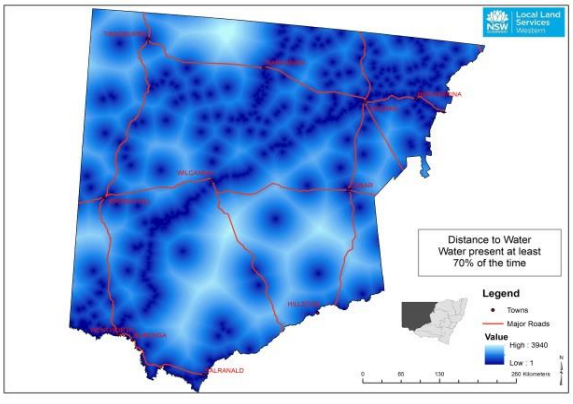


Figure 20: Water present 70 per cent of the time

Table 1 Checklist for Biodiversity adaptation

Biodiversity: Checklist for adaptation
"No Regrets" options capitalising on natural resilience and adaptability
Populations and species
Promote high species level adaptive genetic diversity
Maintain large population sizes of native plants and animals
Reconnecting populations and improving health
Providing corridors and opportunities for connectivity
Ecosystems and communities
Minimise non-climatic stressors and utilisation pressures such as unmanaged grazing and erosion
Promote resilience through diversity
Let nature take its course. If natural systems are adapting adequately to maintain ecosystem processes, intervention may not be needed. Accepting transition to a new structural ecological community type may be an appropriate option
In areas with high pressure to change, key characteristics valued by society can be monitored to identify adaptation decision points.
Landscapes and regions
Minimise new stresses through conservative approaches to ongoing developments. These might include developments for agriculture or other land uses.
Identify, manage and protect refugia
Use Comprehensive, Adequate and Representative (CAR) principles to protect the full range of characteristic Australian environments. This includes attention to maintaining characteristic evolutionary drivers such as soil nutrient levels, marsupial grazing and fire.
Intensive options – where relevant Note: these options may be expensive or risky due to potential adverse outcomes but may be desirable to meet specific goals
Landscapes and regions
Actively facilitate movement of species to projected suitable habitat
Maintain ex situ populations and breeding programs for iconic species
Ecosystems and communities
Use the proximity principle to introduce non-local native species to maintain or restore valued ecosystem services or functions whilst aiming to maintain the evolutionary character of the regional vegetation
Landscapes and regions
Manage fire regimes at site and landscape scales to favour positive biodiversity outcomes. Decision points might include the manageability of wildfire and concerns around loss of ecosystem functions.
Intensively manage natural pressures to help conserve highly valued species or ecological communities. Managing natural pressures, such as natural diseases or competitors, could help target species or communities survive climate stress.

How will Local Land Services Western Region specifically assist with Biodiversity adaptation?

- Prioritise investment using pre-determined Priority Areas for Investment
- Prioritise further investment using Spatial Data sets to identify areas of potential refugia and resilient habitat
- Educate landholders and communities about the risks that climate change poses to biodiversity
- Provide continued support in the management of weeds. Weeds are one of the main threats to biodiversity in Australia and under climate change will become an increasing management challenge.
- Work with Landcare groups and others to encourage monitoring size of populations of native species
- Encourage landholders to preserve and restore habitat for native species as well as nature corridors
- Continued investment in rangelands rehabilitation projects, riparian projects and protection of high conservation areas
- Continued support in the management of pest animals.

Figure 21: Brolgas in western wetlands

Grazing: impacts and adaptation

The climate projections with the most significant implications for grazing enterprises are increasing maximum and minimum temperatures, greater number of hot days, heatwaves and seasonal changes in rainfall. Also significant is the response by plants to rising CO_2 levels in their water use and growth.

As in current conditions, the challenge will be managing for climate variability. However, the changing climate is likely to introduce conditions outside past landholder experiences who will also face the impact of more extreme events such as storms, fire and drought. While landholders have experienced these events, the duration and/or intensity may exceed those previously seen. High intensity storms will also increase soil erosion risk with subsequent loss of water quality in streams and rivers.

A shift in rainfall patterns, shorter growing seasons and greater CO2 availability is likely to affect species balance and is likely to lead to changes in digestibility as a result of accelerated maturation.

Water scarcity is likely to continue under all climate change scenarios. Apart from the obvious impact on pasture, water availability and competitiveness will become an increasing issue for pastoralists in terms of ensuring that the needs of both domestic and native animals are met while controlling the impact of invasive animals on water supplies.

Increased heat stress in livestock may also result in reduced grazing time (animals seeking shade), reduced feed intake, increased body temperature, increased respiration rate, weight loss and implications for reproduction rates.

Table 2 Grazing adaptation options

Grazing: adaptation options for land managers
Groundcover/Pasture
Control of Total Grazing Pressure and maintaining critical levels of groundcover
Monitoring for pasture condition, weeds and other indicators of change. This may include the use of technology like remote sensing of groundcover to improve grazing planning
Regular review of groundcover targets
Improved grazing management, ensuring pastures have periods of rest to promote palatable perennial forage
Conservative approach to stocking rates, focusing on groundcover or utilisation targets rather than a reliance on stock condition parameters
Control of feral herbivores to ensure that total grazing pressure can be managed
Repairing degraded country to help maximise rain -use efficiency and improve groundcover
Human health and safety
Formal recognition of risks involved and actions to reduce them e.g. planning for heat issues
Changing times for carrying out outdoor work, use of shade structures in yards etc.
Using technology such as remote monitoring of water and stock

Grazing: adaptation options for land managers
Animal welfare
Providing more shade for livestock in general and particularly around stockyards
Changing times for shearing and other stock management to promote animal health and comfort
Improving water infrastructure to improve efficiency as well as reduce heat, evaporation and fouling – repairs following failure will become more time critical
Continued assessment of water availability and infrastructure and respond to suit livestock, wildlife and feral management
Productivity
Change best practice management if necessary e.g. modify joining times to suit pasture conditions and avoid hot periods
A structured yearly program of stock management involving joining, weaning, culling and nutrition should be implemented. Joining should be managed so that offspring are born during the season with highest feed availability.
Selective breeding for greater heat tolerance in stock or choosing breeds more appropriate to the changing conditions
Improve understanding of animal nutrition and supplement if necessary
Infrastructure and water
Embrace innovation and conservation in capturing, storing and pumping water
Ensuring robustness of infrastructure to extreme events – the ability to cope with both current and future climate scenarios. This involves both the siting of infrastructure in accordance with land capability and the implementation of erosion prevention measures to protect facilities.
Drought
Be prepared –ensure total grazing pressure is managed to build pasture resilience
Prepare drought management strategies and implement promptly as key dates or trigger points for decision-making are reached

Spatial identification tools for more precise planning and management

Cutting edge developments in geospatial technologies and satellite remote sensing can provide land managers with tools, data and skills to dramatically improve access to property-scale information and knowledge. These capabilities will underpin better management decisions and more measurable improvements in landscape condition, ecosystem sustainability and livestock production. (NRM Spatial Hub)

For Rangelands managers the NRM Spatial Hub brings together the world's latest mapping and imagery technology to provide a simple web based tool for rangeland managers to manager their environment more profitably and sustainably. The hub combines the latest geospatial mapping technologies with time-series satellite remote sensing of ground cover, in a way that's not been available to individual landholders before. This capacity for land condition monitoring will allow for more strategic grazing pressure management and better long-term outcomes for groundcover, the environment and production.

