Grazing and Climate Change in the East Coast Cluster: Impacts & Opportunities

Briefing Note #1: A resource document for exploring adaptation options within the grazing industry

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Key messages

- **Grazing industry bodies are aware of the major challenges and risks they face** with managing climate variability, disaster management, emissions reduction and rising input costs. A major industry focus at present is improving enterprise level risk management, disaster preparedness and encouraging greater efficiencies to build the resilience of grazing businesses.
- Over the next two to three decades, **changes to rainfall patterns** are likely to be masked by natural variability in the Cluster regions. However, rainfall may occur in less frequent, **higher intensity storm events** that can erode soils of farms but also increase the contribution to downstream water quality impacts on the environment.
- Due to expected changes in rainfall and temperature in coming decades, **land suitable for grazing** in the northern regions **is predicted to contract and shift**, generally from the northwest towards a southern and central-eastern direction. However, western areas of the Burnett may become more suitable due to opportunities for growing fodder. In the North Coast LLS region, areas suitable for grazing are predicted to increase in the northern, and decrease in the southern end of the region.
- There are **significant opportunities for carbon farming**, however these benefits may not be realised for some time. Bigger opportunities exist at the landscape scale rather than individual property level, suggesting cooperation and coordination amongst neighbouring properties to set-aside areas suitable for sequestration would be beneficial. These areas could be linked with landscape level biodiversity management.
- Industry investment in training and **property-level planning to encourage best practice, maintain natural resource condition and improve disaster preparedness** is a key area for cooperation with regional NRM/LLS groups. However, adaptive capacity of the industry will also be enhanced by encouraging better networks between enterprises to help manage spatial and temporal variability through, for example, more flexible agistment networks.

Background

The focus of this briefing note is to assist regional Natural Resource Management (NRM) and Local Land Services (LLS) groups within the East Coast Cluster to plan future engagement with grazing industry stakeholders on issues related to climate change. The grazing resource base is highly sensitive to climate changes making the grazing industry vulnerable to climate changes. However, the industry need not be negatively impacted if well prepared. Preparing for climate change adaptation sooner than later is important, and may mean that any opportunities associated with the future prosperity of the industry will be better secured.

This briefing note reports on climate change vulnerability and adaptation opportunities for the grazing industry within the six NRM/LLS regions of the East Coast Cluster (Figure 1).

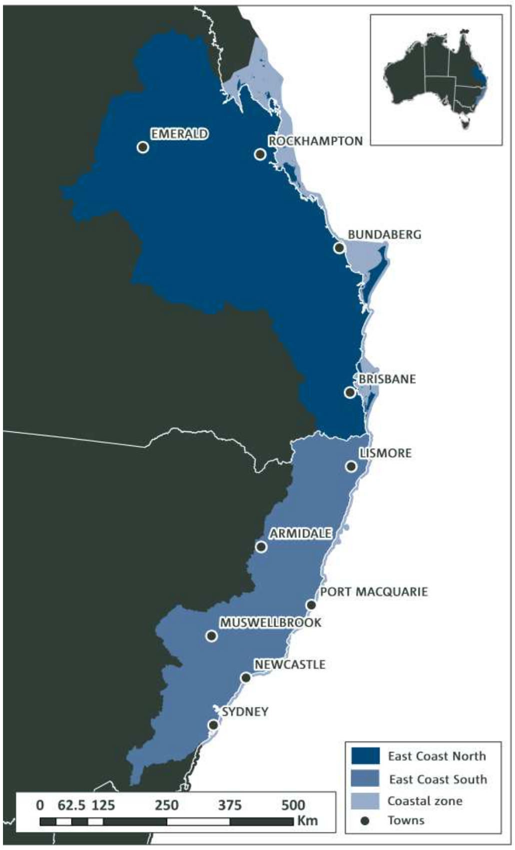

Figure 1. Map of the East Coast Cluster (Dowdy et al. 2015)

These regions include from north to south, the Queensland NRM regions of Fitzroy Basin, Burnett-Mary, and South East Queensland (SEQ)(also referred to as East Coast North), and the New South Wales LLS regions of North Coast, Hunter and Greater Sydney (East Coast South). The briefing note is structured using a series of headings and sub-headings that reflect the main parts of an *integrated vulnerability assessment framework*, e.g. exposure, ecological/biophysical impacts, socio-economic impacts, and adaptive capacity. This framework has been developed specifically to help think about sector-based adaptation to climate change in resource dependant industries, and has been adapted to suit the writing of this briefing note (Marshall et al., 2013). The briefing note also summarises grazing industry policy perspectives and outlines a suite of adaptation responses where opportunities for cooperation between industry and NRM groups on shared priorities exist for reducing vulnerability to climate change. Detailed scientific data used in this analysis were commissioned by the Australian Government's Department of Environment and can be accessed through the references listed in the final section.

