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Resilient Future Rangelands: Integrating Environment and Livelihoods

2-5 September 2019, Canberra

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Resilient Future Rangelands:

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ABSTRACTS

The Australian Rangeland Society

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Grazing management practices for the future of Chinese grasslands

Warwick Badgery[1], Prof David Kemp[2], Prof Yingjun Zhang[3], Dr Zhongwu Wang[4], Prof Guodong Han[4], Dr Yi Sun[5], Prof Fujiang Hou[5], Dr David Michalk[2], Dr Karl Behrendt[6]

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Biography:

Dr Warwick Badgery is the Rangelands and Tropical Pastures research leader with NSW Department of Primary Industries (DPI). He has worked with DPI for the last 14 years performing research on grazing management, farming systems, pasture agronomy, soil carbon and weed management. Warwick is currently the Program Leader of the Feedbase program for the national Livestock Productivity Partnership where he has projects on tactical decision making, tropical pastures and perennial legume persistence. Previously he worked on an ACIAR project examining the sustainable development of grazing systems in Western China. He is passionate about improving farm management practices.

There are 400M ha of grasslands in China of which 90% are considered degraded by overgrazing due to the large increase in people and animals since the 1950s. The aim of this paper is to synthesize the information from three grazing experiments located in desert steppe at Siziwang, Inner Mongolia (41°46'N, 111°53'E), typical steppe at Guyuan, Hebei (41°45'N 115°39'E) and alpine meadow at Maqu, Gansu (N35°85', E101°85'). The research helped develop criteria for the optimal grazing management and utilisation to enhance grassland composition, while maintaining livestock production and essential ecosystems services (GHG mitigation and prevention of erosion). Stocking rates, over the summer growing season, needed to be half the district average at the desert steppe (i.e. 150 sheep equivalent (SE) grazing days per ha per year) and typical steppe (i.e. 400 SE grazing days per ha per year) sites to improve livestock performance, maintain a desirable grassland composition and improve soil carbon and system greenhouse gas emissions (only significant at Guyuan). While the district average stocking rate at the alpine meadow site was considered sustainable (600 SE grazing days per ha per year) with no benefits from lighter stocking rates. The optimum management was associated with maintaining >0.5 t DM/ha at the desert steppe and typical steppe sites and this was considered a bench mark that could be used to determine when to start and finish of grazing. The alpine meadow had a residual herbage mass of close to 2 t DM/ha. Beside the negative effect of winter grazing, determine from unintended grazing on the Siziwang experiment, there was no clear benefit from other grazing management strategies. Although, no experiment was grazed during the vulnerable period during spring.

Incentivising the co-benefits of carbon farming through multifunctional auction schemes

Dr Alex Baumber[1], Professor Graciela Metternicht[2], Dr Rebecca Cross[3]
[1]University of Technology Sydney, Sydney, Australia, [2]UNSW Sydney, Sydney, Australia, [3]The University of Sydney, Sydney, Australia

Biography:
Alex's research focuses on ways to incentivise the protection and restoration of land through carbon farming, bioenergy cropping and other market-based approaches. He is currently working with NSW DPI on a project relating to the co-benefits of carbon farming and has recently completed a project on landholder collaboration for landscape-scale conservation. In 2016 he released his first book, exploring how woody bioenergy crops could create incentives to restore degraded land. His research has been published in the Journal of Environmental Management, Ecosystem Services, Environmental Science and Policy, Biomass and Bioenergy, Ecological Management and Restoration and the Rangeland Journal.

Carbon farming, in the form of assisted natural regeneration, environmental plantings, avoided deforestation and savanna burning, has emerged as a major new land use activity in rangeland Australia. These practices have been linked to a diversity of potential co-benefits, such as habitat for biodiversity, soil protection against erosion and salinity, and cultural benefits for Indigenous communities. While the outcomes of carbon farming are yet to be fully assessed through empirical research, previous studies into the practices that are typically involved have identified a variety of land management strategies that could be employed to optimise outcomes for biodiversity, soils, water and people. However, despite the potential for carbon farming to deliver these co-benefits, the primary policy driver for carbon farming in Australia, the Australian Government's Emissions Reduction Fund (ERF), does not differentiate between activities that offer these co-benefits and those that do not. The ERF is now at a critical juncture, with the Liberal/National government extending it in February 2019, Labor proposing to introduce a new emissions trading scheme, and voluntary trade growing in carbon offsets. In this policy climate, there is an opportunity for the ERF to benefit from the kinds of reforms that have been made to other payment for ecosystem services schemes around the world, where multifunctional land use practices have been incentivised rather than simply focusing on lowest-cost delivery of a single ecosystem service.