Local Land Services Western Region and other rangelands NRM regions in Australia saw the need for a tool like this to assist rangelands managers and helped to design the scope of the hub. Local Land Services Western Region continues to support the *NRM Spatial Hub* project and is taking a proactive approach to training land managers in the use of this versatile tool for improving land management in the region to help build adaptive capacity.

How will Local Land Services Western Region specifically assist graziers with adaptation to climate change?

Groundcover

- Provide incentives funding to help land managers control total grazing pressure more effectively to increase groundcover and the abundance of native perennial grasses
- Improved training and technical advice for land managers to ensure that they have the best, up-to-date information and resources for improving grazing management, groundcover and maintaining landscape integrity
- Continued funding of rangeland rehabilitation projects to restore landscape-scale surface hydrology and improve groundcover through techniques that reclaim scalded areas and manage erosion.

Livestock

- Provide advice and run workshops such as Tactical Grazing Management (NSW DPI) on stocking rates, strategic spelling and pasture budgeting
- Provide advice, training and workshops on livestock nutrition
- Work with relevant stakeholders to provide advice about changing to more suitable livestock breeds if applicable
- Work with DPI and RSPCA on providing up to date and relevant information on animal welfare
- Provide advice on infrastructure and techniques to understand and reduce risk of heat stress on livestock
- Collaborate with DPI, MLA, AWI and other relevant stakeholders and changes to best practice management
- Encourage innovation and provide information about new and emerging techniques for stock management, water and fencing infrastructure etc.

Water

- Encourage water efficiency and conservation measures
- Encourage investment in increased infrastructure to capture and store water from extreme weather events
- Encourage innovation in water management and monitoring tools
- Encourage investment in new infrastructure that reduces water loss..

Horticulture/Viticulture: impacts and adaptation

As well as a strong pastoral industry, the southern part of the Local Land Services Western Region includes a diverse range of agricultural industries including horticulture, viticulture, and cropping. Climate change projections present both challenges and opportunities for agriculture in the region. Changes to temperature and water availability are likely to affect horticulture and viticulture as well as some day to day farming practices. Some of these changes are outlined below.

Timing of production

Many horticultural crops are sensitive to water availability, temperature and extreme weather events. Consequently planting and harvesting windows for some crops are likely to change. Harvesting of crops such as grapes and citrus may occur up to 10-14 days earlier while increased soil temperatures in spring will allow some crops to be planted earlier. While these may not seem like big changes they are likely to have flow on effects for farm activities such as workforce planning, fertilizer purchase and transport to market.

Figure 22: Viticulture enterprise in the Southern part of the region

Crop yield and quality

Increased heat stress will affect the quantity and quality of many crops, especially for cultivars that are not adapted to higher or more variable temperatures. Out of season, high temperatures may induce bolting in crops while others may abort above certain temperatures. Crops that require chilling for bud development or crop set may be affected by changes to the timing and frequency of frosts.

Declines in crop pollinators or mismatches between crop flowering and pollinators being available may also occur. Reduced water availability and increased salinity will also influence crop quality and yields.

Horticultural inputs

More irrigation water will be required to meet increased evaporation rates and faster plant growth in some crops. As well as increased competition for water resources other changes will include pumps running under hotter temperatures being less efficient and more prone to breakdown and additional summer cooling being required for greenhouses.

Farm related costs such as freight, packaging, pesticides; fertilizer, fossil fuels and labour are also likely to increase.

Pests and diseases

Higher temperatures are likely to increase pest and disease activity and alter the rates at which they grow and develop. Some pests and diseases will also colonise new areas whilst beneficial insects may also be affected.

Post-harvest changes

Increased temperatures may change the look (and possibly taste) of some crops. Poor citrus rind colour associated with higher night temperatures may occur e.g. re-greening of Valencia's during summer will take longer while de-greening may be required for navel oranges in other regions. There may also be new costs associated with grading and marketing of susceptible fruit and vegetables to remove blemished products. Post-harvest cooling costs for many crops will increase as additional field heat will need to be removed prior to transport.

Table 3: Horticulture adaptation options

Horticulture: adaptation options for land managers
Changing to new crop varieties where possible
Monitoring and adjusting planting and harvesting times
Looking for new and innovative ways to use water
Monitoring potential pests and diseases to take action early
Monitor and maintain soil health
Replacing glass greenhouses with controlled environment structures for increased growth periods and better durability
Adjust row direction and width of rows
Use cover-crops to reduce vineyard temperatures
Changes to canopy structure foliage wires
Changes to nutrition and fertiliser programs

How will Local Land Services Western Region specifically assist with adaptation for Horticulture/Viticulture?

Horticulture/Viticulture

- Work with industry to assist farmers with monitoring changes and adjusting to new planting and harvesting times.
- Work with DPI, Research & Development Corporations (RDCs) and industry to identify new risks of pests and diseases and ensure that information is shared quickly and effectively.
- Run innovation workshops to assist farmers understand new opportunities to improve management.
- Investigate transition to more resilient products and varieties of crops more suitable to conditions.

Water management

- Encourage water conservation measures.
- Encourage investment in increased infrastructure to capture and store water from extreme weather events.
- Encourage innovation in water management.
- Encourage investment in new infrastructure that minimises water consumption and reduces water loss.

Cropping: impacts and adaptation

Cropping faces many similar changes identified in the previous section for horticulture and viticulture such as changes to flowering times, reduced soil moisture, increased demand for water and post-harvest changes.

Other issues that cropping may face include:

Planting time and crop management

Higher temperatures may reduce risk of frost allowing earlier planting. This may also increase yields as grain fill is more likely to occur in the cooler months when water stress is lower. The timing of the "autumn break" may change but is unclear at the moment. Crops such as canola and some pulses are sensitive to dry conditions and adjustments to planting and rotation patterns may be required.

Increase CO_2 may reduce the protein content in grain but this can depend on the cultivar being used and the amount of nitrogen available. Increased water stress may also influence protein levels in grain.

Pests and diseases

Many crop pests such as Heliothis moth, armyworms, sucking bugs and diamond-backed moths respond strongly to climate signals. How these pests respond in the future depends on how variable the climate will be.

Crop diseases are also expected to respond similarly. But some positive changes may also occur such as drier winters reducing the severity of diseases such as Take-all. Increased temperatures may also limit the impacts of stripe rust. Some changes are, however, unpredictable. Lower rainfall may reduce the infection of Septoria blotch but higher temperatures may increase infection.

Diseases transported by insects such as aphids (e.g. Barley Yellow Dwarf) may also increase with warmer winter temperatures while higher temperatures are likely to increase pest and disease activity, alter the rate at which these grow and develop and increase their chances of survival. Some pests and disease will also be able to colonise new areas. The beneficial insects that keep some of these pests in check may also be affected by climate change.