A brief overview of the industry in the face of climate change

The grazing industry in the East Coast Cluster represents a significant proportion of both land use and livelihoods within the region. Grazing commodities include cattle/calves slaughterings and disposals, sheep/lamb slaughterings and disposals, milk and wool (Smith et al., 2014). The East Coast Cluster contains 20% of all Australian cattle, signifying some 5.7M head (ABS, 2011).

The Fitzroy Basin has nearly 3M head of cattle and is the top cattle region in the country. In 2012-13, the total gross value of production of the grazing industry in the East Coast Cluster was just over $2.1B (Table 1). In the same years, the grazing industry contributed 67% of the gross value of agricultural commodities in the Fitzroy Basin, 49% in Hunter-Central Rivers, and 46% in Northern Rivers (ABS, 2014). The industry employs around 20,000 people in the East Coast Cluster. This represents 85%, 56% and 56% respectively of the agricultural workforce within the Fitzroy, Hunter-Central Rivers and Northern Rivers regions (ABS, 2011). These figures emphasise the important role that the cattle industry plays in the East Coast Cluster and the extent to which the region is dependent on the industry.

The region also hosts 1.7M sheep, representing 2% of the sheep in Australia, and a large number of goats. New South Wales is the largest producer of goats in Australia and whilst Australia produces less than 2M goats per year, it is the world's largest exporter of goat meat.

Table 1: Percentage of persons employed and total gross value of agricultural commodities produced (VACP) in the grazing (including dairy) industry

	No. employed(a)	% of persons employed in Ag.(a)	Gross VACP ($m)(b)	% of total gross VACP (b)
Fitzroy	4,487	85%	820.7	67%
Burnett-Mary	3,145	41%	329.8	30%
SEQ	3,214	31%	218.3	18%
Northern Rivers	4,934	56%	383.2	46%
Hunter-Central Rivers	2,923	56%	302.8	49%
Hawkesbury-Nepean	1,335	26%	84.2	11%
Total	20,038		2,139.0	

Source: Table adapted from Smith et al 2014 (a) Census of Population & Housing (ABS, 2011); (b) Value of Agricultural Commodities Produced, Australia, 2012-13 (ABS, 2014)

The cattle industry represents the highest value of production for any primary production industry within the region, even though the northern beef industry was recently described as in a "very unprofitable and unsustainable state" (McLean et al., 2014). Such a state has been attributed to increases in land values (that have encouraged debt), doubling of debt levels, below-average rainfall, increases in the cost of production, and increases in finance ratios such that 20% of all income is paid out in interest and finance costs. The trend among producers across the region is described as in "stagnation" due to only small increases in productivity coming at ever increasing cost. Critically, whilst the top 20% of businesses consistently record higher returns, their level of profit has declined over the past five years (McLean et al., 2014). Against this backdrop, climate change presents a very real threat to the viability of grazing within the cluster region.

In the next sections we explore how climate change threatens the natural resource-base upon which the industry is dependent, the ecological and social impacts that may be experienced if left unchecked, and the opportunities available to the industry to improve their chances of adapting to climate change.

Industry perspectives on the challenge ahead

Understanding how the grazing industry sees and describes the challenges it faces with managing climate variability and extreme weather events is crucial to designing appropriate and effective responses from an NRM perspective. Of course, it needs to be recognised that graziers already operate in a highly variable climate with many having well developed strategies to manage climate variability and extreme weather events. Nonetheless, a review of recent industry policies and submissions (2009-2014) highlights six important themes or challenges, which are described below.

(i) An increasingly variable climate

Managing climate variability and the impacts of extreme events such as drought and flood are priority issues for the grazing industry. Industry organisations recognise that managing for seasonal and climate variability is an ongoing and increasingly challenging problem. For example, they see that the scale of impacts from extreme events is occurring at "a speed never before seen in the history of this sector and may indeed be at the door of current practice" (AgForce Queensland, 2009, p.1). Descriptions of very recent drought events in Queensland in 2013 were also characterised as a "rapid decline in weather with many areas slipping back into drought conditions" (AgForce Queensland, 2014a). While there is an acceptance that drought is inevitable there is also a tendency to discuss drought as stemming from "unfavourable and unseasonable climatic conditions."

(ii) Physical and ecological impacts on farms

Recently revised disaster recovery guidelines for producers identify a range of physical and ecological impacts associated with major flood events (and other natural disasters) on land and natural resource condition. These impacts include deterioration of pasture condition and composition; weed seed introduction by floodwaters or regrowth; scouring; silt deposition; sheet erosion; land slippage; drainage channel damage; reduced access for machinery. Deterioration in pasture condition or composition results directly in reduced carrying capacity (AgForce Queensland, 2014b).