Highlights:
- Carbon farming can create co-benefits for biodiversity, soils, water and people
- Australia's auction-based carbon farming policy mechanism is at a critical juncture
- Experiences around other payments for ecosystem services markets has shown how multifunctional benefits can be built into auction-based policy mechanisms

Modelling Chinese grassland systems to improve herder livelihoods and environmental outcomes

Dr Karl Behrendt[1,2], Prof. David Kemp[1], Dr Haibo Liu[1,3], Dr Taro Takahashi[4,5]

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Biography:

Prof Karl Behrendt joined Harper Adams University in January 2018 and is Director of the Global Institute for Agri-Tech Economics. He is also a Senior Research Fellow within the Graham Centre. His focus is on working with industry and other research institutions to provide economic intelligence and agri-tech solutions for UK and global agriculture and value chains. His core disciplines are in the bioeconomic modelling of agricultural systems and decision support for farmers. Prof Behrendt is currently undertaking research into the economics of precision livestock farming, robotics in agriculture and improving grassland policies and practices in China and Mongolia.

Environmental, financial and political influences affect Chinese herders' livelihoods with the expectation that they maintain biologically and economically resilient systems. Making decisions regarding the management of a grassland resource is an important and complex bioeconomic problem. It involves the consideration of interactions between grassland ecology, the use of technology to improve and manage the resource, environmental externalities, utilisation of the resource by grazing animals, and the profitability of the grassland system. Climate and price risk also influences the future profitability and productivity of the system, as well as the future state of the soil and grassland resource. The use of conventional production economics to support socially acceptable decision making regarding shorter term production and profit objectives of livestock systems is not fit for purpose, where the focus is increasingly on improving environmental outcomes. The challenge lies in identifying profitable and ecologically sustainable livestock production systems from dynamic grassland resources. This paper introduces a suite of models that have been developed through ACIAR supported projects in China since 2001 to help understand grassland systems and investigate options for changes in their use and management. The four models developed are: feed balance analyser (StageONE), linear program optimiser (StageTWO), dynamic sustainability (StageTHREE SGM), and precision livestock management (PhaseONE). These models have all been built as standalone units, but share much common data and functions to address different questions. These research questions addressed a range of particular challenges identified in Chinese grassland systems. In addition, the development of the models left readily adaptable tools for use by Chinese and Australian researchers and analysts, as well as provide an ongoing legacy in supporting interdisciplinary and systems thinking based approaches to the use and management of Chinese grasslands.

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How well does ground cover predict land condition?

Dr Terry Beutel[1], Mr Bob Shepherd[1], Mr Brett Abbott[2], Mr Robert Karfs[1], Mr Trevor Hall[1], Dr Teresa Eyre[3], Dr Scott Parsons[4]

[1]Department of Agriculture and Fisheries, Rockhampton, Australia, [2]CSIRO Land and Water, Douglas, 4814, [3]Department of Environment and Science, Toowong, 4066, [4]James Cook University, Douglas, 4814

Biography:

Terry Beutel is a spatial scientist with interests in rangeland ecology, statistical modelling and spatial analysis. His main work focuses on the use and delivery of remotely sensed ground cover and land condition data.

