Department of Agriculture and Fisheries – Drought and Climate Adaptation Program

DCAP Project Final Report

Project ID	USQ 19 – EVI MODIS Predicting pasture production drought risk
Grantee Name	USQ

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Report authorised by:	Name: Professor Roger Stone Date: 30 June 2017
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1. Executive Summary

The project quantified and mapped change in pasture productivity on grazing lands during drought using remote sensing technology, specifically the enhanced vegetation index (EVI), which measures change in green biomass. The project was carried out across the Darling Downs at farm level scales (250 m) to identify where the most drought vulnerable pastures are and where the pastures that recover the best from drought are.

Using remote sensing technology we were able to effectively and efficiently map pasture responses to drought (and their recovery thereafter). Dry periods showed predominantly negative trends, while wetter periods showed widespread positive trends, indicating pasture recovery. Within the broadly identifiable dry and wet period responses, our fine scale mapping highlighted high temporal and spatial heterogeneity in pasture responses. That is, in relatively close proximity to each other pastures showed notably different responses. Indeed in some places and at fine scales some pastures showed a positive response, while nearby pastures showed strong negative responses. This is important because it means that fine scale mapping is needed to identify pasture decline or increase that could be missed if broader resolution maps were used. We were also able to map trends over long time periods (multiple years). This approach allowed us to identify key areas of potential long term decline that may benefit from target investigation and management actions. Without our fine scale and long term approach such areas of chronic decline could be overlooked.

The project was well received by stakeholders (i.e. regional bodies and landholders) who could see the potential and use of the approach for monitoring pasture related management changes over large areas (e.g. all of QLD) and through time. For example, stakeholders identified that they could use the mapping to help them assess the impacts of their on-ground activities to help them manage drought (e.g. fencing, fertiliser application to pasture), while regional bodies highlighted that the maps could be used to identify areas for targeted management action to increase pasture drought resilience. Into the future the methods outlined in this project could be efficiently up-scaled and applied across all of Queensland's grazing lands.

2. Project Background

Drought reduces pasture productivity and causes decline in the extent and quality of land suitable for sustainable, productive and economically viable grazing. Significant damage to pastures occurs when stock numbers are not appropriately managed or reduced during periods of drought (Partridge 1993). An enhanced understanding of the drought risk associated with grazing lands at appropriate landscape and farm level scales will assist land managers to better prepare and plan for drought.

In order to maintain healthy and productive pastures and plan for extended periods of low rainfall (e.g. the recent Millennium Drought), land managers need to know which pastures are most at risk of declining productivity in drought. Although pasture productivity mapping (based on NDVI) and AussieGRASS models are already available, these currently provide pasture productivity at 5 x 5 km scales. This project will supplement existing information resources by developing maps of pasture productivity drought risk based at the finer 0.25 x 0.25 km (paddock) scale and over long time periods (e.g. multiple years).

Furthermore, under future climates, land managers will need to be able to predict what parts of their landscapes will potentially be most impacted by drought and therefore provide for targeted and pro-active early (i.e. strategic) management intervention and adaptation.

Identifying pastures most at risk from drought would allow managers to better understand the carrying capacity of grazing lands and to make more informed decisions about livestock grazing intensities at the farm level and for different parts of the broader landscape under drought. More informed decision making will also enhance the drought resistance and post-drought recovery potential of grazing lands.

3. Project Methodology

We investigated the relationship between primary productivity and drought impact (risk) in grazing lands using remotely sensed (MODIS) data. These data provide a cost-effective and efficient way to analyse and map pasture productivity under different climatic conditions and, hence, to identify pastures most at risk during drought. Remote sensing techniques and imagery provide a range of vegetation indices of productivity (Pettorelli et al. 2005). Time-series normalised difference vegetation index (NDVI) or the more recently derived enhanced vegetation index (EVI) have been used to assess and monitor pasture condition and productivity for grazing over extensive areas (Karnieli et al. 2013; Oltjen and Gunter 2015). EVI is a cost-effective and efficient way to analyse and map pasture productivity and can be used to map entire landscape at high spatial (ca. 250 m) and temporal resolution (ca. monthly)

This project complements current AussieGrass models by masking out areas of high woody vegetation (i.e. foliage projected cover >0.5%) and focusing on pastures with highest growth, hence utility for graziers. In AussieGRASS, pasture growth estimates in areas of mixed pasture and woodland are potentially biased by the smearing of tree basal area over the 5 x 5 km grid cells (DSITI 2015). Our approach avoids this issue as the finer scale of analysis allows preselection of areas with low tree cover. We also use the more recently available EVI product which reduces atmospheric influences that can bias NDVI. The finer scale of assessment of long-term trends used in this project provides enhanced information and support for graziers making farm level herd and pasture management decisions and/or timely decisions to destock under worsening drought conditions.