(iii) Linking social and ecological vulnerabilities

Industry policies clearly acknowledge the relationships between the ecological impacts of climate variability, extreme events and the human adaptive capacity. Policies highlight the negative effects of a string of events, with small intervening recovery periods between them:

> The quick deterioration of native pastures in grazing areas and the declining potential for crop yields in farming areas means there has been little opportunity for producers to recover, let alone put preparedness measures in place (AgForce Queensland, 2014a).

Policies also highlight the social impact of drought on farming families, businesses and communities:

> Drought brings a range of challenges in the areas of enterprise productivity, financial management, and community and interpersonal relationships. These will change depending on whether preparing for, enduring or recovering from a drought event (AgForce Queensland, 2014a).

(iv) Balancing preparedness and recovery

A shift in drought and disaster-related policies from a 'recovery' to a 'preparedness' focus is seen to be likely and even preferable. However, the industry emphasises the importance of making this shift at a time when "the existing 'condition' of the industry and capacity of producers to cope with changes to financial assistance measures" is appropriate:

> A policy framework which includes 'preparedness' is part of the future of national drought policy – but any talk of drought reform must be held in the context of prevailing seasonal conditions and on the premise that agriculture has had time to recover from the previous drought…. balance encouraging risk management, preparedness and building of individual enterprise and industry resilience, with the delivery of appropriate assistance during long or severe droughts that are beyond a reasonable capacity of producers to prepare for (AgForce Queensland, 2014a).

Even with this shift, it will be necessary to "[provide] the sector with the support that is, from time to time, required" (AgForce Queensland, 2009, p.2).

(v) Addressing variability in a broader landscape context

Industry submissions stress the importance of planning for extreme events and increasing variability as part of a broader strategy of improving "landscape resilience". This strategy involves attempting to reduce other pressures such as competition between conflicting land uses that might remove agriculturally productive land from the market (AgForce Queensland, 2009).

(vi) Progress on mitigation but adaptation advice lacking

The industry recognises the likely benefits that would accrue from government investment in research and development into livestock emissions, soil carbon sequestration and nitrous oxide retention – as mitigation focused information. However, an equivalent investment in adaptation-related research is seen to be lacking:

> AgForce sees that it is imperative that these [adaptation] principles are taken into account in any further works programs surrounding the sector and climate change (AgForce Queensland, 2009, p.2)

From the above we can see that the grazing industry clearly recognises the imperative to manage variability and the impacts of extreme events on the natural resource base and on the social and economic well-being of producers. Moreover, there is an identified need to support improved preparedness; manage impacts holistically at landscape level; and seek more guidance on adaptation. Industry perspectives on appropriate and suitable adaptation responses are reported in the final section of this paper.

Exposure

This section provides a summary of future climate projections for the East Coast Cluster region based on the CMIP5 model, which also underpins the Fifth Assessment Report of the IPCC. A set of four scenarios, also referred to as Representative Concentration Pathways (RCPs), has been produced which represent the full range of plausible future emission scenarios. This briefing note focuses on the **high** scenario (in terms of future carbon emissions – RCP8.5) and the **moderate** scenario (intermediate scenario resulting from moderate emissions reduction - RCP4.5).

Due to the large climate diversity of the East Coast Cluster region, projections are presented individually for the Queensland and the New South Wales parts of the region, namely: **East Coast North** (comprising Fitzroy, Burnett Mary and SEQ), and **East Coast South** (comprising North Coast, Hunter and Greater Sydney) (Dowdy et al., 2015).

Current climate for the East Coast Cluster

The East Coast Cluster region spans a large range of latitude and altitude, resulting in a diverse range of climatic conditions. Its climate is predominantly subtropical, with regional variations such as tropical influences in the north and temperate influences in the south. Since the close proximity to the ocean has a moderating influence on temperatures, the East Coast Cluster generally experiences fewer hot days than locations elsewhere in Australia at similar latitudes. Overall, the **East Coast North** region exhibits a clear seasonal variation in temperature with daily mean temperatures ranging from about 26°C degrees in summer to about 15°C in winter (Figure 2). In the **East Coast South** region temperatures are somewhat lower, with daily mean temperatures ranging from about 22°C in summer to about 10°C in winter. The annual average temperature is 21.3°C for **East Coast North** and 16.4°C for **East Coast South** (Dowdy et al., 2015).

