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Northern Australia Climate Project Phase 1

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Executive Summary

The productivity and profitability of the red meat industry in northern Australia is driven by summer rainfall but variability causes large swings in annual production and profit. Despite this reliance on rainfall during the wet season, many producers are cynical about using climate prediction in strategic and tactical decision making. For example, the level of use of predictions such as wet season onset, seasonal forecasts or planning for wet season failures (drought) among producers is relatively low.

This NACP Phase 1 planning project has identified key reasons for producer concerns about climate prediction in northern Australia which include:

- Many regions experience low and variable forecast skill,
- Low relevance of existing forecast systems and technologies to key management decisions,
- Lack of understanding on how to use climate resources and the technologies within these resources,
- Lack of support from climate experts, and
- Lack of proof of value.

As such, this NACP Phase 1 planning project has developed an RD&E program (NACP Phase 2) to overcome these barriers by providing new and improved climate forecasts at multiple timescales, new and locally relevant decision (and discussion) support tools and a trusted extension service to help producers integrate climate prediction technologies into decision making (Table 1).

Table 1: Climate issues concerning the red meat industry in northern Australia and the proposed RD&E activities to generate the required predictive reliability, confidence, trust and understanding of producers to use historical and forecast climate information in decision making to increase production and profitability

Climate issue	RD&E action
Low and variable forecast skill	Improve climate model skill at multiple timescales Mapping forecast skill (region*season)
Relevance of existing forecast systems and technologies	Longer forecast lead times (seasonal) Drought forecasts (multi-year) Forecasts of summer wet season Forecasts of onset, delays and end of wet season Region and local scale forecast products Forecasts of unseasonal rain in dry season Forecasts of extreme heat
Use of climate resources and the technologies	Trained and supported local climate advisers Provide an integrated 'end to end' climate service targeted for the region Targeted, relevant and updated tools Climate advice by local advisers Integrating forecasts into management
Support from climate experts	Provide an integrated 'end to end' climate service with two way flow of engagement, information and evaluation
Proof of value	Case studies with producers (post-drought assessments, innovative management for reducing drought vulnerability,

	use of critical indicators and triggers for drought planning and the use of forecasts in better decision making) Integrated climate, biophysical and herd modelling to show forecast value.

The proposed NACP2 program will directly link the world's foremost climate and weather science institutions (UKMO, BoM) with leading climate science application groups (BoM, USQ) through to advanced product and decision-support development (BoM, USQ) to advanced state-of-the-art producer extension services (DAFQ, NTDPI, DAFWA) in northern Australia. This institutional integration from 'end-to-end' will help ensure fundamental breakthroughs in weather and climate research and will directly feed through to changes in on-property management decisions.

The proposed NACP2 RD&E will deliver:

Research: climate and weather research will do fundamental, but much needed, climate research and deliver major advances in multi-week, seasonal and longer-term climate forecasting. As part of this, new and advanced products will be developed including 'flash drought' prototype forecast products (e.g. probability of onset of flash drought etc.), improved seasonal forecast prototype products from ACCESS-S1/2 for seasonal and longer lead-time forecasting and forecasts of wet season onset and breaks in the wet season

Development: a range of decision tools will be developed that are targeted (region*industry), timely, relevant, accessible and useful for managing drought and climate variability. They will include products for use in drought monitoring, planning and prediction for producers and policy makers.

Extension: integrate and embed climate forecast information into northern Australia grazing industry networks to improve producer resilience to drought and climate variability.

Providing a climate program that is enabled by a vertically integrated institutional arrangement providing interaction between leading climate scientists, climate forecasters, climate applications specialists, climate advisers, producers and policy makers will enable a transition from simply providing climate information (currently in place) to providing a climate service. This is expected to significantly improve understanding, trust and use of climate information in decision making.

Local advisers will be trained and supported by the climate experts, and industry consultation identifying the need for regionally relevant and specific products will be fed back to USQ, BoM and UKMO. This will give producers and advisers an effective voice in the design, production, and evaluation of climate products and services. These products and climate services will be delivered at a local scale to be relevant to on-property decision-making. Case studies with producers will foster dialogue and bring together climate and agricultural expertise. These could include post-drought assessments, innovative management for reducing drought vulnerability, use of critical indicators and triggers for drought planning and the use of forecasts in better decision making. The highly regarded managing for climate variability workshops where producers are given the skills to complete their own forecasts will be incorporated into the extension plan. The face-to-face dialogue between producers, advisers

and climate experts is an effective way to communicate historic and predicted seasonal climate information and the more technical, and often poorly understood, terms such as probabilities.

The NACP2 RD&E is expected to significantly improve the reliability (or skill) of climate forecasts (depending on current benchmark and location, seasonal 20-50%, multi-week 30%, multi-year 100%), stakeholder knowledge of climate and associated decision tools, the relevance and use of climate in tactical and strategic decision making, the value and sustainability of red meat production and drought risk management and resilience.

A preliminary economic analysis based on the two key premises that NACP will provide considerable benefits through improved climate and drought risk management practices by:

- Making climate sensitive decisions with confidence due to more accurate and reliable sub-seasonal, seasonal and multiyear climate forecasts;
- Upscaling practice change through a comprehensive extension and capacity uplifting program resulting in improved adoption of climate technologies.

Under a range of profitability and adoption assumptions, the economic analysis indicates significant benefits to northern Australian red meat industry. Based on the core economic indices, changing practice and using seasonal forecasts, will generate a Benefit Cost Ratio (BCR) of 7.7 using current skill of SOI forecasts (10% increase in profit), and with increased forecast skill (20% increase in profit) a BCR of 16.3.

The NACP2 RD&E proposal has a high likelihood of achieving the planned rates of producer engagement and practice change for the following reasons; 1) involving producers and advisers in co-design, co-production and co-evaluation of climate services 2) building partnerships that can bridge the gap between climate, agricultural research, advisers and producers 3) providing targeted and relevant products at the local scale and 4) continuously evaluating and improving climate science, product development and service delivery.

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1. Background

The northern Australian beef industry is strongly influenced by the impact of climate and weather variability. Prolonged droughts or failure of the wet season can cause abrupt changes in water availability and is one of the biggest challenges graziers face and has a significant impact on agricultural output, productivity and on-farm income. The success of the northern Australian beef industry depends heavily on capitalising on the opportunities and minimising the risks associated with climate variability. Reliable and skilful seasonal forecasts are pivotal for managing climate risks.

Recently conducted research surveys (RRDfP Round 1, ICACS USQ MS 4 Report in May 2017; MLA Drought Resilience Co-Innovation Scoping Study, Mushtaq et al 2016; DAF DCAP1 Coutts J&R Benchmarking Survey May 2017; DAF DCAP1 Coutts J&R Interim M&E Progress Report May 2017) identified the key issues preventing the improvement of business resilience and capacity building to manage climate risk across northern Australian red meat industry. These surveys have collected responses from 250 producers and 50 community members and have played a major role in directing the RD&E plan for NACP2.