Erosion management

An increase in extreme rainfall events may lead to more flooding, erosion and soil loss, especially for readily eroded soils (e.g. solodised soils). This may require increased residue retention, maintaining erosion control infrastructure and adopting or modifying controlled traffic systems.

Salinisation management

Increased high intensity rainfall events may also increase drainage below the root zone – the driver for dryland salinity, especially on lighter-textured soils.

Table 4: Cropping adaptation

Cropping: adaptation options for land managers
Adopting zero-tillage practices – especially if rainfall intensity increases to allow greater infiltration with fewer but heavier events
Developing minimum disturbance techniques
Changing management to effectively capture and store more soil moisture
Monitor planting time optimisation, using wider row spacing, stagger planting times and reduce planting densities
Monitoring and rapidly responding to emerging pests, diseases and weeds
Assessing fertiliser inputs
Erosion control and reducing impacts of extreme weather events

How will Local Land Services Western Region specifically assist croppers with adaptation to climate change?

Cropping

- Work with industry to assist farmers with monitoring changes and adjusting to new planting and harvesting times.
- Work with DPI and industry to identify new risks of pests and diseases and ensure that information is shared quickly and effectively.
- Run innovation workshops to assist farmers understand new opportunities to improve management.
- Investigate transition to more resilient products and varieties of crops more suitable to conditions.
- Exploring conservation farming approaches such as minimum-tillage to minimise soil disturbance and improve water retention.
- Investigate the use of break crops, such as lupins, after cereal cropping to fix nitrogen and improve soil health.

Water management

- Encourage water conservation measures.
- Encourage investment in increased infrastructure to capture and store water from extreme weather events.
- Encourage innovation in water management.
- Encourage investment in new infrastructure that minimises water consumption and reduces water loss.

Figure 23: Irrigated cotton – photo by Kyra Roach

Biosecurity: impacts and adaptation

Biosecurity is a broad term which includes the identification and management of risk posed to the environment, human, animal and plant health and the economy from pests, disease and other matters.

Uncertain climate scenarios add another layer of difficulty in biosecurity management as follows:

- The potential for incubation and transmission of new diseases.
- The potential for introduction and spread of pest species from other regions.
- Higher temperatures may increase the rate of mutation, producing new variants of pathogens.
- Shifts in local climates may favour currently established vectors to extend their range and impact.

Legislation

In 2015 both the Commonwealth and NSW Governments passed new Biosecurity Acts which become operational in 2016 and 2017 respectively. Neither of these acts reference climate change.

Biosecurity management

At differing scales, biosecurity is managed within a continuum of prevention, emergency management, detection, response, recovery and ongoing control of pests and disease.

Prevention requires effective surveillance to prevent entry of new pests and diseases and robust systems to ensure that new incursions or emerging outbreaks are identified, communicated and managed in a timely manner.

Close partnerships between government, industry, education, research institutions and community are required for effective landscape and regional approaches. Adequate resources are needed to support training of land managers and community so that identification of emerging threats and eradication can take place.

Traceability

Product traceability is essential for assurance of food safety and market confidence. Tracing of livestock sale and movements through identification using the National Livestock Identification System (NLIS) ensures that we can follow the potential spread or source of disease across the major livestock industries within a very short timeframe.

Notification

The ability for early identification of suspected pests and diseases relies on good communication systems, well-informed communities, as well as industry and government partnerships.

In addition to automatic notifications arising from standard surveillance and monitoring systems, public notifications of suspected pests and diseases in NSW can be reported through dedicated hotlines and web based notification systems.

Education and engagement

Biosecurity is a shared objective and a shared responsibility across the whole community. It is important that a high level of awareness of biosecurity issues is accompanied by engagement across government, industry, community and individuals to ensure:

- Compliance with best biosecurity practice.
- Cooperative efforts to address biosecurity issues (e.g. reporting suspected weeds or diseases).

Monitoring changes in the biosecurity risk profile

It is expected that current biosecurity challenges will continue and potentially increase under changing climate conditions, with a mix of existing and new biosecurity threats. Changes to existing biosecurity risks will be difficult to predict due to the complexities of ecological processes, interaction's and species' responses in a changing environment.

New pest and disease interactions will occur, which may result in currently innocuous organisms emerging as major threats. The rate of spread of pests, vectors and diseases may also change.

A key tool in managing biosecurity in a changing environment will be robust mechanisms to detect change. This will require resources for coordinated, effective monitoring and reporting systems.

Maintaining and improving current management focusing on system resilience

Maintaining the health of production plants and animals and the resilience and diversity of natural systems reduces their vulnerability to pests and diseases under a range of conditions.

Focus on awareness and communication

A changing climate will increase the need for communication and co-operation across sectors and the integration of operational experience with formal scientific and economic knowledge.

This will need strong partnerships and effective communication with all stakeholders.

How will Local Land Services Western Region specifically assist with adaptation for Biosecurity?

- Monitoring changes in the biosecurity risk profile
- Maintaining and improving current management focusing on system resilience
- Improve awareness and communication
- Continue to strengthen partnerships and collaborative approaches to pest management with:
    - landholders
    - pest management groups
    - government stakeholders; local, state and national
    - industry stakeholders.

Figure 24: Control of foxes and wild dogs is important for biodiversity and production

Emergency Management

Local Land Services plays a crucial role in the delivery of emergency management in NSW.

Working alongside the NSW Department of Primary Industries (NSW DPI) and other agencies, we provide a vital support service in emergencies where agriculture and animals are impacted.

Operating under a joint Emergency Management Strategic Plan, Local Land Services assists NSW DPI across a wide range of emergencies, including natural disasters such as flood, bushfire, drought and biosecurity events involving plants, animals and pest insects such as locust plagues.

Local Land Services Western Region enhance the capacity of all landholders to plan and prepare for, respond to, and recover from biosecurity emergencies and natural disasters.

Figure 25: Local Land Services assist with animals affected by emergencies

Climate change projections indicate that in years to come we can expect more extreme weather events and the potential for increases in biosecurity issues.

Local Land Services Western Region has a role in enhancing the capacity of landholders to plan and prepare for, respond to and recover from biosecurity emergencies and natural disasters. Our local staff are part of local response and we support the coordination of assistance to all animals affected in an emergency. Local Land Services Western Region ensures that staff participate in ongoing emergency management training to enhance their ability to prepare for and respond to biosecurity emergencies and natural disasters.

Climate change mitigation and the carbon economy in the Western Region

Australia's action on climate change mitigation and the carbon economy

In addition to developing strategies for adaptation and resilience, like all other countries Australia has an international obligation to reduce carbon emissions to try and keep global temperature rise this century below 2 degrees Celsius above pre-industrial figures. Australia's 2020 emissions reduction target is to reduce emissions by 5 per cent on 2005 levels. As part of the Paris Agreement in 2015 the Australian Government agreed to a target of reducing national emissions by 2030 to a level 26-28 percent below 2005 emissions.