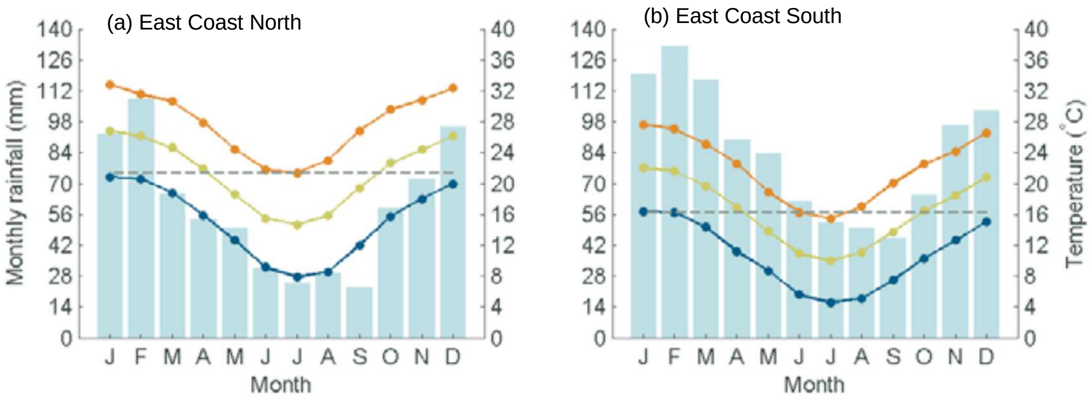

Figure 2. Seasonal rainfall (blue bars) and temperature characteristics for the East Coast Cluster North (a) and South (b) (1986-2005). Monthly mean temperature (green line), monthly mean maximum temperature (orange line), monthly mean minimum temperature (blue line), and annual average of mean temperature (grey line). Temperature and rainfall data are from the Australian Water Availability Project (AWAP) (Dowdy et al., 2015).

The seasonal rainfall characteristics in the East Coast Cluster are determined by a complex series of rain-bearing weather systems that occur in this region (i.e. trade winds, easterly trough, tropical cyclones, fronts and low-pressure systems, changes in sea surface temperatures). There is a clear variation in rainfall throughout the year in both the **East Coast North** and the **East Coast South** regions.

In both regions, February is the wettest month, followed by a dry period during the cooler months (June to September). However, in contrast to the **East Coast South** region, the **East Coast North** region has a more pronounced difference between the wet and the dry months of the year, relating to stronger tropical influences. Across the region, there is a spatial gradient in rainfall, where locations near the coast generally experience more rainfall than locations further inland (Dowdy et al., 2015).

Climate futures for the East Coast Cluster

Overall, the East Coast Cluster region is projected to continue to warm throughout the 21st century. Mean surface air temperature between 1910 and 2013 has already increased by about 1°C in the **East Coast North** and by about 0.8°C in the **East Coast South**. For the near future (2030) the mean warming is around 0.4 to 1.3°C above the climate of 1986-2005, with only minor differences between the model scenarios (RCPs) (Table 2). For the far future (2090) the mean warming is 1.3 to 2.5°C for the moderate scenario (RCP4.5) and 2.7 to 4.7°C for the high scenario (RCP8.5). There will also be changes to temperature extremes, including a substantial increase in temperature of the hottest days, a greater frequency of hot days, and a substantial decrease in frost frequency (Dowdy et al., 2015).

Table 2. Projected temperature change (°C). Compared to 1986-2005. For 20-Year Periods (centred on 2030 and 2090) and three RCPs. The median projection across the models is shown. With the 10th to 90th percentile range of model results in brackets.

	RCP2.6 Low emissions	RCP4.5 Intermediate emissions	RCP8.5 High emissions
2030	0.8 (0.4 to 1.1)	0.9 (0.6 to 1.2)	1.0 (0.6 to 1.3)
2090	0.9 (0.5 to 1.5)	1.9 (1.3 to 2.5)	3.7 (2.7 to 4.7)

Source: Adapted from Dowdy et al., 2015

Projections of rainfall changes are less clear than temperature changes for the East Coast Cluster. Overall, annual rainfall has not shown any long-term trend during the 20th century, but has demonstrated intermittent periods of wetter and drier conditions. In the **East Coast North** region, models show a range of results under both moderate (RCP4.5) and high (RCP8.5) emission scenarios in the far future (2090). Generally, models show either little change or slight decreases of rainfall, particularly in winter and spring. In the **East Coast South** region, models project a decrease in winter rainfall in the far future under both scenarios. A range of changes is projected in the other seasons, with a tendency for increase in summer rainfall. However, uncertainty over driving processes and some inconsistent results from downscaling mean that the direction of change cannot be reliably projected. With such contrasting model simulations, it is important to consider the risk of both a drier and wetter climate in any planning activities for which future rainfall plays a central role (including grazing) (Dowdy et al., 2015).