To assist producers to improve their climate risk management and capacity to prepare for and manage drought, the MLA NACP Phase 1 project was initiated. The aim of the Phase 1 project was to plan and develop projects that address these issues and to provide solutions. The NACP Phase 1 planning project has developed an RD&E program (NACP Phase 2) to overcome these barriers faced by producers by providing new innovative and improved climate forecasts at multiple timescales, new and locally relevant decision (and discussion) support tools and a trusted extension service to help producers integrate climate prediction technologies into decision making. The project will be delivered in three areas of research (UKMO, BoM, USQ), development (USQ, BoM, National Drought Mitigation Centre Nebraska, NDMC) and extension (DAF, USQ, NT DPI, DAFWA, DSITI) and run in parallel with the Drought and Climate Adaptation Program (DCAP2) a program funded for Queensland by DAF.

1.1 Aims of the project

The aim of the NACP Phase 1 project is:

- To identify core RD & E challenges faced by the northern beef industry, especially in consultation with key stakeholders, industry experts and climate researchers.
- Conduct planning and development of potential NACP RD&E projects, and develop a full proposal for implementation through MDC and DCAP2.

1.2 The project deliverables

- A focussed review of the literature around the previous research, on-going research and highlight key research problems, to be addressed through NACP – Phase 2.

- A report detailing the stakeholder engagement, expert engagement, key findings (issues, goals and potential strategies) identified in the workshops, and RD&E gaps.
- A full proposal for implementation through MDC and DCAP2.

2. Approach adopted to identify core RD&E challenges for northern Australia

A multifaceted approach was used to identify the key issues that prevents producers in the northern Australian red meat industry to implement climate adaptation measures in the decision making process. The methodology includes:

- A comprehensive focused literature review was completed with the aim to understand what research has been done in northern Australia, identify any research gaps, and to distil out the key issues that would be modelled as part of the MDC project.
- Workshops, meetings and teleconferences were conducted with industry experts, stakeholders and key partners to discuss what are the key issues in the industry, what are the possible solutions and the type of research was required to improve the current issues.
- Consultation with beef producers and community members to identify key issues concerning risks (at the business enterprise and community level), as well as innovation and adaptation barriers, experienced by stakeholders in, and associated with, the Australian livestock industries.
- A preliminary analysis to demonstrate the relationship between northern Australian rainfall and impact on the profit and income, specifically to demonstrate the importance of a rainfall forecast to improve business profit/income.

3. Previous research and research gaps in northern Australia related to the red meat industry

The Australian northern beef industry has developed and grown over the past two decades and is a major contributor to regional economies in Queensland, the Northern Territory and northern Western Australia (Figure 1). The northern beef herd comprises ~50% (~15 million cattle) of the national herd; with annual production valued at over AU$5 billion (MLA 2013; DIRD 2015). Queensland has the largest beef cattle herd with 11.2 million or 47% of the Australian total, and is the nation's largest producer and exporter of beef. It is the most significant agricultural commodity for Queensland with cattle and calf sales worth an estimated $3.259 billion in 2013–14 (Department of Agriculture Fisheries and Forestry 2014). However, the industry is facing increased uncertainty over the potential changes to rainfall across northern Australia under climate change. Australia has one of the world's highest levels of year to year climatic variability with drought a naturally occurring component of this

variability, which may persist for many years (Stone 2014). Drought or failure of the wet season is one of the biggest challenges graziers face and has a significant impact on agricultural output, productivity and on-farm income. There are many recent examples of the significant and widespread economic, environmental and social impacts of droughts across Queensland/Northern Australian and Australia (1982/83, 1986/88, 1991/95, 2002/06, 2014/16). The El Niño-Southern Oscillation (ENSO) has a profound influence on climate variability in Australia and is a key factor driving the frequency, intensity and spatial distribution of droughts. The impact of drought on the Australian economy was highlighted in 2002–03 with a 19% fall in the value of agricultural production which led to a decline in Australia's GDP growth of ~1% (Lu & Hedley 2004). The 2013-16 drought was regarded as one of the worst droughts in living memory for inland and western Queensland (Counsell & Houston 2017). Queensland was severely affected with over 80% of the state drought declared in 2016.

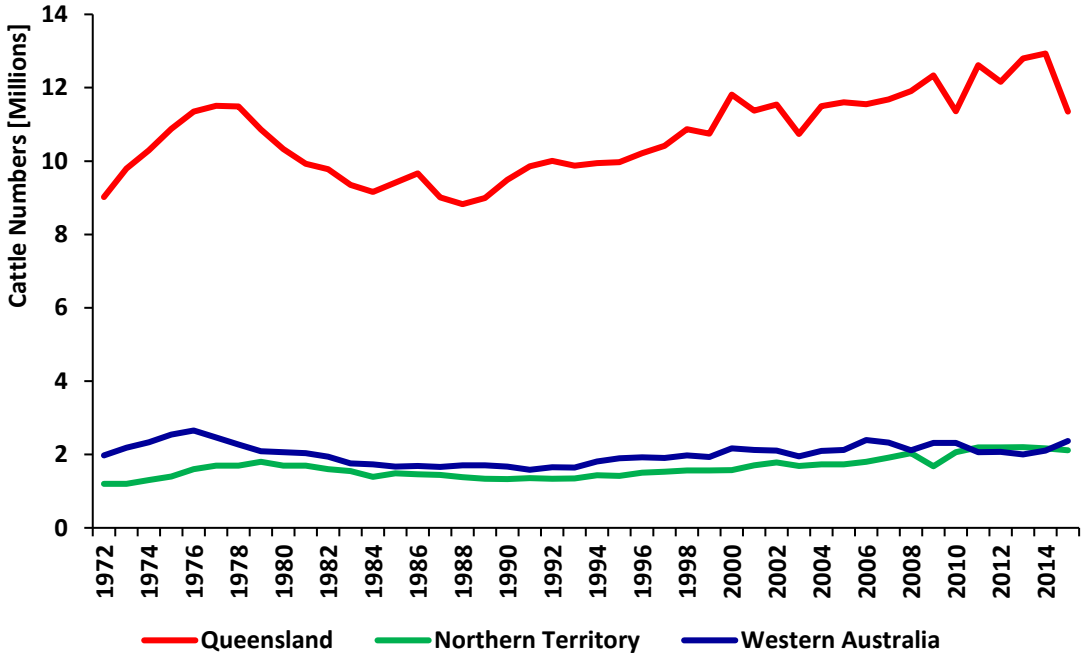

Figure 1: Northern Australian cattle numbers 1972 to 2016 based on ABS data.