Reducing emissions means supporting climate mitigation activities.

Climate mitigation activities are aimed at the ***causes*** of climate change and involve preventing or reducing levels of greenhouse gas emissions in order to limit the magnitude or rate of climate change. There are two main ways to achieve mitigation:

Emissions reduction: activities which reduce the actual amount of CO_2, methane or other greenhouse gases going into the atmosphere

Carbon sequestration: capturing carbon from the atmosphere, usually through photosynthesis, and storing it in trees or soils.

Internationally, the need to reduce emissions has led to the development of emissions accounting schemes which puts a price on carbon, or to be more specific on a carbon dioxide equivalent or CO_2e. The CO_2e is a standard international measure used to compare the emissions from various greenhouse gases based upon their global warming potential. For example, the global warming potential of methane (CH_4) over 100 years is 25, and nitrous oxide (N_2O) is 298, times that of carbon dioxide.

In Australia, businesses and land managers can earn money by registering projects and following specific, legislated *methods* which either reducece greenhouse gas emissions or sequester carbon in a measurable way. Each tonne of CO_2e saved or sequestered is worth one *Australian Carbon Credit Unit (ACCU)* which has a financial value and is tradable. Eligible carbon *methods* are being developed over time and cover activities such as:

- upgrading commercial buildings
- improving energy efficiency of industrial facilities and housing
- reducing electricity generator emissions
- capturing landfill gas
- reducing coal mine waste gas
- upgrading vehicles and improving transport logistics
- managing fires in savanna grasslands
- reforestation, revegetation, regeneration and soil carbon
- improving Australia's agricultural soils
- agricultural methods such as reducing greenhouse gas emissions from cattle, pigs and irrigated cotton.

The last three activities on this list are currently the most relevant for farmers and land managers in Western NSW.

Opportunities in the carbon economy for Western Region landholders

Landholders in Australia have the opportunity to diversify their income by reducing emissions or sequestering carbon on their properties in ways which contribute to lowering national greenhouse gas emissions. Carbon abatement activities, sometimes known as carbon farming, involve management change that results in either a reduction in greenhouse gas emissions or capturing and holding (sequestering) carbon in vegetation and soils.

As explained there are two types of mitigation activities; *emissions reduction* or *carbon sequestration* and both offer opportunities for landholders in the Western Region of NSW. Emissions reduction opportunities for land managers mostly focus on opportunities to reduce emissions from livestock. Sequestration projects involve storing carbon in either vegetation or soils and involve an obligation to *maintain that stored carbon for a "permanent" period of either 25 or 100 years.*

Local Land Services Western Region provides information to landholders about relevant carbon methods and provides links to Clean Energy Regulator, Department of Environment and a range of other relevant links on our website. Local Land Services Western Region has also developed some fact sheets to assist landholders make informed decisions about the risks and opportunities of carbon farming. These are:

- Guiding principles for carbon projects (Appendix A)
- Considering a carbon project? (Appendix B)
- Managing a carbon project (Appendix C)

Providing regional guidance on the implementation of carbon projects

To address Principle 1 of the Regional NRM Planning for Climate Change project, Local Land Services Western Region set out to build a strategy for guiding the implementation of carbon sequestration and mitigation activities that would clearly define potential risks and opportunities to regional biodiversity, production systems and social fabric. In order to build an integrated spatial perspective of high risk or priority areas for sequestration activities NSW Office of Environment and Heritage were contracted to map and validate trends in woody cover change across western NSW.

This sub-project determined the extent of and trends in the growth of trees and woody shrubs using a Landsat-trend product modelling the slow-varying, persistent-green foliage in the landscape. The results of this trend product were then verified using aerial photograph interpretation.

One of the major limitations in understanding the relative importance of drivers of woody cover change at a regional scale may be that perspectives arising from short-term, small-scale, local experiments are rarely tested over larger scales and longer time frames. Remote sensing approaches have powerful ecological application that can overcome restrictions in spatial and temporal extents. Landsat is particularly well suited to ecological studies of biophysical and habitat change detection. In this project time series of Landsat TM/ETM+/OLI imagery of Western NSW from 1987 to 2012 was used to derive a linear trend fitted to seasonal estimates of the proportion of persistent green cover at a resolution of 30 metres. Persistent green is assumed to represent the longer-lived, less transient woody, rather than the shorter-lived, ephemeral herbaceous component of vegetation. (Gill, Horn, & Gibson, 2016)

Persistent green cover

Across western NSW, the mapped Landsat trend product indicates several distinct regions of relatively large increases and declines in persistent green cover. A predominant area of large increases was evident around the Cobar Peneplain where relatively high rainfall mulga and bimble box pine communities dominate. Large declines were detected in the central north, dominated by mulga, the central south, dominated by belah communities, and in the south west, dominated by low rainfall mallee. Relatively neutral changes were observed across the far north western corner of the region, dominated by downs country. Greater shrub change relative to tree change occurred at sites with higher total woody cover increase, providing evidence that shrubs are the dominant driver of woody thickening and senescence or clearing of trees is a dominant driver of woody decline. (Gill, Horn, & Gibson, 2016)

NSW Office of Environment & Heritage developed the trend product for Local Land Services Western Region for the purpose of using it as a decision support tool for prioritising areas for carbon sequestration projects. It was designed to be interpreted in conjunction with the woody extent map, local knowledge of land use and vegetation history of the processes influencing the relative change in woody cover at a regional scale. Although Local Land Services Western Region will be using this tool in future strategic planning for the region, whilst it was being developed landholders in the region were already implementing large numbers of carbon sequestration projects.