Importantly, many of the earliest and most significant impacts of a changing climate are likely to be experienced as changes in extreme weather events rather than changes to the mean climate. For instance, whilst the projection for mean rainfall is tending towards a decrease in the East Coast Cluster region, the intensity of heavy rainfall events is projected to increase, causing flooding impacts. Projected changes to drought share much of the uncertainty of mean rainfall change, and there is no clear indication on changes to drought condition. Under the high emissions scenario (RCP8.5) there is evidence which indicates an increase in the proportion of time spent in drought towards the end of this century. However, the picture is less clear for the moderate emissions scenario (RCP4.5) (Dowdy et al., 2015).

Ecological and biophysical impacts

Grazing distribution models were utilised to predict the probability of an area being suitable for grazing in the future. Two potential future climate scenarios (or Global Climate Models (GCMs)) were developed, representing (i) a 'worst case' warmer and drier future, and (ii) a 'best case' wetter and cooler future. According to the distribution models, 'average annual temperature' is the most important predictor for the future suitability of grazing in all six NRM regions of the East Coast Cluster, whilst 'average summer rainfall' is the second most important variable (Hosking et al., 2014a, b, c, d, e, f). Both of these climate variables act as indicators for the growing period.

Climate change will impact the suitability of grazing in the East Coast Cluster regions to varying degrees. In the northern NRM regions of the Cluster, grazing is predicted to contract and shift, generally from the northwest towards a southern and central-eastern direction (Hosking et al., 2014a, c). An exception to this pattern is the suitability of future grazing land in the Burnett Mary NRM region. Here, areas suitable for grazing are predicted to contract in the east and become more suitable in a westward direction. This indicates that a slight warming in the western Burnett Mary NRM region is favourable for grazing due to factors such as improved conditions for growing fodder. In the wetter-cooler GCM, predicted increases in average summer rainfall also lead to more favourable grazing conditions in the western Burnett Mary NRM region (Hosking et al., 2014b).

Another factor to influence the future area and location of grazing is the influence of climate change on areas currently cropped, typically under dry-land grain and oil seed production. A warmer and drier climate will lead to a contraction of the area devoted to grain growing, which generally will shift to grazing. In the Burnett Mary and Fitzroy NRM regions there is currently over one million hectares devoted to grain and oil seed production (ABS, 2013), which is likely to decline under a hotter and drier climate.

In the southern NRM/LLS regions of the East Coast Cluster, grazing is predicted to contract in some areas whilst becoming more suitable in others. For example, in the North Coast LLS region, areas suitable for grazing are predicted to increase in the northern end and decrease in the southern end of the region under both GCMs (Hosking et al. 2014d). In summary, modelling undertaken within each of the NRM/LLS regions of the East Coast Cluster shows the following results:

- In the Fitzroy Basin NRM region, grazing suitability is predicted to shift and contract south and east (Hosking et al. 2014a).

- In the Burnett Mary NRM region, areas suitable for grazing are predicted to contract in the east, and, in the wetter-cooler GCM, expand in the west (Hosking et al. 2014b).
- In the SEQ NRM region, grazing is predicted to contract in suitability from northwest SEQ and shift towards southern and central SEQ, particularly under the warmer-drier GCM (Hosking et al. 2014c).
- In the North Coast LLS region, areas suitable for grazing are predicted to increase in the northern end and decrease in the southern end of the region under both GCMs. There is less overall impact of climate change on grazing land suitability (in comparison to cropping and horticulture), probably due to the widespread distribution of this activity (Hosking et al. 2014d).
- In the Hunter LLS region, grazing is predicted to contract in the west, but suitability of land increases in some eastern regions. There is less impact of climate change on grazing under the wetter-cooler GCM (Hosking et al. 2014e).
- In the Greater Sydney LLS region, grazing is predicted to shift and contract, predominantly to south west regions, but remains patchily suitable in some other areas (Hosking et al. 2014e).

As well as altering grazing suitability, climate change is expected to shift the distribution of climates suited to native plants and animals. Modelling of biodiversity under future climate suggests substantial pressure for ecological change, even by 2050 (Williams et al., 2014). Pressure on native biota from altered climate in the East Coast Cluster is expected to be particularly high in the Fitzroy NRM region and the Greater Sydney LLS region, but all regions can expect significant impetus for biodiversity change. However, this potential for climate-derived impetus for change may not result in whole-scale ecological turn-over. We have limited understanding of the capacity of native species to adapt to change, or of the functional interactions with other organisms that determine where species are able to live within their broader environmental tolerances. For this reason, we suggest that it is still sensible to firstly consider species native to a particular site when deciding the aim for ecological restoration and what species to plant for environmental planting.