The main rainfall season in northern Australia is in summer, which usually is followed by a long and variable dry season of between 6 and 8 months (Park et al. 2001). The northern Australian beef cattle production systems are highly reliant on native pastures as the main feed source and pasture growth itself is dependent on rainfall through the wet season (Gleeson et al. 2012). It is projected that by 2030, production and profitability across the Australian livestock industry is estimated to decline by 25% in the absence of climate adaptation measures which is largely due to a decline in pasture availability (Ghahramani & Moore 2015). With rainfall being a key driver of pasture growth, cattle numbers and the resulting animal productivity and beef business profitability, it is crucial for producers to be able to anticipate possible management strategies within such uncertainty (Phelps et al. 2014).

An estimated 30% of native pasture lands has been reduced in productivity and health (Tothill & Gillies 1992) due to high rainfall variability and the consequential delay in detecting the on-ground changes (Phelps et al. 2014). The predicted changes in climate and weather may result in more variable pasture productivity and quality; increased livestock heat stress, more frequent and longer droughts, more intense rainfall events, and an increased risk of soil erosion (Stokes et al. 2010). Maintaining good land condition builds resource resilience, maximises opportunities under higher rainfall years and reduces the risk of degradation during drought and failed wet seasons (Phelps et al. 2014). Maintaining stocking rate to a safe long-term carrying capacity is important for the profitability and sustainability of grazing enterprises (Johnston et al. 2000). Management of stocking rate may also be improved through the use of appropriate long-term carrying capacities and seasonal forecasting tools.

Research suggests that producers' successful adaptation to future climate variability and change is dependent upon the increased use of climate information (Meinke & Stone 2005). However, producers have not widely adopted the use of climate information in their risk management decisions (Ash et al. 2007). The literature suggests that research into **improving the forecasting skills and lead time may increase the use of climate information in decision making** by producers (Hammer 2000; Meinke & Stone 2005).

The use of seasonal climate forecasting (SCF) as a tool offers the potential for improved risk management and decision-making across all sectors, leading to enhanced profitability including international competitiveness. Seasonal climate forecast information can be incorporated when making business decisions which may increase the confidence of that decision-maker, and be perceived as having insurance value by a risk-averse manager. However, many **decision-makers have indicated that they require more confidence in using SCF tools** (Paull 2002).

An economics assessments by McLean et al. (2014), who have analysed the performance of the beef industry, especially performance of the top 25% beef producers, under highly variable seasonal (rainfall) conditions, have shown that, while performance of both average and top producers fell during drought (<30% percentile summer rainfall) years, top producers were able to reduce the impact of drought on their businesses better than the average producer. The difference in terms of reduced impact of climate risks between top and average producers could be explained in terms of better risk management strategies, improved climate information, better capacity (quarantine capital raised from the sell down process for use in the herd rebuilding phase) and knowledge and practices by top growers. The average estimated value of improved climate (drought) risk management strategies, after disaggregating the impact of management, is $16.35/AE.

Information on current conditions and seasonal forecasts have been generated and disseminated in Australia since the late 1980s but the uptake by agricultural decision-makers has been modest (one in three in Australia), and the use by governments has largely been limited to crisis management during droughts. The uptake of SCF by agricultural producers in decision-making range from 30 to 50% (Cobon et al. 2017) but there is evidence that in regions with access to local champions, adoption of seasonal forecasts into management decisions is increased to 75% (Cobon et al. 2008; Cliffe et al. 2016). **Factors that limit the uptake and use of climate**

forecasts have been identified as the reliability of the forecast, the presentation style, use of terminology, proof of value, access to expertise, and perceptions regarding the climate information (Childs et al. 1991; Changnon et al. 1995; Nicholls 2000; McCrea et al. 2005). Another aspect that **limits the uptake is that most forecasts are issued as probabilities that reflect the uncertain and nondeterministic nature of the climate system, but many producers do not fully understand probabilities and other terminology** (Dalgleish et al. 2001; Keogh et al. 2004; Keogh et al. 2005; Cobon et al. 2008). This creates the potential for misunderstanding and misinterpretation, and highlights the **need for providers of forecasts to simplify the language and to support this with education and training opportunities that help producers interpret scientific data**. Having local champions with climate science and applications training working in the regions has proved to be successful in increasing the use of seasonal forecasts in decision-making on pastoral enterprises (Cobon et al., 2008).

Preliminary results from a very recent Queensland Benchmarking Web Survey (May 2017) conducted by Coutts J&R indicated that producers were moderately confident (6.0 avg.) in the ability to access resources/tools/information needed to effectively make planning decisions for climate variability. When asked to identify any barriers preventing the access to relevant tools/resources and/or knowledge, '**lack of understanding about how to use resources**' (54%) and '**lack of understanding of technologies used in the resources**' (41%) were mentioned 2nd and 3rd on the list. Internet access was said to be a problem by 63% of respondents. In regards to key management practices used when planning for climate variability by industry, adjusting stocking rates according to forage amount and quality (89%), carrying capacity (82%), adjusting stocking rates - buy, sell, agistment, etc. (79%), fencing (62%) and animal segregation, controlled joining or pregnancy testing (60%) were in the top five. Identifying climate change impacts and developing climate change adaptation (26%) was listed in 13th position. The results are based on 180 responses from the beef, dairy or sheep industry.

In a review by Counsell and Houston (2017) in regards to the attitude of producers to weather forecast it became apparent that they may be using forecast information, but it was also found that there is plenty of scepticism towards the BoM 3 monthly weather forecasts. These results indicate that more work is required to improve producer acceptance of the merit and accuracies of medium and long term seasonal forecasts. There is a need to increase the accuracy of forecasting on timeframes of value for producers, to provide climate products, services and tools for managing climate risk and increase the knowledge and confidence to adopt climate risk management. This could be achieved through developing extension resources so producers develop more confidence, capability and acceptance in including long and medium term weather forecast analysis in their decision-making processes, particularly towards the timing of destocking and restocking decisions (Counsell & Houston 2017). Facilitated collaborative learning amongst graziers and other stakeholders may also assist to develop strategic skills, increasing climate awareness, developing financial security and adopt climate tools such as seasonal climate forecasts (Marshall 2010).

4 Workshops with industry experts, stakeholders and key partners

A number of activities (e.g. workshops, meetings, teleconferences) were conducted with industry experts, stakeholders and key partners with the aim to discuss the key issues in the red meat industry and to develop the project report and MDC proposal. A summary of the activities are presented here:

4.1 Teleconference workshop on the 9 May 2017 with industry experts and stakeholders from MLA, DAF QLD, USQ, DAF WA, NT DPIF, Rangelands WA

The discussion focused on identifying the key issues in the northern Australian beef industry. A summary of the main discussion points are below.

A short and long version of the workshop notes are attached in Appendix 1.

- To get on the ground activity, capacity building, extensions and communication tools to producer so they can have an influence on production and profit.
- To teach producers how to do their own forecasting through a hands-on approach in workshops. The producers get ownership of the whole system and are therefore much more likely to use it as a management decision tool.
- Strategic engagement activities, like regular webinars etc. could be developed to ensure that the producers receive support to incorporate information into their decision making process.
- Improved climate forecasting services could help to build drought resilience.
- Producers are interested in short and long-term climate forecast.