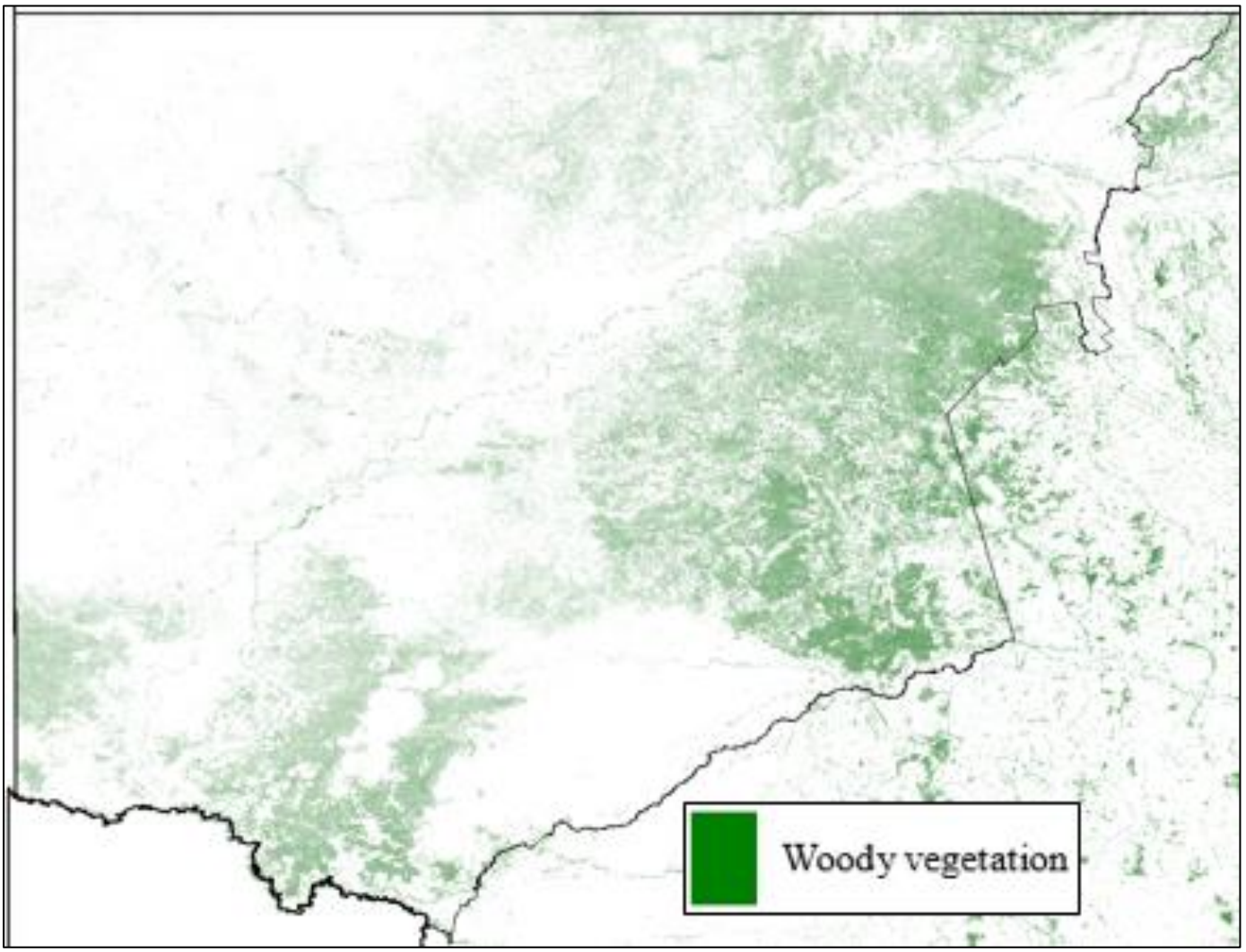


Figure 26: Woody vegetation trends

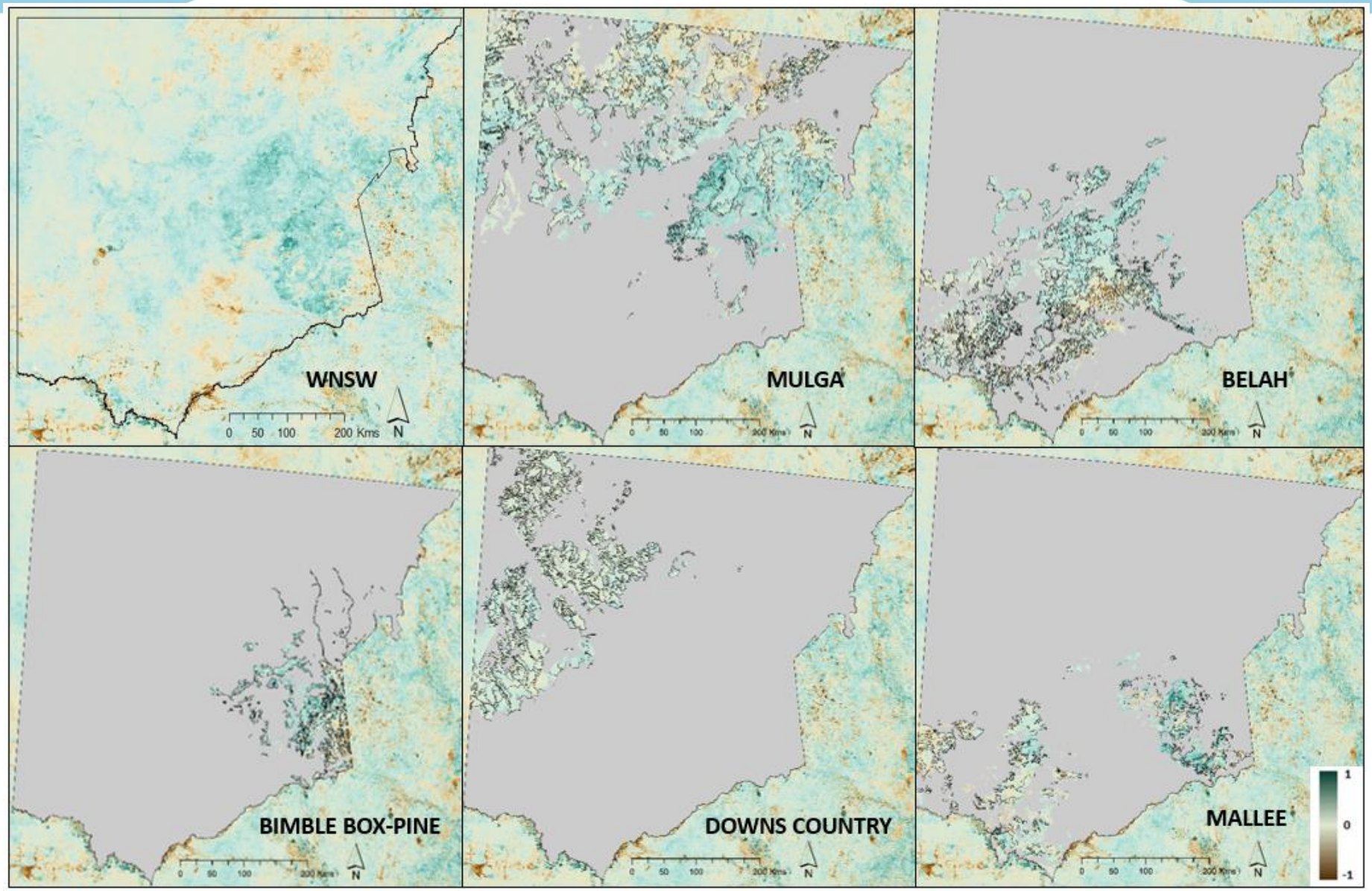


Figure 27: Persistent green trend derived from Landsat time series (1987-2012) across western NSW and the major range types

Carbon sequestration projects in the Western Region

At a time when many others were just trying to understand the opportunities for carbon farming in Australia, landholders in the Local Land Services Western Region were early adopters of carbon sequestration projects and are already significant contributors to Australia's emission reduction targets and climate mitigation.

As of November 2016 there are 120 carbon projects in the Western Region with Australian Government contracts as shown in green and red in Figure 28.

There are a further 46 carbon projects registered with the Clean Energy Regulator which are represented in blue and purple.

All of these projects are vegetation projects where the abatement involves carbon sequestration in trees and shrubs.