The extent to which pressure for biodiversity change might impact ecosystem services such as carbon storage is also difficult to predict. There is growing evidence that carbon stocks in native forests are threatened in many regions by changing climate, particularly through extreme events such as hotter droughts (Allen et al., 2010). There is also significant potential for economic benefit from activities to increase carbon storage in grazing lands (Butler and Halford, 2014).

Socio-economic impacts

Climate change is likely to have a profound impact upon the social and cultural lives of graziers and grazing industries of the East Coast Cluster region. The most significant changes are likely to be associated with extreme events in which the condition (quality or quantity) of the natural resource is affected and grass productivity is lowered. Other impacts may be associated with secondary impacts through economic volatility, increasing costs and increased problems associated with pests and weeds, disease and fire risk (Marshall et al., 2014).

Large changes in resource condition threaten the viability of grazing businesses. Because of the dependency that graziers have on the natural resource base, impacts are likely to include psychological impacts, family impacts, cultural impacts and economic impacts. Unemployment and rural decline are likely community impacts. Some economic opportunities as a result of changes in resource condition or employment in repairing the region may also be experienced (Marshall et al., 2014).

Psychological impacts are likely to be associated with extreme changes in resource condition that negatively affect the productivity of the land. Graziers that are unable to adapt to the impacts of these changes and whose enterprises become unviable will need to consider an alternative occupation. However, the occupational identity that can be created around primary production can be so significant that many graziers will be unable to consider another occupation, and mental health issues will likely become apparent. In extreme cases mental health issues may result in elevated suicide rates and occurrences of domestic violence (Berry et al., 2011; Marshall et al., 2014).

Family impacts are likely to be associated with changes in resource condition that decrease the economic viability of the land, making the grazing enterprise a less enticing option for younger family members and women. Unemployment within rural regions may result from changes affecting the productivity and viability of primary industries. Employment opportunities that do exist are likely to be more easily secured by non-graziers, since graziers typically have fewer transferrable skill sets. Cultural impacts are likely to develop in the region as a result of climate change through a shift in the nature and size of primary production enterprises. The tendency will be to move from lifestyle-based enterprises towards larger and more integrated, corporate-style production enterprises (Marshall et al., 2014). Economic impacts are inevitable and likely to be severe in years of extreme climatic events.

Social vulnerability to climate change

Climate change impacts within the East Coast Cluster are likely to reflect the nature and extent of vulnerability to change within the region. Each region has its own strengths and weaknesses and these are important to recognise in climate adaptation planning. Geographic remoteness, percentage of labour force employed in agriculture, socio-economic advantage and disadvantage, economic diversity and age are five influences on the likely social impacts of graziers in the East Coast Cluster. Geographic remoteness is important because areas that are further from services centres are generally more vulnerable due to the interaction between socio-economic characteristics of the population and the characteristics of the particular places. Regions with higher proportions of people employed within agriculture are more sensitive to climate change because more people are dependent upon natural resources that are climate sensitive. The Index of Relative Socio-economic Advantage and Disadvantage is used by the Australian Bureau of Statistics to measure people’s access to material and social resources, and their ability to participate in society. Populations with higher levels of disadvantage tend to be more vulnerable. Economic diversity can be important to reduce vulnerability as it provides a broader range of employment opportunities if needed.

Finally, age is a complex factor influencing vulnerability. People of different age groups are sensitive to climate changes in different ways. Older people tend to be more sensitive to negative health impacts but younger people may have reduced adaptive capacity to economic changes that adversely affect their employment, families, emotional state and income levels (Smith et al., 2014).

Strengths of the grazing industry within three different regions of the East Coast Cluster have recently been identified (Smith et al., 2014). Generally, grazing areas in the Fitzroy region show lower levels of socio-economic disadvantage than other parts of the region. The situation is similar in south western parts of the Northern Rivers region. Here, grazing areas around the regional service centre Armidale have low levels of socio-economic disadvantage. Furthermore, in the Northern Rivers and Hunter-Central Rivers regions there is a relatively young age profile within the dairy industry workforce.

Weaknesses within some grazing areas - the Fitzroy region in particular – include high levels of remoteness where access to services is poorer than in less remote areas. Overall, grazing areas in the Fitzroy, Northern Rivers and Hunter-Central Rivers regions have lower levels of economic diversity, few alternative employment options and an older age profile. They are highly dependent on the grazing industry as pertaining to the percentage of the labour force employed in grazing, and are thus sensitive to climate changes (Smith et al., 2014).

Adaptive capacity

The grazing industries of the region have already proven themselves to be highly resilient. The region has experienced vast variation in weather and seasons in recent decades. Landholders have also had to navigate tremendous changes in how they manage their land and livestock in response to changing community, market and government expectations. However, current research into the northern beef industry more broadly suggests that willingness and capacity to change is not evenly distributed. The work shows that only 15% of cattle producers across Northern Australia are currently positioned to make the most of future opportunities associated with adaptation to climate change; the remaining 85% having little interest in changing, inadequate strategic skills, limited networks or are unsure about how to manage for risk and uncertainty (Marshall et al., 2014).