4.2 Collaboration on development of seasonal prediction model meeting on 11 May 2017 with BoM and USQ (at BoM's office)

The aim of that meeting was to align research needs and research partners (UK Met Office, BoM and USQ) with core skills for modelling improvements in the seasonal forecasts.

4.3 Workshop in Brisbane on the 18 May 2017 was attended by key partners from MLA, USQ, DAF QLD and BoM

The main focus of the meeting was to develop the research, development and extension project plans for the NACP 2017-2021 MDC proposal.

The three research plans are discussed in more detail in the 'key research problems in northern Australia' section and the individual plans are attached in Appendix 3 to 5.

4.4 Collaboration on development of seasonal prediction model meeting on 26 May 2017 with BoM and USQ (at BoM's office)

The aim of that meeting was to align research needs and research partners (UK Met Office, BoM and USQ) with core skills and additional staffing requirements for modelling improvements in the seasonal forecasts.

4.5 Budget meeting on 1 June 2017 with BoM and USQ (at BoM's office)

The aim of that meeting was to discuss the working of the proposed cash and in-kind budget between the UK Met Office, BoM and USQ.

4.6 Teleconference meeting on the 2 June 2017 with key industry partners from the UK Met Office, BoM and USQ.

The focus of the discussion was in regards to the staffing of two positions in the UK Met Office that are planned to be integrated into the model development teams.

The notes of the meeting are attached in Appendix 2.

5. Consulting beef producers and the community

USQ has been involved and reviewed four surveys which were completed within the last 12 months (Mushtaq et al. 2016; Coutts & Coutts 2017b, 2017a; ICACS 2017) (RRDfP Round 1, ICACS USQ MS 4 Report in May 2017;; DAF DCAP1 Coutts J&R Benchmarking Survey May 2017; DAF DCAP1 Coutts J&R Interim M&E Progress Report May 2017). As part of that, the livestock industry and community members were consulted to identify key issues (Table 1) concerning risks (at the business enterprise and community level), as well as innovation and adaptation barriers, experienced by stakeholders in, and associated with, the Australian livestock industries.

Table 1: Key issues identified by beef producers and community members in, and associated with, the Australian livestock industries (Mushtaq et al. 2016).

Identified R&D Projects	Northern WA	Western QLD	Southern WA	Northern VIC
1. Pasture management and total grazing pressure - decision support				
Key indicators and thresholds for pasture quantity and quality & land condition	✓	✓	✓	✓
Timing of key decisions and/or decision points based on key indicators	✓	✓	✓	✓
Protocols and tools for monitoring and evaluation of key indicators	✓	✓	✓	✓
Assessing total grazing pressure (livestock & non-domestic herbivores)	-	✓	✓	✓
Assessing/addressing biosecurity threats - BMPs	✓	✓	✓	✓
Tools & support for timely decision-making - decision support framework	✓	✓	✓	✓
Managing total grazing pressure (livestock & non-domestic herbivores) - BMPs	-	✓	✓	✓
2. Forecasts – provide producers with the confidence and capability to sell or agist livestock early before pastures degrade, stock lose weight & prices decline				
Accuracy and lead-time of Nov-Mar rainfall (summer rainfall areas)	✓	✓	-	-

Identified R&D Projects	Northern WA	Western QLD	Southern WA	Northern VIC
Accuracy and lead-time of Apr-Aug rainfall (winter rainfall areas)	-	-	✓	✓
Skill testing of GCMs at seasonal scale	✓	✓	✓	✓
Testing of multi-year forecast systems	✓	✓	✓	✓
Cyclone forecast systems	✓	✓	✓	-
Forecasts of upper or lower tercile rainfall for the wet season	✓	✓	-	-
Forecasts of start and end of wet season	✓	✓	-	-
Forecasts of unseasonal rain during the dry season	✓	-	-	-
Forecasts of extreme heat periods SOND	✓	-	-	-
3. Integrating livestock, finance, business and marketing management				
Whole farm analysis of pasture condition/productivity, environmental factors, herd dynamics, red meat production, profit, transport and taxation to meet (and compare) different market specifications	✓	✓	✓	✓
BMPs	✓	✓	✓	✓
Engaging better with the marketplace	✓	✓	✓	✓
Managing change in production system (or similar) (e.g. transitioning from dairy to beef)	-	-	✓	✓
4. Building social networks, health & wellbeing				
Tools and support for physical and mental health	✓	✓	✓	✓
Personal/professional development	✓	✓	✓	✓
Planning for the future	✓	✓	✓	✓
The role of peer to peer learning and industry champions in facilitating adoption of new technologies and practices	✓	✓	✓	✓
5. Decision making for better management of drought and recovery				
Identifying key drought indicators and thresholds	✓	✓	✓	✓
Seasonal and multi-year forecasts	✓	✓	✓	✓
Water security(e.g. water buy back decisions)	-	-	-	✓
Tools and support for making key economic and environmental decisions - BMPs	✓	✓	✓	✓
Early decision making with confidence	✓	✓	✓	✓
Monitoring and reporting of drought and drought recovery (of natural resource/pasture condition? stock numbers? financial? other?)	✓	✓	✓	✓
Better understanding and application of hydrological, hydro-illogical and hydro-psychological cycles	✓	✓	✓	✓
Different types of pastures or crops to suite the climate situation	✓	✓	✓	✓
6. Assist NBF and PKCA in developing new markets				
New market identification and feasibility	✓	-	-	-

Identified R&D Projects	Northern WA	Western QLD	Southern WA	Northern VIC
7. Helping meet market specifications for beef within age and seasonal boundaries				
Lot feeding stock for short periods	✓	-	-	-
Selling crops grown in region as beef liveweight	✓	-	-	-
8. Working with Indigenous Land Council & others to increase the productivity of beef on indigenous pastoral leases				
Extension and communication program	✓	-	-	-
9. Importance of biosecurity in maintaining and expanding markets that pay a premium price (plants and animals)				
Extension and communication program	✓	-	-	-

6. Assessing the relationship and impacts of northern Australian rainfall, business income and profitability

The preliminary analysis has been based using the MLA dataset (http://apps.daff.gov.au/MLA/mla.asp). The aim of this analysis was to understand to what degree the rainfall can explain the variability in income. The analysis showed that northern Australian producer's income is impacted by rainfall. However, there can be additional factors that also play an important role, which are not modelled. For example, the rainfall/cash analysis does not always pick up lag periods connected to certain events and activities (e.g. in drought years the income can be higher due to stock being sold off). Figure 2 is an example of a cash income versus yearly rainfall analysis. Any future improvement in forecast skills will help to increase the profit of producers.