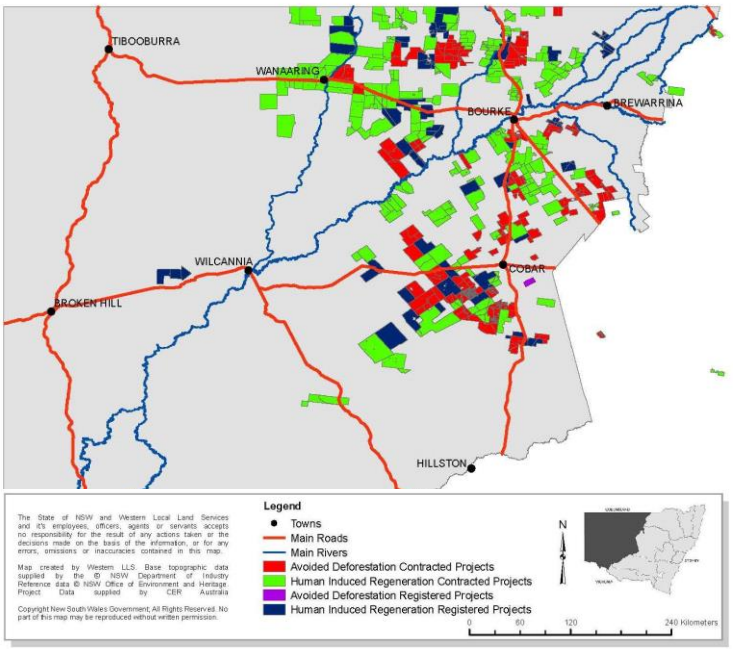


Figure 28: Carbon projects in Western NSW as at Nov, 2016

Carbon projects in Western NSW are registered under the following methods:

Avoided Deforestation. This method protects native forest in areas that would otherwise be cleared under an approval mechanism such as an Invasive Native Species Property Vegetation Plan (PVP) under the *NSW Native Vegetation Act 2003.*

Human-Induced Regeneration. This method, which is currently gaining momentum in the Western Region, involves the removal of pressures (such as grazing) that may have been suppressing the regeneration of native plant communities. The aim of this method is to encourage woody thickening with the intention of "regenerating" a forest. Effectively this method involves changing management to transform open areas into forest.

Both these project types represent a change in land use for pastoral properties in Western NSW and a change of direction from the natural resource management goals that have traditionally been encouraged in this region.

Potential Issues

There are both short-term and long-term issues that may potentially arise through carbon projects under the two methodologies described:

- Short-term issues relating to implementation of management practices that affect biodiversity and landscape function. Some of these issues were investigated through the Invasive Native Scrub Research Program undertaken following the implementation of the *Native Vegetation Act 2003*.
- Long-term issues associated with non-reversible productivity decline and permanence.

A SWOT analysis presented as Tables 5 and 6 addresses some of the strengths, weaknesses, opportunities and threats that carbon farming presents for our region in terms of:

- Biodiversity conservation
- Pastoral production
- Natural resource management and landscape function
- The resilience and sustainability of primary industries
- Regional implications and government policy

Invasive Native Scrub (INS)

The Western Region of NSW is predominantly semi-arid rangelands made up of pastoral properties on Western Lands lease tenure with the main activity being grazing of native pastures. However, rangelands environments in NSW were impacted heavily at the time of early colonial settlement by severe over-grazing from introduced species (mostly sheep) and the removal of traditional Aboriginal land management technique, especially burning.

Since the 1800s widespread thickening and encroachment of woody vegetation by "woody weeds" or Invasive Native Scrub (INS) has been a major issue impacting on both farm viability and the natural environment, affecting large areas of central and western NSW. The encroaching and dense regeneration of native trees and shrubs impacts on farm production, communities and the environment. (Local Land Services Western & Central West, 2014).

Figure 29: Mulga acting invasively

INS competes for resources (i.e. light, water, nutrients) and can reduce or exclude the growth of other plant species, particularly native perennial grasses. Widespread INS reduces habitat diversity and soils in INS sites can be crusted and hard setting. The reduction in groundcover can increase soil erosion and can be made worse when combined with high total grazing pressure.

Most INS species are unpalatable to stock. INS limits pasture production and stock carrying capacity…..Dense INS also harbours feral animals such as foxes, cats and pigs. With poor vehicle access, controlling these pests is more difficult.

However, INS species are native to NSW and provide shade and shelter for livestock, habitat for a wide variety of native plants and animals, and connections for the movement of wildlife across the landscape.

Effective INS management produces mosaic landscapes with native pastures, open woodlands and denser areas for social, environmental and economic benefits. (Local Land Services Western & Central West, 2014)

There is no simple solution for managing INS. It requires a complex approach including a range of actions such as mechanical, chemical and grazing management. To support the management of INS Local Land Services Western Region has worked with land managers in the region to develop Invasive Native Species Property Vegetation Plans (INS PVPs) under the *NSW Native Vegetation Act 2003,* allowing them to clear native vegetation to achieve better outcomes for both biodiversity and production. Providing PVPs, advice and even financial support to land managers to control INS has been a major goal of natural resource management in Western NSW for many years.

A new approach to Invasive Native Scrub

The rapid development of carbon sequestration projects, largely driven by the proactive approach of carbon project developers, represented a complete shift in understanding and managing Invasive Native Scrub (or woody weeds) in Western NSW. Rather than being seen as a problem to be removed, woody weeds now offered land managers a chance to diversify their production and deliver income potential. Vegetation sequestration projects generally have a 100 year "permanence" obligation requiring the land managers to maintain the carbon in that vegetation for a period of 100 years.

Most of the contracts themselves are for ten years meaning that there is an obligation to maintain the carbon in the vegetation for a further 90 years after the last payment has been received. One acknowledgement of this significant change in land use was that project proponents had to obtain an "alteration of conditions of a Western Lands Lease" from Crown Lands.

A new approach to guiding regional carbon projects

With the rapid development of the carbon farming industry in this region, the original approach of this project guiding the best *locations* for implementing carbon projects no longer seemed relevant or appropriate.

Instead Local Land Services Western Region has taken the approach of identifying the *risks* and *opportunities* offered by carbon farming and developed some guiding principles and criteria for vegetation sequestration carbon projects to ensure that they align with the strategic direction of Local Land Services and to promote further collaboration with industry and legislators to ensure an appropriate long term approach to carbon projects in the region.

The project team took a SWOT analysis approach to identify the main risks and opportunities involved in carbon sequestration projects in the Western Region.

Table 5: SWOT analysis of Western Region carbon projects- strengths and weaknesses

	Strengths	Weaknesses
Short term	• Contracted income from over set period of time allows successful proponents to plan ahead, invest in their enterprise and become more financially resilient • Clearing INS is tedious and financially risky. Landholders now have a lower risk option to maintain returns from affected areas • Areas where INS could never viably be treated and are pastorally unproductive provide an income stream. • Region is recognised for a positive contribution to carbon economy and receives some financial flow-on benefits. • Increased income can improve viability and sust ainability of primary industries through: o Adoption of innovation o Improving management o Investment in infrastructure	• Finite number of properties with suitable INS PVPs for Avoided Deforestation projects • Carbon income is not deemed "primary production" income by ATO making tax planning more complex • Human Induced Regeneration projects aren't as lucrative as Avoided Deforestation projects but have similar obligations • Landholders currently applying best practice INS management may be disadvantaged in project development. • Carbon income may be diverted off-property with no benefit to resilience. • Focus on fire suppression may influence groundcover management. Litigation implications for broader fire management.