Climate adaptation planners within the East Coast Cluster region will need to be aware of the likely impacts and vulnerabilities associated with climate change, however adaptive capacity can be a major influence on what impacts actually eventuate (Adger et al., 2012). Recognising and enhancing adaptive capacity becomes increasingly important for resource-dependent industries facing significant climate change.

Adaptive capacity also becomes important to meet the demands of an ever-increasing human population. Industries and enterprises dependent on climate sensitive resources must enhance their productivity without compromising their capacity to be productive in the future if they, and the communities dependent on them, are to be sustained (Marshall et al., 2012). Recognising and enhancing adaptive capacity becomes increasingly important for resource-dependent industries facing significant climate change, and for the communities dependent on them (Kelkar et al., 2008).

What does successful adaptation look like for graziers? The literature suggests that adaptive success depends on maximising productivity during any one season and minimising impact on the future ability of the land to produce (Webb et al., 2013; Marshall and Stokes, 2014; Marshall et al., 2014). Adaptive capacity is the ability to respond to challenges through learning, managing risk and impacts, developing new knowledge and devising effective approaches. Enhancing adaptive capacity is not about providing additional resources, but rather being able to convert existing resources into a successful strategy. Adaptive capacity can be measured through assessing: i) how people assess risks and manage for uncertainty, ii) extent of planning, reorganising, experimenting, iii) financial and psychological buffers, and iv) the level of interest and extent of proactive behaviour (Marshall, 2010; Marshall et al., 2012).

Adaptation opportunities and responses

Considering the range of material discussed above, this section proposes a number of adaptation responses that may be suitable for the grazing industry in the East Coast Cluster. These responses fall into three broad and often inter-related categories:

- Enhancing the adaptive capacity of producers and grazing businesses
- Property level management and preparedness
- Benefiting from landscape and regional level change

Each of the three categories above represents a different level or scale of intervention. Some of these responses may be actionable by individual graziers or the industry as a whole. In other cases these may require local or strategic partnerships between industry and other stakeholders such as governments, research organisations, regional NRM or LLS groups and other NGOs.

Enhancing the adaptive capacity of producers and grazing businesses

As mentioned above, investing in the adaptive capacity of producers may be the next important step to assist the grazing industry to effectively adapt to climate change. Climate, soil fertility and the level of pasture improvement have largely determined the breeding and range enterprises possible within the region. Graziers will now need to further expand the number of management factors they consider to remain viable and indeed make the most of opportunities in the future. To do this, they will need to understand how to manage for future uncertainty, they will need the strategic skills to plan for change, experiment, reorganise and learn. They will need financial and emotional buffers and they will need to be encouraged to develop a strategic interest in the future. These factors are well-known to be limiting the industry, and NRM/LLS groups are likely to be able to play an important role in assisting graziers to develop these skills and the capacity to adapt.

At all scales, adaptive capacity can be enhanced through better networks, increasing environmental awareness, recognising and responding to environmental and other feedbacks, developing strategic/business skills, developing an interest in science and technology and fostering a culture of shared learning.

Adaptive capacity can be enhanced by NRM/LLS groups through facilitating workshops, partnerships or coordination on extension services to landholders, communications and monitoring. Education of the next generation of leaders is vital to enhance adaptive capacity of the region. Examples here include mentoring, job placement, training in adaptive thinking and scenario development.

Property level risk management and preparedness

Closely related to capacity development above are more specific interventions that could improve property level risk management and preparedness for extreme events. Industry groups have proposed several responses to drought and disaster risk reduction and recovery policies that are highly relevant to grazing industry adaptation in the East Coast Cluster. These responses include:

- Taxation measures that help to smooth income, encourage saving and facilitate investment in drought preparedness;
- Business development support for new entrants to enable them to invest in initiatives that improve preparedness and achieve long-term self-reliance;
- Following on the recent National Rural Advisory Council review, further development of risk management tools such as cost recovery or index-based insurance products;
- More investment in weather forecasting technologies and tools (such as more reliable six and twelve month seasonal forecasts), including user-friendly reporting, to help producers improve productivity and proactive decision-making, and
- Flexible training and skills development programs in agricultural production and finance that allow producers to voluntarily select modules that best cater for their stage of the business cycle and to support effective strategic farm planning (AgForce Queensland, 2014a).