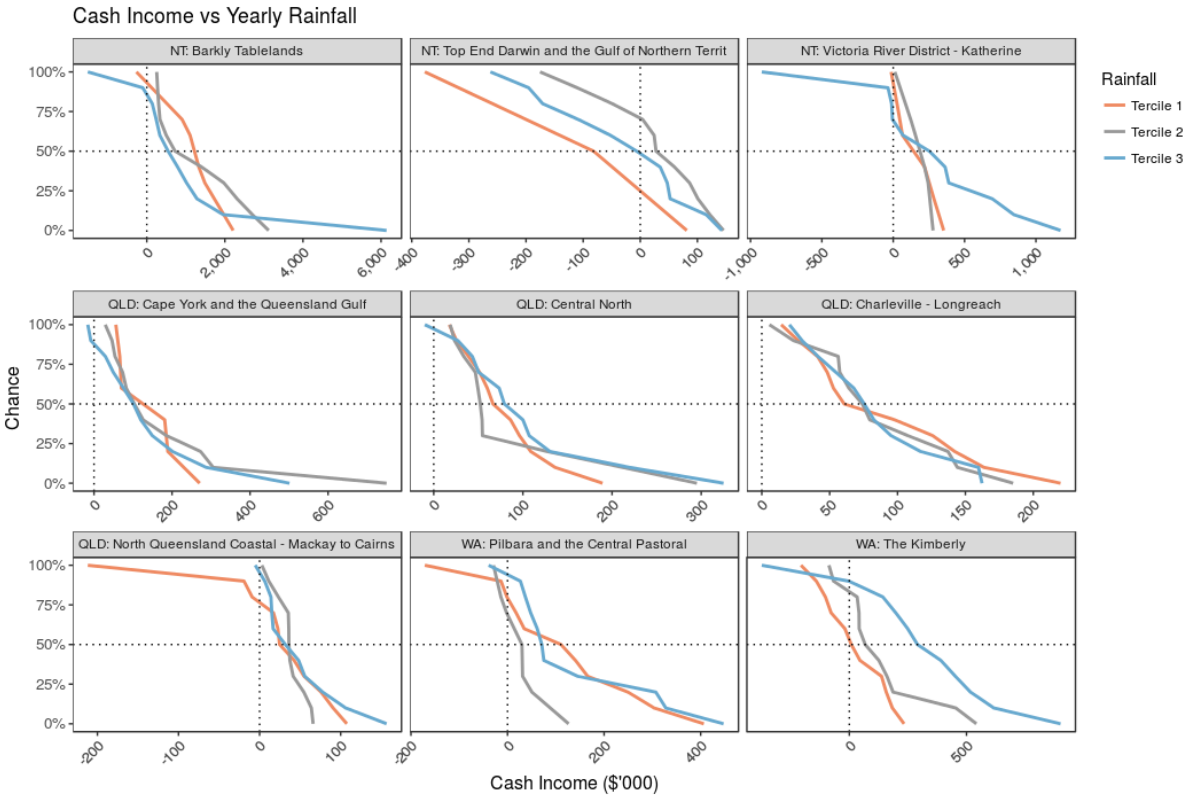

Figure 2: Cash income versus yearly rainfall analysis for locations in QLD, NT and WA

7. Key research problems identified in northern Australia

The following key issues have been identified (based on literature review, industry expert workshops, consultation with beef producers and the community, and a preliminary assessment on rainfall-income relationships) to prevent the enhancement of business resilience and capacity building to manage climate risk across northern Australian red meat industry.

- The skill of current operational SCF systems vary spatially and temporarily and are issued with minimal lead time (Figure 3 & 4). This makes it difficult for producers to implement key management decisions.
- Most forecasts are issued as probabilities that reflects the uncertain and non-deterministic nature of climate systems but many producers do not fully understand probability, and other terms such as median, which creates the potential for misunderstanding and misinterpretation.
- The lack of understanding how to use climate forecasting tools and when to apply them has also been identified as a barrier.
- These factors can lead to scepticism of producers to adopt SCF tools in decision making and risk management.

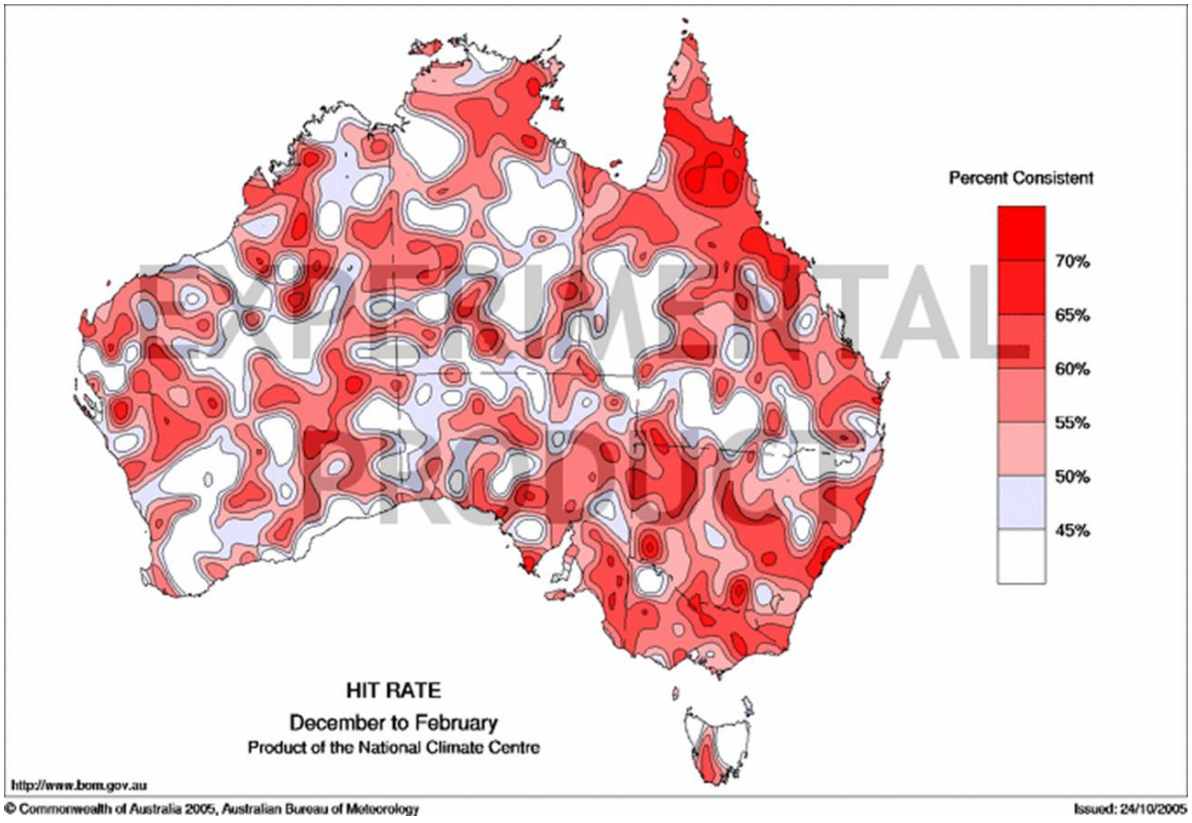

Figure 3: Independent verification in real time: SOI 'phase' system (Stone & Auliciems 1992; Stone et al. 1996)