	Strengths	Weaknesses
Long term	• Areas of INS can support good biodiversity of a certain range of species. However extensive homogenous areas are unfavourable compared to patchy heterogeneous landscapes including grasslands, woodlands and shrublands. • In degraded landscapes on some soil types, INS can improve landscape function and soil health, but not to the extent of established grasslands. There is evidence that INS does contribute significantly to soil carbon. • Potential intergenerational improvement in financial capacity of farming families and retention of people on the land. • The injection of funds into regenerative practices provides the opportunity for a long-term shift in land management and condition.	• Government contracts are a maximum of 10 years but carbon sequestration projects must be maintained for the remainder of the "permanent" period (up to 90 years) • Permanence - could impact on property prices or saleability of property due to maintenance obligations and perceived reduced productive capacity • Avoided Deforestation method detracts from the environmental outcomes sought through the Property Vegetation Plan process • Carbon abatement from Avoided Deforestation projects not effective as INS in project areas may not have been cleared anyway (i.e. no additionality, a risk for Australian Government, not contracted landholders or LLS) • Potential for carbon "leakage" as landholders can use carbon income to clear other areas on their property for production purposes (AG issue). • Reduction of pastoral productive capacity for "permanent" period of project. There is a documented 40 per cent canopy cover threshold above which pastoral production is severely limited. • Decline in soil properties and landscape function on a range of soil types. INS can increase soil acidity and promote runoff. • Decline in biodiversity with loss of landscape patchiness. This results in habitat loss for grassland or open woodland species. • Potential implications for pest and weed management as the project audit and monitoring regime declines over time.

Table 6: SWOT analysis of Western Region carbon projects- strengths and weaknesses

	Opportunities	Threats
Short Term	• Regional economy potentially benefits from carbon income invested in to property development or other goods and services. Flow on effects for a range of service providers. • Landholders relieved of financial stress may be more open to adopting sustainable or regenerative land management practices. • Local Land Services could engage in the carbon economy either as an aggregator or a partner where co-funded projects develop carbon credits. • Soil carbon methods appropriate to rangelands have yet to be developed. Such methods, when implemented, may assist landholders in funding regenerative practices.	• Risk of increased issues associated with absentee landholders (potential that some properties may be purchased simply for carbon potential) • Direct Action policy and reverse auction provides advantages for competing industrial projects. • Carbon brokers have varying trading practices and values. Landholders should investigate: o Responsibly for monitoring/auditing o Management criteria for project areas o Fee structures
Long Term	• National policy is likely to include land-based methods into the future. • International policy is likely to increase opportunities for carbon economy into the future • Alternative methodologies are likely to be developed to suit rangelands (*e.g.* Beef Cattle Herd Management, development of sheep management method)	• Potential for changes in Australian Government policy could impact on viability of carbon farming methods • Contested science of long-term environmental impacts of transforming open areas into "forests" • Risk that some carbon brokers may not be around in the long-term and landholders will be left with the burden of monitoring and auditing expenses • Risk that landholders might abandon leaseholds when properties are no longer viable for pastoralism. • Expectation that compliance for adverse land management issues will fall to State Government. • Long-term project outcomes (forest growth) are vulnerable to bushfire, drought and future climate change.

Carbon farming into the future

Understanding the potential impacts

Carbon farming offers successful project proponents an alternative income stream which can provide landholders with opportunities for improving management and infrastructure on their properties as well as reinvigorating local communities. However there are a range of issues that should be considered as more carbon projects are being registered and implemented on large tracts of the Western Region landscape. These issues include changes to short or medium-term land management outcomes, the effects of permanence and the potential for adverse long-term impacts on production and biodiversity.

Incorporating natural resource management planning

It has been proposed to the Australian Government that the Clean Energy Regulator could amend the carbon projects register to include "NRM Region" and generate automatic notification to organisations like Local Land Services Western Region when sequestration projects are registered in the region. This would provide an opportunity to interact with both landholders and carbon brokers in the development of appropriate projects.

Consistency with regional NRM plans

This process could help ensure that consistency with regional NRM plans is considered more strongly in the future. To some extent, regional plans are developed at an inappropriately large scale to guide property-level management activities and more specific guidelines may be of value to landholders and carbon brokers in order to align outcomes with the strategic intent.

Fact sheets and guiding principles for carbon projects in the Western Region

Local Land Services Western Region has developed the following documents to provide guidance and support for landholders thinking about participating in carbon farming.

- Guiding Principles for carbon projects in the Western Region (Appendix A)
- Considering a carbon sequestration project? (Appendix B)
- Managing your carbon sequestration project (Appendix C).

Figure 30: Native vegetation protected for carbon farming in western New South Wales

Soil Carbon

In addition to the role that vegetation sequestration carbon projects play in Australia's mitigation efforts and the emergence of this industry as an opportunity for enterprise diversification in Western NSW, Local Land Services Western Region recognises the key role that soil carbon plays in the global carbon cycle.

Carbon sequestration in soils represents great potential for land managers across the world to play a part in climate change mitigation, although the development of appropriate methods for accounting for soil carbon remains a challenge.

Soil carbon sequestration methods that are currently eligible for carbon trading in Australia rely on intensive measurement regimes. These methods are not viable in rangeland situations as the extensive spatial scales and associated variation in soil types renders the density of measurement impractical and uneconomic.

There is, however, potential for farmers in the southern part of the region to enter the carbon economy using a soil carbon modelled method for management change from cropping to grazing. In order to ensure that landholders are aware of all appropriate opportunities, Local Land Services Western Region regularly shares information about developments and opportunities for land managers in the carbon economy.

For rangelands pastoralists, increasing soil carbon goes hand in hand with improving ground cover (or pasture) which has a win-win-win outcome in that it will improve traditional forms of production (i.e. grazing) as well as having positive environmental outcomes for carbon sequestration and biodiversity.

Local Land Services Western Region is committed to working with key stakeholders, including NSW Department of Primary Industries, to investigate the potential for developing rangelands soil carbon projects which may involve the use of modelling and remote sensing of groundcover.

Local Land Services Western Region is currently collaborating on a project with NSW Department of Primary Industries and NSW Office of Environment & Heritage to:

- investigate the carbon carrying capacity of rangelands soils
- determine the risks for soil carbon loss and redistribution through erosion
- investigate the influence of climate extremes on carbon carrying capacity
- investigate the potential for using remote sensed date to determine the loss of soil carbon
- assess the potential of whole farm approaches to climate mitigation in rangelands environments
- understand the trade-offs and synergies between carbon farming and resilience including:
- understanding the impacts on biodiversity
- understanding the impacts on farm and regional economies
- assessing resilience, adaptation pathways and potential for transformation with changes in land use

Please see Appendix E (copy of project flyer) for further information about this collaborative project.