National and state agencies in Australia have invested heavily in the remote measurement of ground cover over recent decades. Consequently, a number of datasets and services now provide public access to a vast archive of ground cover measurements. These data have found many uses in the rangelands, one of which is indexing rangeland condition, and while cover indices are regularly interpreted as surrogates for rangeland health and productivity, few studies have quantitatively tested the relationship between cover and condition across a large number of sites. This study tests that relationship on a set of over 2000 sites in Queensland. At these sites, condition was assessed using the ABCD land condition framework. Land condition ratings were then correlated with a number of land condition indices derived from remotely sensed ground cover data. The results show that ground cover is a useful, though limited predictor of land condition. They also show that ground cover predicts land condition significantly better if it is scaled to regional conditions. These results have a number of important implications for how we interpret and use remotely sensed ground cover data across a range of scales and activities. We use our findings to provide guidelines for better interpretation of remotely sensed ground cover data.

Observing and Tracking the role of Aboriginal Culture in sustaining Country and enabling resilient rangelands

Mr Sandy Booth[1], Mr Geoff Simpson[1], Dr Mal Ridges[1], Mr Mick Kelly[1], Ms Sarah Paddingtom[2]
[1]*Science Division NSW Office of Environment and Heritage, Parramatta, Australia,* [2]*NSW Aboriginal Affairs, Mascot, Australia*

Biography:
Sandy natural resource management practitioner and researcher with over 40 years' experience in community participation, capacity building, strategy development and review. He is passionate about frameworks for sustainability. Starting out as a Soil Conservationist researching woody shrubs west of the Darling and Paroo, he became State Director Catchment Management before leaving the public sector and completing over 200 consultancies Australia, Indonesia and China. As a Principal Scientist in OEH, he is currently Lead Investigator on a NSW Environmental Trust funded project researching the role of Aboriginal Culture in resilient environmental management engagement in the mallee of far south-western NSW.

Observing and Tracking the role of Aboriginal Culture in sustaining Country and enabling resilient rangelands.

Sandy Booth$_1$, Geoff Simpson$_1$, Mal Ridges$_1$, Mick Kelly$_1$ and Sarah Paddington$_2$

$_1$Science Division, NSW Office of Environment and Heritage
$_2$NSW Aboriginal Affairs

Wider application of Aboriginal Culture by indigenous and non-indigenous people holds huge potential to improve our pursuit of sustainability in rangelands and beyond. Aboriginal Culture has sustained Country for millennia, embracing periods of considerable climate change. The challenge in researching the role that Culture can play, requires respectful and continuing engagement with Aboriginal people. Participating in shared experiences is an important first step in helping to build sincere relationships. Coming together on-Country around a camp fire to share and reflect on each other's' contributions, stories, knowledge and laughter sets a solid foundation for identifying the synergies between people and the disciplines of science and Culture. In terms of gathering evidence that involves people on Country, an adaptive approach that draws on both Culture and Science is showing promise in far South-Western NSW. Culturally-informed, less intrusive multiple methods are showing utility. They are better allowing Culture to shape and influence, and Country to speak, to help bring about change. A Cultural Process Model and associated MER metrics are exploring the role that Aboriginal Culture plays in sustaining engagement. A Thinking and Feeling Colour Wheel simply records cognitive and emotional responses which are mapped against the metrics recorded at culturally-informed environment management activities. Initial results are indicating that:
* Walking Aboriginal Culture and science alongside has generated an innovative approach
* A cultural pathway is enabling a simple, yet unobtrusive and rigorous way to observe and track changes from culturally-connected rangelands management activities
* Co-developed monitoring tools are being used indigenous and non-indigenous researchers and are suitable for use by indigenous communities themselves.

Developing enabling rangelands policies in dialogue with land managers, regulators, policy makers and researchers

Mr Greg Brennan[1]

[1]*Grazing Innovation, GERALDTON, Australia*

Biography:

Greg Brennan worked in Australian and Papua New Guinean rangelands for 5 decades as a pastoralist, wholesale butcher, consultant and extension officer with the WA Dept of Agriculture. He has university qualifications in science, economics and social science. Since arriving at Kalgoorlie WA in 2000 he has developed a passion for revitalising the Australian southern rangelands. He believes that developing enabling policies for regenerative management is a 'wicked problem', requiring new multi-disciplined approaches that capture the enthusiasm of stakeholders and the emerging opportunities of contemporary social, environmental and economic forces. These policies will be equally applicable to northern rangelands.