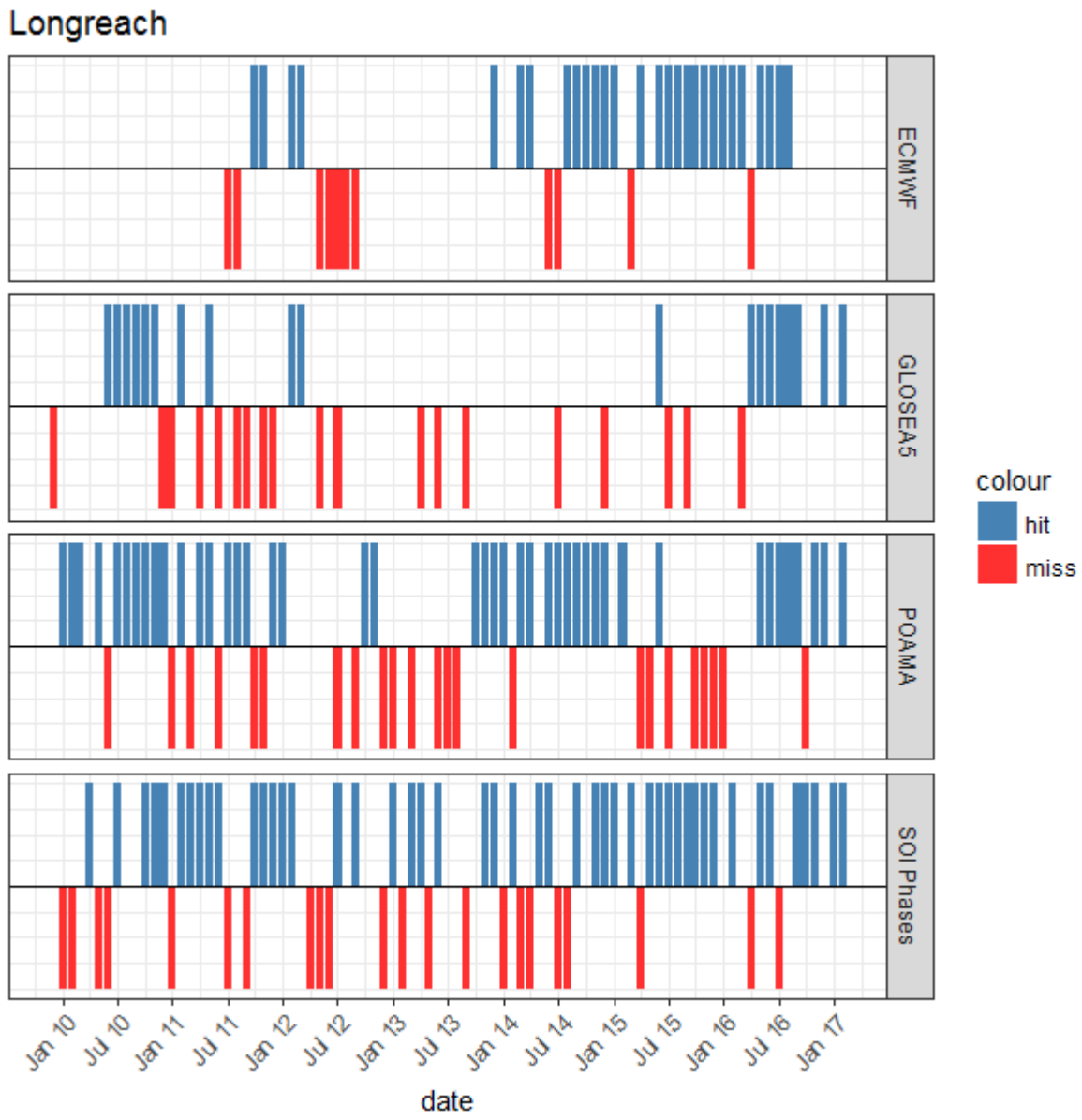

Figure 4: Climate forecast systems skill at Longreach, Queensland.

As these findings highlight there is a need to increase the accuracy of forecasting on timeframes of value for producers, to provide climate products, services and tools for managing climate risk and increase the knowledge and confidence to adopt these tools in climate risk management decisions. These findings suggest there is potential for RD&E projects to address the problems. The following three main projects are proposed.

8. RD&E Plan

8.1 Research Project

The research project will address issues of forecast skill at multi-week to multi-year timescales, flash droughts and wet season onset and finish, and improve predictions of multi-year droughts.

The research component of NACP has three projects 1) model improvement, 2) multi-year prediction, and 3) product development (e.g. flash drought, wet season start/finish).

Objectives

1. Improving the understanding of ENSO and other systems such as the Indian Ocean Dipole and the Quasi-biennial Oscillation (QBO) including ocean-land feedbacks for promoting regularly occurring droughts in Queensland. Include the need for urgent investigation of the recently discovered impact of the stratospheric QBO on the Madden Julian Oscillation (MJO) that is known to have a major influence on the timing of rainfall events (including within drought periods), the onset of the wet season and periods of dry spells within the summer wet season.
2. Improving the understanding and predictability of ENSO and other major climate systems on timescales of three years and longer (thus, to better understand the mechanisms responsible for multi-year, protracted droughts).
3. Improving the understanding of local climatic features and systems together with this overall predictability is realised by coupled-model forecasts – primarily through the UK Met Office ACCESS-S system).
4. Improve the understanding and predictability of the development of shorter-term very intense and devastating drought periods (called 'flash drought' in the United States).

The research sub-projects build on the DCAP Phase1 USQ 13 project which delivered improved seasonal forecasts and multi-year forecasts for Queensland.

A research plan for the proposed projects has been developed at the 18 May 2017 workshop meeting in Brisbane and is attached in Appendix 3.

8.2 Development Project

Title: Developing innovative and targeted products for use in drought monitoring, planning and prediction for producers and policy makers.

The development project will provide a range of decision tools that are targeted timely, relevant, accessible and useful for managing drought and climate variability. The development component of NACP will develop products for use in drought monitoring, planning and prediction for producers and policy makers and produce innovative and targeted decision support tools for managing climate variability.