Emission avoidance methods

In addition to opportunities for carbon sequestration projects, there are a range of *emissions avoidance* methods which involve destroying, reducing or avoiding emissions.

These methods involve activities that actually *reduce* the number of greenhouse gases entering the atmosphere and there is *no permanence obligation.* ACCUs are earned for each event where emissions are avoided. Methods most relevant to land managers currently involve changing fertiliser use; herd management to reduce emissions; destruction of methane generated from manure and; feeding nitrates to livestock.

There are currently no livestock methods for sheep, the main regional focus of grazing in Western NSW, but Local Land Services Western Region is part of a technical working group to help guide the development of appropriate sheep methods that may increase opportunities for regional participation in the carbon economy.

Control of unmanaged grazing animals

Pest animals are controlled for a variety of reasons which include impact on native ecosystems and production systems and the potential to carry disease to native fauna, domestic animals and humans. However, pest animal control can also assist in the mitigation of climate change. The impact of invasive herbivores such as goats, pigs and camels on greenhouse gas emissions has so far attracted little attention but there is some potential for using pest animal control to contribute to national emissions reductions.

Firstly, a significant reduction in goat (and other pest animal) populations would reduce emissions of methane, a potent greenhouse gas (although quantifying these emissions would require further scientific investigation).

Secondly the increased carbon sequestration potential of native vegetation through reduced browsing from unmanaged goats (and other pest herbivores) would contribute to emissions reduction as well as having the co-benefits of protecting the value of agriculture, reducing impacts on native species and reducing disease transmission.

There are no current methods to account for the carbon abatement potential of reducing the impact of unmanaged grazing animals but it is worthy of further scientific investigation.

The carbon economy is an emerging industry and new methods are being developed all the time.

Local Land Services Western Region supports landholders to undertake activities that have positive outcomes for the landscape and long term productivity, and help them understand and navigate both the ***opportunities and the risks*** involved in carbon projects.

We are working with the Australian Government, NSW Department of Primary Industries and regional carbon project developers to help ensure the best long term outcomes for the environment, communities and agricultural sustainability.

Conclusion

The climate of Australia and the Local Land Services Western Region has already changed and is projected to face further changes in the coming decades. Higher temperatures, longer heatwaves, less predictable rainfall and increased risk of drought are some of the impacts that will change our landscape and the people, plants and animals that are connected to it.

These changes will impact on the environment and the way that we conduct agriculture in the Western Region of NSW. To successfully adapt to these changes it is crucial for land managers to be equipped with the best information and tools available.

Local Land Services Western Region has a key role in providing the necessary information and tools. The organisation is committed to working with regional communities and land managers to help them face the challenges of climate change and variability by working to understand the impacts of climate change and reduce vulnerability to them and strengthen the resilience of our people, agriculture, economy and environment.

In addition to supporting regional agriculture, communities and land managers Local Land Services Western Region has a key role to play in assisting regional biodiversity cope with a changing climate. By focusing on existing priority areas for investment as well as using newly developed spatial identification tools to help develop new priority areas for investment, Local Land Services Western Region is taking an adaptive and strategic approach to managing for long term biodiversity outcomes.

Adaptation strategies for climate change preparation are iterative by nature as they must change and adapt as situations evolve, and as different approaches are tried and tested. Local Land Services Western Region will take the approach of focusing on reducing vulnerability and building the capacity and resilience of communities and land managers through education, program support, updating investment priorities and building collaboration approaches across industry and other sectors.

Local Land Services Western Region is also committed to working with all levels of government, industry and communities to continue strengthening the viability of the emerging carbon farming industry in the region, ensuring that projects are robust, regionally appropriate and designed to achieve good long term outcomes for both production and the environment through climate change mitigation.

Figure 31: Wild flowers in the Western Region

Glossary of terms

ACCU **Australian Carbon Credit Unit**	A carbon credit is a generic term for any tradable certificate representing one tonne of carbon dioxide equivalent (tCO2-e) abatement. An ACCU is an Australian carbon credit.
Adaptation	Adaptation means taking appropriate action to prevent or minimise the damage of climate change impacts and/or take advantage of opportunities that may arise. Examples of adaptation measures include: using scarce resources more efficiently; adapting building codes to future climate conditions and extreme weather events; developing drought-tolerant crops; choosing species that are less vulnerable.
Atmosphere	The gaseous envelope surrounding the Earth.
Carbon abatement	The means to reduce or offset greenhouse gas emissions
Carbon dioxide (CO2)	A naturally occurring gas, also a by-product of burning fossil fuels from fossil carbon deposits such as oil, gas and coil, of burning biomass, of land use changes and industrial processes. Carbon dioxide is the principle anthropogenic greenhouse gas that affects the Earth's radiative balance.
Carbon dioxide equivalent or CO2e	A measure used to compare the emissions from various greenhouse gases based upon their global warming potential
Climate	The average weather experienced at a site over a period of many years. The relevant measured quantities are most often surface variables such as temperature, rainfall and wind.
Climate change	A change in the state of the climate that can be identified by changes in the mean and/or variability of its properties and that persists for an extended period of time, typically decades or longer.
Climate change impacts	How climate change will affect us
Climate models	Climate models are based on established laws of physics and are rigorously tested for their ability to reproduce past climate. These projections draw on the full breadth of available data and peer-reviewed literature to provide a robust assessment of the potential future climate including temperature, rainfall, evapotranspiration and mean sea level.
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used.
Climate scenario	A plausible representation of the future climate, based on an internally consistent set of climatological relationships
Climate variability	Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes etc) of the climate beyond that of individual weather events.
Confidence	The validity of a finding based on the type, amount, quality, and consistency of evidence

	and on the degree of agreement
Emissions scenario	A plausible representation of the future development of emissions of substances that are potentially radiatiavely active (eg greenhouse gases, aerosols) based on a coherent and internally consistent set of assumptions
Extreme weather	An event that is rare at a particular place and time of year.
Fire weather	Weather conditions conducive to triggering and sustaining wild fires
Greenhouse gas	Greenhouse gases are gases that contribute to the greenhouse effect by absorbing infrared radiation. Carbon dioxide, methane and nitrous oxides are examples of greenhouse gases
Mitigation	With respect to climate change, mitigation refers to efforts to reduce or prevent emission of greenhouse gases. Mitigation can involve improving energy efficiency, renewable energy or abating emissions by sequestering carbon.
Refugia	An area in which a population of organisms can survive through a period of unfavourable conditions. A habitat that species are able to retreat to, persist in, and expand from under climate change.

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Appendices

Appendix A: Guiding principles for carbon projects in the Western Region

Appendix B: Considering a carbon project?

Appendix C: Managing a carbon project

Appendix D: Nationally Important Wetlands in NSW

Appendix E: Carbon Farming – Opportunities and impacts (collaborative project with NSW Department of Industry)

Appendix F: Final Report NSW OEH Western Refugua and Trend Product