PROCEEDINGS OF THE AUSTRALIAN RANGELAND SOCIETY BIENNIAL CONFERENCE

Official publication of The Australian Rangeland Society

Form of Reference

The reference for this article should be in this general form;
Author family name, initials (year). Title. *In*: Proceedings of the nth Australian Rangeland Society Biennial Conference. Pages. (Australian Rangeland Society: Australia).
For example:
Anderson, L., van Klinken, R. D., and Shepherd, D. (2008). Aerially surveying Mesquite *(Prosopis* spp.) in the Pilbara. *In*: 'A Climate of Change in the Rangelands. Proceedings of the 15th Australian Rangeland Society Biennial Conference'. (Ed. D. Orr) 4 pages. (Australian Rangeland Society: Australia).

The Australian Rangeland Society

MANAGING RANGELANDS FOR CLIMATE VARIABILITY: EVALUATION OF 'SKILL' IN SEASONAL OUTLOOKS

B. Henry[1,2], *D. Bruget*[1], *N. Flood*[1], *P. Timmers*[1], *A. Peacock*[1], *G. McKeon*[1] *and J. Carter*[1]

[1] Queensland Department of Natural Resources, Mines and Water, Indooroopilly, Qld 4068
[2]Corresponding author: Email Beverley.henry@nrm.qld.gov.au

ABSTRACT
Understanding when and where seasonal climate outlooks provide reliable decision support information is an important step to increasing confidence in and adoption of climate risk assessment in managing grazing lands. A continental-scale framework was developed to allow statistical tests, e.g. LEPS scores, to be calculated for seasonal forecasting systems. These tests indicated that seasonal climate outlooks using pasture growth as the predicted variable had greater reliability than for rainfall. We discuss preliminary 'skill' analysis and how spatial and temporal variability in reliability of outlooks could be utilised by scientists and advisers to improve the value of climate risk information available to support more sustainable management of inter-annual climate variability in the rangelands.

INTRODUCTION
The arid and semi-arid rangelands of Australia are characterised by a highly variable climate. This variability on inter-annual and longer time scales can have a major impact on profitability of grazing enterprises (Nelson and Kokic 2004) and risk of degradation of landscapes (McKeon *et al.* 2004). Future climate cannot be known with certainty; we can only improve the odds for planning strategies. A 2002 "Best Practice Survey" of more than 1500 wool growers (Land, Water and Wool Program, www.landwaterwool.gov.au) found that lack of confidence in the 'accuracy' of forecasts was the main reason for failure to respond to predictions of unfavourable conditions. Climate scientists and extension officers are faced with the difficult task of communicating regionally-relevant, useful information to graziers when reliability of forecasting systems is variable. A first step in increasing adoption of climate risk information is, therefore, to accurately represent the reliability of outlooks and the spatial and temporal variability in the strength of indices that relate a measure of ocean or atmospheric state to a factor (e.g. rainfall or pasture growth) influencing climate-dependent management decisions. We present the results of initial tests of the reliability of an operational seasonal climate forecasting system across Australia and discuss how these results could be used to enhance communication of climate risk for grazing land management to increase adoption of climate information in decision making.

METHODS
El Nino-Southern Oscillation (ENSO) is a major driver of inter-annual variability over much of Australia (Figure 1). To analyse the strength of the relationship between SOI or SST measures of ENSO state and rainfall, an application called *Map Arranger* was added to the AussieGRASS framework. AussieGRASS provides probabilities of exceeding the long-term (115 years) median value of rainfall and pasture growth on a 0.05^{o} grid nationally. *Map Arranger* was programmed to allow statistical tests to be calculated for each of the approximately 280,000 5km square pixels across the continent and for a range of forecast periods and lead times. In the operational AussieGRASS system, probabilities are based on

the SOI 5-phase seasonal climate forecasting system (Stone *et al.* 1996) which provides outlooks for rainfall three months ahead. In principle any seasonal climate forecasting system which could split historical years into groups (year-types) could be tested but this discussion is restricted to the SOI phase operational system.

Statistics for hindcast verification and forecast skill have been applied in the test framework. Discrimination between the sets of analogues generated by dividing historic years into year-types (e.g. corresponding to the SOI phases) can be tested using Chi-square or Kruskal Wallace tests (Henry *et al.* 2004). These tests establish whether the forecasting system may provide a better estimate of future climate than from all-years climatology. The Kolmogorov Smirnoff test or KW test for individual year-types can indicate which phases of the forecast system provided the discrimination. To measure the skill of the forecast of rainfall and pasture growth outlooks produced by the seasonal outlook system in AussieGRASS, the Linear Error in Probability Space (LEPS) score was also programmed into *Map Arranger.*