This project's key objective was to quantify and map change in pasture productivity on grazing lands during drought using EVI across the target landscape (the Darling Downs) at farm level scales (250 m) to identify where the most drought vulnerable pastures are and where the pastures that recover the best from drought are.

The focus of this pilot study was the grazing pastures of the Darling-Downs, southern Queensland. We assessed pastures mapped as grazing lands (from QLD land use mapping) that have low (<0.05%) tree cover. This area was chosen as a case-study area due to its proximity to Toowoomba and the fact that the research group currently has extensive data for this area; the region is also associated with relatively small paddock sizes/grazing scales where finer scale drought risk management information will be of greatest value in decision making. The goal was to develop and refine the approach so that it can be easily applied to other areas.

4. Project Results

Achievements and Outcomes

There are three key results/findings from our study.

First, our approach was able to effectively and efficiently map pasture responses to drought (and their recovery thereafter). Dry periods showed predominantly negative trends, while wetter periods showed widespread positive trends, indicating pasture recover.

Second, while there were broadly identifiable dry and wet period responses, our fine scale mapping approach highlights that high temporal and spatial heterogeneity in pasture responses. That is, in relatively close proximity to each other pastures can show notably different responses. Indeed in some places and at fine scales some pastures show positive response, while nearby pastures show strong negative responses (see Figure 13 in Final report).

Third, we were able to map trends over long time periods (multiple years). This approach allowed us to identify key areas of potential long term decline that may benefit from target investigation and management actions. Without our fine scale and long term approach such areas of chronic decline could easily be overlooked.

Out studies results also highlighted important points of difference with current approaches. The key findings of our study highlight important points of difference with current approaches. For example, we are aware of current AussieGrass models (which FORAGE utilises) and believe our proposed project compliments these products by

• Masking out areas of high woody vegetation / foliage projected cover > 0.05% and focusing on pastures with highest growth / utility for graziers. In AussieGRASS, areas of mixed pasture and dense forest, pasture growth estimates are biased by smearing of tree basal area over the 5 x 5 km grid cells (DSITI 2015). Our proposed approach avoids this issue with a finer scale of analysis and allows preselection of areas with low tree cover. The importance of this is evident in the high heterogeneity observed in our maps (see Figure 13 in Final report).

• We used the more recently available EVI product which reduces atmospheric influences that can bias NDVI. EVI thus might also be more appropriate for comparing responses between different climate conditions (e.g. drought and wet periods) where atmospheric conditions may vary considerably.

• Using finer scale of assessment of longer term trends used in this project will provide enhanced information and support for graziers making farm level herd and pasture management decisions and/or timely decisions to destock their property under drought conditions.

Unintended Outcomes

There was more interest from regional natural resource groups than anticipated. This is detailed below in the partnership formation section.

Partnership Formation

To evaluate the utility of fine scale pasture drought response mapping using EVI we showed the maps to key stakeholders in the area (i.e. Condamine Alliance, Queensland Murray Darling Committee, Conservation Farmers and graziers). All of these groups were interested in the drought pasture maps we produced and other potential applications that could derive from them (e.g. the monitoring and testing of management actions). These groups were also interested in the rolling out of our approach to other areas they manage (e.g. grazing lands across southern Queensland).

Lessons Learned

In order to evaluate the utility of the fine scale pasture drought response mapping using EVI, we showed the maps to key stakeholders in the area. These included the regional Natural Resource Management (NRM) organisations, Condamine Alliance and Queensland Murray Darling Committee, Conservation Farmers Inc., Condamine Catchment Management Association Inc. (which is composed of a number of landholders) and selected graziers.