Objectives

1. Identify, review, develop and disseminate drought indices that meet the needs of northern Australia to identify periods of emerging drought risk in a timely manner, which are presented and updated in an appropriate spatial format online.
2. Develop and disseminate a drought monitor product (similar to the US Drought Monitor, http://droughtmonitor.unl.edu/) that incorporates a combination of drought indices, in situ verification and satellite technology, and used as a drought management tool for better drought monitoring and planning for advisers, producers and policy makers.
3. Develop and disseminate a drought outlook product (similar to the US NIDIS Drought Outlook, http://www.cpc.ncep.noaa.gov/products/expert_assessment/season_drought.png that is used as a drought management tool for better drought planning and prediction for advisers, producers and policy makers.
4. Produce other products that represent state-of-the-art climate science that are targeted, useful, trusted and valued by advisers and producers in northern Australia. To achieve this, develop a product development plan in consultation with the project research and extension teams (by Nov 2017).
5. Disseminate products to advisers and producers via relevant and accessible platforms.
6. Liaise with the research and extension teams to update and respond to emerging findings and issues.
7. Monitor product use and dissemination platforms and update.
8. Provide training in product interpretation and use to advisers.

The development project build on the DCAP Phase1 USQ 7.1 and USQ 9 projects which provided drought indices for Queensland (USQ 7.1) and updated decision tools for agricultural producers (USQ 9).

A plan for the proposed project has been developed at the 18 May 2017 workshop meeting in Brisbane and is attached in Appendix 4.

8.3 Extension Project

Title: Integrating and embedding climate forecast information into Northern Australia grazing industry networks to improve producer resilience to drought and climate variability.

Objectives

1. Build capacity of producers to better manage climate risk through using knowledge of historical climate and climate forecasts in decision making.
2. Communicate and demonstrate the value of climate forecasts at farm and regional scale (including describing and mapping forecast skill at a regional scale, communicated through the development arm of this project).
3. Build and integrate climate information and climate forecasts into existing extension programs (EDGENetwork, Grazing BMP, Profitable Grazing Systems).
4. Provide a reputable climate information service to producers through knowledgeable advisers and industry embedded advocates.

5. Strengthen partnerships with world leading climate science researchers to deliver high quality feedback and products to producers.
6. Monitor changes in KASAP and demonstrate impact and return on investment.

The extension project builds on the DCAP Phase1 USQ 5 and USQ 13 projects which delivered Climate Change Adaptation Workshops (USQ 5) and Managing for Climate Workshops (USQ 13) in Queensland.

A plan for the proposed project has been developed at the 18 May 2017 workshop meeting in Brisbane and is attached in Appendix 5.

9. Benefits to livestock producers in northern Australia

The 'Northern Australian Climate Project' (NACP) – a combination of RD&E projects identified above – will deliver new research and practical outputs, especially in the area of increased lead times in preparedness for protracted droughts and with a focus on the more severe and devastating droughts. It will also create new development and extension systems (integrated RD&E) to significantly improve the capacity of the red meat industry to manage extreme drought/ associated climate risk across northern Australia.

NACP will deliver on a number of policy objectives including National Drought Reform through the delivery of innovative training and decision support tools utilising the best climate forecasting modelling available. The core development & extension projects, with relevant tools and capacity building workshops, will ensure sustained practice change and beneficial on-farm impact.

The project will enable producers to make climate risk management decisions with confidence through:

- Greatly improved risk management of extreme climate variability in northern grazing regions through better management and use of improved forecast systems. Improved risk management aspects will allow producers to integrate risk management processes into business decision-making.
- A suite of new innovative decision support tools (through ClimateARM, BBSAFe), allowing producers to obtain more targeted and timely seasonal climate forecast information, more directly relevant to their business operations.
- Decadal and multi-year climate modelling process and forecasts, including thorough accuracy testing processes, appropriate for operational use in the northern grazing industry, providing much more advanced warning of serious droughts than currently exist.
- Improved understanding of the economic value of seasonal climate forecasting targeted to the grazing industry, including means to incorporate this understanding into grazing business decision making.
- New grazing industry focussed Managing for Climate and Weather (MFC) workshop material readily available for use by the northern grazing industry.

- Tailored and innovative delivery methods, also utilising USQ's expertise in distance education and 'e-learning' methods.
- Workshop information and training material, workbooks etc., to be made available in a central and prominent location and to be tailored to every location in northern Australia of relevance to the northern grazing industry.

10. The NACP innovation and significance

This project will drive a step-change in the level and sustainability of drought preparedness amongst red meat producers in northern Australia. It will develop a suite of tools and frameworks to increase the rates of sustained adoption of research outputs and the associated technical and management recommendations. This will be achieved through:

- Utilisation of major advances being made in seasonal to decadal climate forecasting - in close conjunction with BoM - that will also forecast impending 'flash droughts' – those droughts that suddenly develop from otherwise fairly innocuous drought patterns into crippling, local industry destroying droughts via land-surface/atmospheric feedback processes (the summers of 2002/03 and 2012/13 are examples of this).
- Utilisation of recent research advances that can identify longer-term protracted drought periods affecting grazing regions over periods of many years.
- Within a comprehensive and integrated project such as this, there is a low marginal cost in adapting key findings from these breakthrough science areas that ICACS/USQ is developing and which is based on close collaboration with the UK Met Office, the US National Integrated Drought Information Services, the US National Drought Mitigation Centre, and the Australian Bureau of Meteorology!
- This project presents a unique holistic approach through integrating 3 innovative sub-projects in the area of research, development and extension (integrated RD&E approaches) as a means of addressing a major and persistent problem for northern Australia – limited adaptation to climate variability, especially droughts.

11. Value Proposition: Return on Investment analysis

A number of modelling studies of pastoral enterprises in northern Australia have shown that there is a clear positive relationship between skill and adaption. The proportion of Australian beef producers taking seasonal climate forecasts into account in relation to a measure of forecast skill (White et al. 2013). Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).

A preliminary economic analysis is based on the two key premises that Northern Australia Climate Program (NACP) will provide considerable benefits through improved drought risks management practices by:

- Making climate sensitive decisions with confidence due to more accurate and reliable sub-seasonal, seasonal and multiyear climate forecasts;
- Upscaling practice change through a comprehensive extension and capacity uplifting program – improved adoption; uplifting individual capabilities and motivations

Under a range of profitability ((Parton & Crean 2016) Table 1) and adoption assumptions (based on White et al. (2015) Table 11 & White et al. (2015) Table 7), the economic analysis indicate significant benefits to northern Australian red meat industry (see Table 2). Detailed results are attached in Appendix 6. Based on the core economic indices, changing practice and using seasonal forecasts, will generate a benefit cost ratio (BCR) of 7.7, and with increased forecast skill (20% profit) a BCR of 16.3 (Table 2).

Table 2: Value proposition - the potential value for money or return on investment shown here as net present value (NPV), Internal Rate of Return (IRR) and benefit cost ratio (BCR) for the project expenditure ($8M) if producers change practice and use the SOI (or new forecasts with improved skill) in management decisions which results in a change in profit # commensurate with modelling studies.