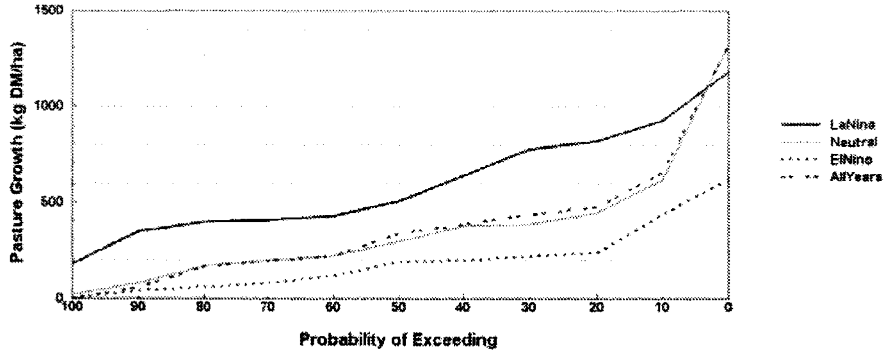

Figure 1: Illustration of the impact of ENSO on simulated pasture growth for a site in northern NSW. In this example the probability of growing more than 400kg/ha ranges from approximately 10% in an El Niño year to 75% in a La Niña year

Briefly, a LEPS score measures the departure between forecasts and observations in cumulative probability space. It evaluates model skill by penalising errors in terms of the magnitude of this departure. In applying a LEPS scoring matrix to verification of a probabilistic categorical forecast, e.g. the probability of above or below the median value as calculated in AussieGRASS for rainfall, the expected score for a constant forecast of any category is the same as the climatological distribution in each category (Potts *et al.* 1996). In addition to examining the skill for the forecasting system, calculation of LEPS scores for individual year-types showed which phases have skill for each forecast.

LEPS scores were calculated for pasture growth outlooks as well as for rainfall. Pasture growth depends not only on rainfall and other climate variables but also the initial condition of the grazing system. Calculation of LEPS skill scores for pasture growth is thus complicated by the need to consider not only the season ahead but also the past as reflected in current conditions. The first step is to generate analogue years to enable a probabilistic forecast of above or below median growth. This process is computationally demanding because these analogues must be applied to simulations of current conditions for each month of each year in the historical record (i.e. 115 years x 12 months in AussieGRASS which uses all years since 1890). This procedure resulted in 115 observed/predicted pairs for each three-month forecast period throughout the year. The 'observed' values are simulated rather than measured but validation over more than a decade of AussieGRASS modelling provides some confidence that the simulations reflect actual growth and the system provides a valid test of ability to forecast simulated growth in the absence of actual climate data given the historical record, current conditions and a classification that provides discrimination between year-types identified by phases of the SOI system. To reduce the number of calculations, the number of pixels for which the calculation was done across Australia was reduced by a factor of 5.

DISCUSSION

LEPS scores (Figure 2) show that the SOI phase system like other statistical seasonal forecasting systems based on measures of ENSO (Drosdowsky 2002, Fawcett *et al.* 2005) demonstrate 'skill' for only a few months of the year over much of the rangelands. The challenge is how to communicate to land managers the value of seasonal climate forecasts without over-selling current capability. There is a risk of loss of confidence in the system at any time if the strength of signal together with the probability is not communicated clearly.

Calculated LEPS scores for pasture growth are markedly higher than for rainfall (Figure 2). Pasture growth relates more directly than rainfall to decisions such as stocking rate and while absolute simulations of growth at 5 km resolution may not be accurate at a point or capture property scale variability, validation studies show that relative values reflect reality (Carter *et al.* 2003). The additional 'skill' in pasture growth outlooks derives largely from knowledge of initial conditions. Factors such as soil moisture, nutrient status and grass basal cover at the start of the season have a major influence on pasture growth for any future rainfall scenario. Preliminary sensitivity analysis in selected regions indicates that the key parameters in the reliability of simulated pasture growth outlooks vary across ecosystems but grass basal cover, soil moisture and available nitrogen can be drivers. This understanding provides a potential to integrate climate risk information with graziers' knowledge of their own property conditions and pasture response. However, the analysis also indicated the sensitivity to components of the pasture model (pasture basal cover, nitrogen uptake and use) which should be improved.