Australian rangelands are enjoying attractive economic opportunities with the burgeoning demands for livestock products and for some regions, the emerging markets for carbon products. However, in some regions of Western Australia, incremental losses of range condition since pastoralism began, have in aggregate, amounted to substantial reductions in productive capacity. These forces will be exacerbated by the predicted changes in climate.

• Economic analysis shows that regenerative management practices can be commercially unattractive due to risks of failure and the lengthy time lags before pastures regenerate.
Traditional policies for sustainable rangelands development focus on regulation, information transfer and market mechanisms; all of which show sparse evidence of effectiveness. Therefore, alternative policies must be developed to address the increasing challenges and opportunities.
• The management of rangelands involves complex relationships between land managers, regulators, policy makers, researchers, markets and the Australian community.
This complex mix of multiple perspectives, often involving conflict and uncertainty, poses serious challenges to traditional science-based policy development. These multiple perspectives all represent valid responses to different needs, different experiences and different knowledge systems.
• Social technologies such as 'social learning', offer means to engage these multiple perspectives in processes to improve rangelands policy development.

These processes bring stakeholders together in dialogue to explore each other's assumptions and the complexities, manage the conflicts and find common ground while developing trust and respect.

A process of concerted action to support regenerative management can then be created incorporating on-going processes that accommodate the inevitable unexpected consequences of new ways of working. To be effective, these social technologies demand high level facilitation skills and substantial up-front resourcing.

This paper will draw on Australian and international research, explaining how social technologies might improve processes for developing enabling rangeland policies.

Territory Conservation Agreements: partnerships protecting native vegetation and biodiversity across the NT

Mr Andy Bubb[1], Ms Karen May[2], Ms Ann Palmer[2]
[1]Andy Bubb Consulting Pty Ltd, Darwin, Australia, [2]Territory Natural Resource Management, Darwin, Australia

Biography:
Andy Bubb has lived and worked in remote Northern Australia since 2003 in the agriculture, natural resource management and research services sector. This has included working with Government Agencies, Cooperative Research Centres, Aboriginal Land Managers and private enterprise. Since establishing Andy Bubb Consulting in 2015 Andy has worked closely with pastoralists across the Northern Territory on both production and conservation projects. Andy Bubb has a Bachelor of Applied Science in Agriculture from the University of Melbourne and is undertaking graduate studies in evaluation.

The Territory Conservation Agreements (TCA) program was established by Territory Natural Resource Management (NRM) in 2011. The program is built upon voluntary 10 year agreements between Territory NRM and partnering landholders. It supports the introduction of best practice management to protect and enhance ecological and productive values at defined sites of conservation significance.

Under the TCA program, site management actions are consistent with the broader management goals for the property, and enable multi-use strategies which can demonstrate production benefits as well as deliver conservation outcomes.

Territory NRM has invested more than $1.3million to establish TCAs, with participating landholders contributing a further $1.8million of cash and in-kind. A total of 47 TCA sites have been established across the Northern Territory. There are 55,000Ha of TCA's across 28 pastoral properties.

Examples of TCAs include the fencing off of fragile springs and waterholes and pumping water for stock and native animals to other sites away from the sensitive areas. TCAs have also been used to establish fencing to protect riparian areas on rivers and important flora species.

This review of the TCA program found that participating landholders have had a positive experience in establishing and maintaining the areas. Both environmental and production benefits have been identified by pastoralists that have TCA sites on their properties. Few negative impacts of participation in the program were identified.

This review involved TCA sites that covered over 30,000ha across 17 properties. Importantly, the broader area that is under the control of the same managers is over 5.1 million ha. This extended area of influence is a strength of the TCA program. The findings of the review will be discussed.

10 Deserts Project - how an Indigenous-led landscape scale collaboration is building environmental resilience

Mr Gareth Catt[1]

[1]*Desert Support Services, East Perth, Australia*

Biography:

Gareth Catt has been working for over 10 years in environmental management with park agencies and Indigenous land management organisations in central and Western Australia. For the past 7 years he has specialised in fire management with Indigenous rangers to look after their country with right way fire.