The grazing industry has also recently prepared a guideline for landholders to improve disaster recovery at the enterprise level (AgForce Queensland, 2014b). This guideline promotes actions that are highly compatible with the role of regional NRM and LLS groups and related extension and information networks used by these groups in natural resource-related property planning. The proposed actions include supporting producers to "deliver high quality pre and post-natural disaster property assessments and budgeting information to insurance companies, government agencies and financial institutions" (AgForce Queensland, 2014b). Information in these assessments / property maps could include: (i) land and natural resource condition assessments recommended for pre-disaster condition and post-disaster condition (recovery to restoration); (ii) identification of actions to return to condition (but also encourages opportunity for re-design of property infrastructure, boundaries and resource utilisation practices to improve resilience for future events); (iii) examples of possible repair actions to include fencing off damaged stream bank and installing off-stream watering points; and (iv) accessing funding for weed management and on-going weed monitoring (AgForce Queensland, 2014b).

There is also an opportunity to connect these property planning/mapping processes to property vegetation maps, to neighbourhood or sub-catchment level planning and to regional strategies for landscape adaptation that may include carbon-farming with native forest regrowth and tree-planting in suitable regions.

For graziers one of the most critical decisions in relation to managing highly variable climate and seasons is maintaining a conservative long term stocking rate. Supporting this is the ability to monitor pasture levels and to calculate feed availability, particularly at the end of the wet season (this is more critical in the East Coast North). Graziers have to be decisive about adjusting stocking rates to maintain stock condition and groundcover. Recommended best practices for graziers to manage variable seasonal conditions and support climate adaptation include (DAFF, 2014):

- Determine the carrying capacity of the land and ensure that long-term stocking rates align with this. Adjust cattle numbers accordingly.
- Control the movement of cattle and optimise their access to forage supplies by careful placement of fences and water points.
- Wet season spelling of pastures every 3 to 6 years.
- Select genetic stock that are adapted to your environment and desired by your markets. Cross breeding programs are beneficial.
- Use of purchased forage and feed supplements should be minimised as the costs are often greater than the benefits.
- Act with discipline regarding cattle, cash and forage budgets.
- Control the period of mating cows so that all calves are born during wet season.
- Set up and implement a structured yearly program of stock management, involving mating, calving, mustering, weaning, husbandry, culling and nutrition.

Benefiting from landscape and regional level change

Carbon farming is an emerging opportunity that may convey economic benefits to grazing regions. Some carbon farming activities may also increase landscape resilience to climate changes. Restoration of native forests using native forest regrowth or environmental planting has potential to soften the impacts of past clearing on landscapes, by helping to conserve native species and address other negative impacts of past-clearing such as salinity. Increasing the extent of habitat for native species will also generally increase a landscape's adaptive capacity and resilience to climate changes.

Economic analysis suggests that there are areas within each of the East Coast Cluster regions that may support viable carbon farming projects using native forest regrowth, environmental plantings and avoided deforestation. These are mainly in sub-coastal areas, but high sensitivity to assumptions about costs suggests that large projects, with commensurate economies of scale, could be viable in most regions. In addition to these established activities, the new methodology for carbon sequestration into soils in grazing lands may also offer opportunities for economic benefit from activities that have strong co-benefits to regional natural resource management.

There are myriad possible approaches that regional NRM and LLS groups and other stakeholders may use to identify where carbon farming activities could be placed to strategically optimise co-benefits to biodiversity and other ecosystem services. Butler and Halford (2014) and Drielsma et al. (2014) present two possibilities focused on biodiversity co-benefits for the East Coast Cluster region. Either technique could be used to prioritise efforts by NRM/LLS groups to facilitate uptake of carbon farming opportunities or underpin engagement of NRM/LLS groups in strategic land use and allocation planning processes. AgForce has also recently acknowledged opportunities that may exist for its members as managers of carbon in the landscape:

> While the *carbon trading* system has its downsides [fuel electricity and processing sector costs], it may also present opportunities for landholders to play a role as part of the solution to climate change mitigation through land management techniques (e.g. tree planting or regrowth retention) (AgForce Queensland, 2014c).

Despite the clear potential for carbon farming to bring benefits to landscapes, uptake to date has been limited. Most carbon farming projects have been to avoid emissions, such as management of methane from legacy landfill waste or piggeries. The limited uptake of opportunities for sequestration activities may be related to the requirement that carbon stores be maintained permanently. The complex and unstable policy context and political debate around carbon farming and broader climate policy are also likely to have limited uptake. Without significantly higher prices for carbon credits, and a more stable policy context, it is likely to be years or even decades before carbon farming occurs on sufficient scale to have noticeable regional effects. However, identification of strategic locations in the landscape is crucial for not limiting potential future opportunities, and is useful to regional bodies in pursuing other investment opportunities in revegetation.

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