	Change in Profit (%)	Engaged (no)	Practice change during project (%)	Practice change after project (%)	NPV	IRR (%)	BCR
	5	50	5	15	$ 17,882,207	33	2.6
	5	100	5	15	$ 18,424,599	35	2.7
	5	200	5	15	$ 19,509,383	40	2.9
	5	500	5	15	$ 22,763,734	65	3.3
	5	1000	5	15	$ 28,187,653	138	4.1
	10	50	5	15	$ 42,589,082	62	6.2
	10	100	5	15	$ 43,673,866	70	6.4
	10	200	5	15	$ 45,843,434	88	6.7
SOI	**10**	**500**	5	15	$ 52,352,136	167	**7.7**
	10	1000	5	15	$ 63,199,973	327	9.3
	15	50	5	15	$ 67,295,958	90	9.9
	15	100	5	15	$ 68,923,133	104	10.1
	15	200	5	15	$ 72,177,484	137	10.6
	15	500	5	15	$ 81,940,538	266	12.0
	15	1000	5	15	$ 98,212,293	494	14.4
	20	50	5	15	$ 92,002,833	117	13.5
	20	100	5	15	$ 94,172,400	137	13.8
	20	200	5	15	$ 98,511,535	185	14.4
ENSO	**20**	**500**	5	15	$ 111,528,939	357	**16.3**
	20	1000	5	15	$ 133,224,614	647	19.5
	25	50	5	15	$ 116,709,708	141	17.1
	25	100	5	15	$ 119,421,667	168	17.5
	25	200	5	15	$ 124,845,585	230	18.3
	25	500	5	15	$ 141,117,341	443	20.7
	25	1000	5	15	$ 168,236,934	789	24.7

These figures are based on a number of modelling studies (Ash et al.2000, Stafford Smith et al. 2000, McKeon et al. 2000, O'Reagain et al. 2011, Brown et al 2017) of pastoral enterprises in northern Australia that show an increase in profitability of 10-26% by using seasonal forecasts to adjust stock

numbers. The forecasts have used the SOI, ENSO, SST perfect knowledge of ENSO and perfect knowledge of pasture growth. The current skill of the SOI and SOI phase can generate an improved profit of 10% and, at the upper end, a perfect forecast of pasture growth an improved profit of 26%. Improved forecast skill and use of these forecasts in decision making have the potential to significantly benefit the pastoral industry.

12. Conclusion and recommendation

A multifaceted approach has been used to distil the key issues preventing producers in the northern Australian red meat industry to implement climate adaptation measures to improve their climate risk management and capacity to prepare for and manage drought. The following key issues have been identified:

- The skill of current operational SCF systems vary spatially and temporarily and are issued with minimal lead time. This makes it difficult for producers to implement key management decisions.
- Most forecasts are issued as probabilities that reflects the uncertain and non-deterministic nature of climate systems but many producers do not fully understand probability, and other terms such as median, which creates the potential for misunderstanding and misinterpretation.
- The lack of understanding how to use climate forecasting tools and when to apply them has also been identified as a barrier.
- These factors can lead to scepticism of producers to adopt SCF tools in decision making and risk management.

As these findings highlight there is a need to increase the accuracy of forecasting on timeframes of value for producers, to provide climate products, services and tools for managing climate risk and increase the knowledge and confidence to adopt these tools in climate risk management decisions. To address these problems the following targeted RD&E projects are recommended as part of NACP2 program:

- The research project will address issues of forecast skill at multi-week to multi-year timescales, flash droughts and wet season onset and finish, and improve predictions of multi-year droughts.
- The development project will provide a range of decision tools that are targeted timely, relevant, accessible and useful for managing drought and climate variability. The development component of NACP will develop products for use in drought monitoring, planning and prediction for producers and policy makers and produce innovative and targeted decision support tools for managing climate variability.
- The extension project will improving the knowledge and skills of producers across the grazing industry to support proactive management of climate variability which minimises exposure to environmental, profitability and productivity losses due to drought or drier than normal wet seasons, and maximises opportunities presented in above average seasons.

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BoM: Harry Hendon, Oscar Alves, Debra Hudson, Jia Jing Lou, Perry Wiles

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15. Appendices

Appendix 1 - Teleconference workshop on the 9 May 2017 with industry experts and stakeholders from MLA, DAF QLD, USQ, DAF WA, NT DPIF, Rangelands WA

Meeting notes 9 May 2017- Key Point

Meeting notes 9 May 2017.docx

Appendix 2 - Teleconference meeting on the 2 June 2017 with key industry partners from the UK Met Office, BoM and USQ

Teleconference meeting 2 June 2017

Appendix 3 – Research Plan

DCAP2 USQ NACP2 Research.docx

Appendix 4 – Development Plan

DCAP2 USQ NACP2 Development.docx

Appendix 5 – Extension Plan

DCAP2 USQ NACP2 Extension.docx

Appendix 6 – Rate of Investment analysis

Farm and economic parameter	**Total/average**
Total number of (beef) producers	8501
Average herd size (AE/farm)	1462
Total number of (beef) producers directly engaged during the project	50
Total number of producers reached after improved adoption and communication (5%)	425
Total number of producers reached after improved adoption and communication after 5 years of the project (15%)	1275
Total number of (beef) producers directly engaged during the project	$ 439,172
Total number of producers reached after improved adoption and communication (5%)	$ 3,733,400
Total number of producers reached after improved adoption and communication after 5 years of the project (15%)	$ 11,200,201

Average business profit		$ 87,834
Increase in average business profit	10%	$ 8,783

Year	Costs	Benefits				
		Total number of (beef) producers directly engaged during the project	Total number of producers reached after improved adoption and communication (5%)	Total number of producers reached after improved adoption and communication after 5 years of the project (15%)	Total Benefit - Linear adoption	Net benefits
1	$ 74,000					-$ 74,000
2	$ 2,000,000					-$ 2,000,000
3	$ 2,000,000	$ 439,172			$ 439,172	-$ 1,560,828
4	$ 2,000,000	$ 439,172	$ 3,733,400		$ 4,172,572	$ 2,172,572
5	$ 2,000,000	$ 439,172	$ 3,733,400		$ 4,172,572	$ 2,172,572
6				$ 3,733,400	$ 3,733,400	$ 3,733,400
7				$ 3,733,400	$ 3,733,400	$ 3,733,400
8				$ 4,800,086	$ 4,800,086	$ 4,800,086
9				$ 5,866,772	$ 5,866,772	$ 5,866,772
10				$ 6,933,458	$ 6,933,458	$ 6,933,458
11				$ 8,000,144	$ 8,000,144	$ 8,000,144
12				$ 9,066,830	$ 9,066,830	$ 9,066,830
13				$ 10,133,515	$ 10,133,515	$ 10,133,515
14				$ 10,133,515	$ 10,133,515	$ 10,133,515
15				$ 11,200,201	$ 11,200,201	$ 11,200,201
Total cost	8,074,000	1,317,516	7,466,801	73,601,323	82,385,639	74,311,639

NPV	$42,589,082
IRR	62%
BCR	6.2