From these interactions lessons learned are briefly summarised below. For more detail on these refer to the final project report.

Some key comments were:

- The maps could be used as a tool to help communicate issues and provide a point of references or baseline for landholders who are interested in asking questions about drought resilience;
- The maps could help advise and target management activities by identifying areas at high drought risk;
- The maps may be of interest to larger corporate farms, as the small gains they inform may be most noticeable at the scales they operate at;
- The maps may be of interest to government, investors, banks and the insurance industry as a risk assessment tool (i.e. which properties are most at risk from drought).
- QMDC would be keen to use the product if we were able to upscale and produce a seamless version across their entire management areas (i.e. the Queensland section of the Murray Darling Basin). It could form part of the current spatial assessments that they do for the area.
- The maps would be useful to use a discussion starter for engaging with landholders (e.g. asking landholders why they think certain parts of their property are more or less vulnerable to drought and then working together with them to develop management actions try and improve this)

Some key advice included:

- Don't use red colours as they signify 'bad', which may deter some landholders from using the maps;
- Start with fine-scale communication, showing the maps to landholders at the property scale, rather than across the entire area
- Produce a set of guidelines to assist NRM organisations (and others) to update the mapping.

Implications for the Future

The successful application of our methods to mapping pasture productivity trends using EVI on the Darling Downs and subsequent discussion with land managers has indicated several future research directions. Some of these potential project ideas have been put forward as a proposal for DCAP Round 2.

- The methods outlined in this project could be up-scaled and applied across all of Queensland grazing lands. The cost-effective and large temporal and spatial extent of remotely sensed EVI data makes this possible. High performance computing (HPC) facilities available at USQ also make this task computationally feasible. The resulting fine scale maps of pasture responses to drought (or climatic events such as El Niño) could then be used to inform grazing drought management across all of Queensland.
- As mentioned in many of the discussions with stakeholders, EVI data could be integrated with other data sources to enhance the monitoring and evaluation of management actions on the ground. For example, the effects of different stocking decisions, total grazing pressure, burning regimes or nutrient addition could be quantified using EVI. Related to this, large scale actions, such as cluster fencing, could also be assessed.
- The fine scale EVI data could be used to assess the relative effectiveness of different drought warning indices in terms of their association with pasture productivity change. The utility of drought indices could be evaluated by overlaying and testing their relationships with pasture trend mapping across QLD grazing areas (this approach provides a valuable cross correlation with the USQ-led project developing drought indices for Queensland). Where drought indices and pasture trends correlate strongly, this will suggest where (and under what conditions) particular drought indices might be of most use for graziers in decision making to strategically manage drought risk. The relationships between drought indices and pasture trends could also be provided as maps to facilitate easy use by landholders.

5. Conclusion

This project (USQ19) successfully used remote sensing technologies to map pasture responses and recover to drought across the Darling Downs. Stakeholder engagement identified many potential uses for the mapping, e.g. to identify areas of concern for future management or to monitor the impacts of on-ground activities. The methods and results outlined are applicable to other pastures and could be developed for grazing areas throughout Queensland efficiently using the capabilities and high performance computing facilities at USQ.

6. Financial Statement (Revenue received/Expenses paid/Revenue unspent

TBA

7. Additional Information

Additional information can be found in the project report - Drought Climate Adaptation Program. Project 19: Using EVI MODIS to predict pasture production drought risk. Final report, June 2017 (see Appendix 1).

8. References

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9. Appendices/Attachments

9.1 Milestone Reports

9.2 Case Studies

9.3 Project Reports

Appendix 1. Drought Climate Adaptation Program. Project 19: Using EVI MODIS to predict pasture production drought risk. Final report, June 2017

9.4 Scientific Papers

In preparation

9.5 Products/Product Descriptions

Appendix 2. 250m resolution maps of short term (year and year) and long term (across multiple years) pasture responses and recovery from drought.

9.6 Other Relevant Attachments

Appendix 1. Drought Climate Adaptation Program. Project 19: Using EVI MODIS to predict pasture production drought risk. Final report, June 2017

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Appendix 2. 250m resolution maps of short term (year and year) and long term (across multiple years) pasture responses and recovery from drought (these images are available in higher resolution formats if needed)

Map Images DCAP1
USQ19.pdf