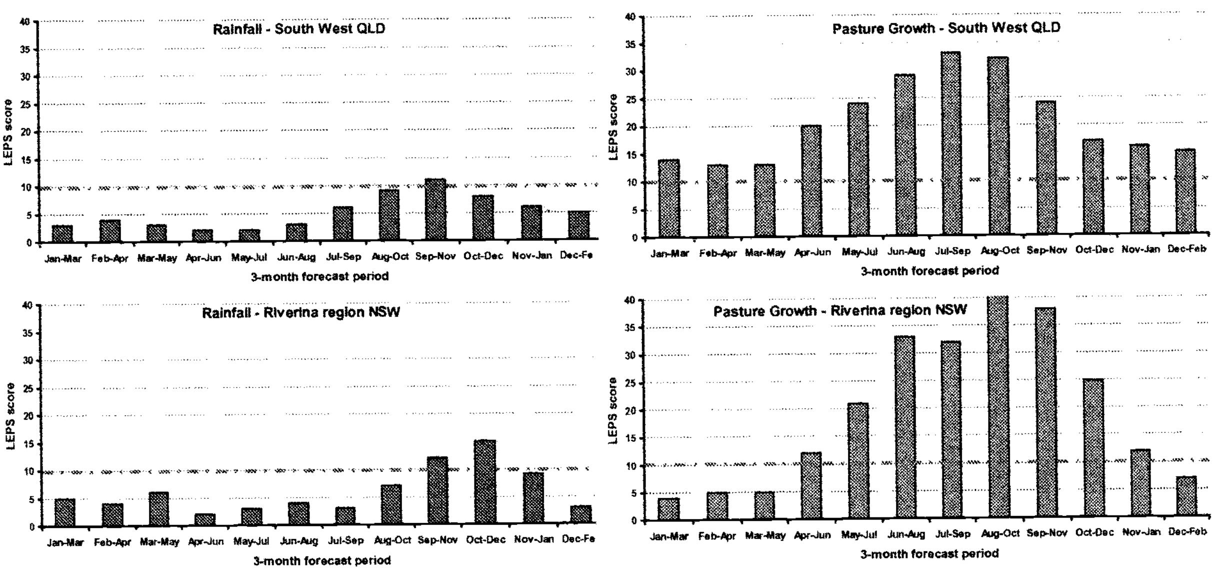

Figure 2: Examples for two pastoral regions of LEPS skill scores for outlooks for rainfall and pasture growth using the SOI phase system

LEPS scores of ≥10 are considered to indicate that the forecast is better than climatology.

Knowledge of the temporal and spatial variability in reliability of seasonal climate outlooks allows the option of issuing rainfall or pasture growth outlooks only when there is confidence in the signal (Hacker *et al.* 2006). Leith (2006) reported that pastoralists expressed a preference for the forecast to be 70-80% reliable. It takes several years to build confidence in a seasonal forecast system so issuing outlooks when reliability is low will likely delay adoption further. In addition, unless the forecast is for a significant shift in probabilities from climatology, land managers are unlikely to change a decision. The 2002 LWW "Best Practice Survey" (www.landwaterwool.gov.au) found that 60% of graziers would be likely to alter management if a seasonal outlook predicted double the chance of a dry season. Further, the time when climate outlooks have statistical skill may not coincide with the time when key management decisions have to be made. These criteria are difficult to meet with the current operational seasonal climate forecast systems, but increased understanding of climate variability, reliability of seasonal climate outlooks and how to interpret climate indices will build confidence to accept future developments and promote informed adoption of current systems. At times when current systems cannot provide reliable climate outlooks, risk can be assessed in the context of enterprise management strategies. Individual approaches to risk varies, e.g. in the absence of a strong climate signal, a risk averse approach would be to match stocking rates to achieve a safe level of utilization of current feed availability assuming no rain in the season ahead.

In summary, increased adoption of seasonal climate risk assessment in rangeland management has the potential to promote opportunities in good years or minimize risk of economic loss or resource degradation in poor years. Confidence in seasonal outlooks will be enhanced with better understanding of their reliability and the framework described in this paper enables analysis of the spatial and temporal variability in statistical skill of current and emerging systems. The type of risk information that is of most value to land managers is being investigated in the context of how to provide useful data at times of the year when seasonal outlooks are reliable and also when strength of the signal of climate indices is low.

ACKNOWLEDGEMENTS

We gratefully acknowledge the funding and support of the Land Water and Wool Climate Program, advice of R. Hacker, I. Watson, M. Rebbeck and D. Cobon, the continuing support of AussieGRASS collaborators nationally and support of Qld NRMW.

REFERENCES

Carter J. *et al.* (2003) Australian Grassland and Rangeland Assessment by Spatial Simulation (AussieGRASS). Proceedings of the National Drought Forum, Brisbane, April 2003.

Drosdowsky W. (2002) SST phases and Australian rainfall. *Australian Meteorological Magazine* 51: 1-12.

Fawcett R.J.B. *et al.* (2005) A verification of publicly-issued seasonal forecasts issued by the Australian Bureau of Meteorology: 19-2003. *Australian Meteorological Magazine* **54:** 1-13.

Hacker R. *et al.* (2006) Betting on rain, managing seasonal risk in western NSW. NSW Department of Primary Industries.

Henry B. *et al.* (2004). Improved Climate Forecasts for Australia's Wool Producers. Australian Rangeland Society 13th Biennial Conference, Alice Springs, July 2004. p.257-258.

Leith P.B. (2006). Conversations about climate: seasonal variability and graziers' decisions in the eastern rangeland. Uni. of Tasmania, Hobart.

McKeon G.M. et al. (2004). Pasture degradation and recovery in Australia's rangelands: Learning from History. NRSc publishing, Queensland Natural Resources, Mines & Energy.

Nelson R., Kokic P. (2004) Forecasting the regional impact of climate variability on Australian crop farm incomes. ABARE Report 04.23, Canberra.

Potts J.M. *et al.* (1996) Revised "LEPS" scores for assessing climate model simulations and long-range forecasts. *J. Climatology* 9: 34 – 53.

Stone, R.C. *et al.* (1996). Prediction of global rainfall probabilities using phases of the Southern Oscillation Index. *Nature* 384: 252–55.