Australia's deserts are globally significant, rich in culture and home to some of Australia's iconic threatened fauna and flora species. They are also home for Aboriginal people who have inhabited and managed their country for thousands of years passing on their knowledge of country and culture from generation to generation.

Despite their relative low level of development, the deserts face common threats – altered fire regimes as patterns of occupation changed; feral predators such as cats and foxes; large feral herbivores that impact on water holes, cultural sites and vegetation; and invasive weeds such as buffel grass.

The 10 Deserts Project seeks to address these threats and build the environmental resilience of desert country by building the capacity of Aboriginal people to look after country using both traditional and contemporary practices. It seeks to do this at scale by increasing the number of Indigenous ranger teams across the deserts, providing training and networking opportunities to overcome isolation and to work together on regional strategies such as fire and feral camel management.

This presentation will provide an overview of the project and in particular the developing fire management strategy that will increase the breadth and scale of fire management to reduce negative impact of large continuous fires on biodiversity and cultural sites.

Northern Australian Beef Industry Situation Analysis

Dr Chris Chilcott[1], Dr Andrew Ash[1], Dr Sigrid Lehnert[1]
[1]*CSIRO, Darwin, Australia*

Biography:
to be added

With an ongoing interest in developing northern Australia, we undertook a beef situation analysis to assist the Cooperative Research Centre for Developing Northern Australian in tailoring their investment decisions. The northern beef industry is dominated by rangeland enterprises that include family farms, indigenous pastoral enterprises and large corporate interests. The analysis was a whole of supply chain examination of current practices, strategies and plans. It included consultation with producers, industry groups, research organisations and government departments. We found that the industry faces challenges in maintaining profitability and its social license to operate. Further, it is not immune to Global megatrends, where megatrends are defined as a significant shift in environmental, economic and social conditions that will play out over the coming decades, and the impacts of associated policy responses, some of which are already influencing industry strategies and investments. Whilst, new research is required to push the innovation frontier, there was widespread recognition in the consultation that there is sufficient technical research currently available to make the vast majority of enterprises more profitable and that the key challenge is translating science into practice. The review challenges the notion that traditional approaches to research extension are effective, and that the social and behavioural characteristics in which research findings are presented needs to be better understood. Pathways to uptake of research based on a typology that characterises the different ways producers behave, find and use R&D products and interact across scale and sector is needed to improve the current practices within the northern beef sector. Given the decline in government extension services, this may require consultants who are system science translators; individuals who are not specialists in one technical or disciplinary area, but rather, who can integrate different findings across production, animal health, resource management and economic aspects.

Consequences of extreme climate conditions on plant productivity and recovery among diverse pastures

Dr Amy Churchill[1], Dr Haiyang Zhang[1], Kathryn Fuller[1], Manjunatha Chandregowda[1], Karen Catunda[1], Dr Sally Power[1]

[1]*Western Sydney University, Hawkesbury Institute For The Environment, Richmond, Australia*

Biography:

I am a plant ecologist researching the interface of plant community and ecosystem ecology and how plants can affect ecosystem scale processes in response to global change factors. My research background has emphasised community structure and controls on ecosystem processes, comparing responses of different plant communities associated with nitrogen deposition in the alpine (PhD work) and changes in hydrology associated with climate change in the boreal forest (MS work). My postdoctoral work expands these research questions into the pasturelands of eastern Australia under manipulations of combined extreme temperature and drought.

One of the most pressing concerns for the sustainability and resilience of rangelands across Australia are the predicted consequences of climate change and how future conditions will impact the livestock and dairy industries. The Pastures and Climate Extreme experiment investigates the effects of extreme climate on ten common pasture forage species. To address future concerns of the impacts of climate change on pastures, we have implemented a warming (+3^{o}C ambient) manipulation that facilitates increased heatwaves during summer months and a 60% reduction in winter/spring precipitation treatment producing extreme drought conditions. Warming has been maintained using infrared heating lamps since April 2018, with drought conditions implemented June 2018 and again in June 2019. In our first full year of treatments we have found that:

- Temperate grasses strongly declined under winter/spring drought conditions, with reductions in biomass of 75% for Rye grass and 65% for Fescue (6 month drought). Phalaris declined by 45% grown alone, and by 65% in a mixed Phalaris-Sub clover pasture (1 month drought). Summer recovery for these species was largely controlled by tiller density due to high mortality of individuals during drought.
- Tropical grasses also declined during drought, with productivity losses ranging from 80% (Digit grass) to 45% (Kangaroo grass); however both non-native species (Rhodes and Digit) had recovered from drought by the first summer harvest period 2-3 months following the end of drought.
- During winter and spring a native Kangaroo-Wallaby grass mixture benefited from the elevated temperature conditions in the absence of drought, however summer warming reversed this pattern-causing a 25% decline in production.
- Lucerne greenness also benefited from warmer winter temperatures; however this benefit was short-lived and did not translate into higher spring production. In fact, warming reduced the crude protein content in winter-spring forage.

The Modern Outback: The rise of large-scale conservation land management in remote Australia

Pepe Clarke[1]
[1]*The Pew Charitable Trusts, Brisbane, Australia*

Outback Australia is one of the last great natural places on Earth – covering more than 70 per cent of the continent. Over the past decade, there has been an unprecedented and internationally significant expansion in the area of land protected and actively managed for conservation in the Outback.

Since 2007, more than 60 million hectares of land in remote Australia has been dedicated for conservation management, with further large-scale commitments anticipated. More than $1 billion in new public funding has been committed and delivered for conservation land management in the Outback, delivering diverse economic, social and environmental benefits for people and nature in the Outback.

This work is being led by local communities and landholders, across three key areas: the creation of Indigenous Protected Areas by traditional owners; the establishment of private protected areas on pastoral land; and, fire management and habitat restoration to reduce carbon emissions and rebuild carbon stocks.

This presentation will provide an overview of these developments in conservation land management in the Outback and detail the key role of civil society advocacy in securing policy and funding to support voluntary conservation commitments by landholders.

Highlights
• Local landholders are leading an unprecedented expansion of conservation lands in the Outback.
• Over the past twelve years, over 60 million hectares of land has been dedicated for conservation, including Indigenous Protected Areas, private protected areas and land managed for carbon.
• Civil society has an important role to play in promoting public policy and funding commitments to support conservation action by landholders in the Outback.

The pros and cons of Carbon Farming in western NSW: stakeholders' views

Dr Alex Baumber[2], Dr Annette Cowie[4], Dr Rebecca Cross[1], Dr Cathy Waters[4]
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Biography:
Dr Rebecca Cross is a postdoctoral researcher in the School of Life and Environmental Sciences with a specialisation in Human Geography. Her research interests are founded in rural geography and sociology at the nexus of human/nature interactions, with a focus on the socio-cultural dimensions of natural resource management, regenerative agriculture, farming sub-cultures, local and Indigenous land and food knowledge, grass-roots innovation and agroecological extension. She has been involved in a number of agri-environmental projects and is currently working on an ACIAR-funded project on sustainable intensification and diversification in NW Cambodia, as well as projects on carbon farming in western NSW and a "grasses for grains" project with Indigenous land managers in Narrabri.

Carbon farming in the rangelands of NSW is an increasingly attractive strategy for income and enterprise diversification for landholders. However, uptake of carbon farming is somewhat limited with only 196 vegetation projects in NSW as of May 2019. Understanding how and why this enterprise option is working for some but not others is critical, especially as new methodologies become available and new stakeholders become involved. To address this, the Department of Primary Industries is creating a decision-support tool for landholders to improve their access to carbon markets. To provide input to this process, two separate but related surveys of carbon farming stakeholders across NSW (focused on the Western Division and Central West regions) were used to determine motivations for and constraints to entering carbon farming; social, economic and environmental perceived risks and rewards; and information access and needs. While economic motivations for entering carbon farming dominated responses, positive economic, social and environmental outcomes (for example, livelihood resilience, community resilience and increased biodiversity) were prevalent rewards for those involved in carbon farming. Constraints to entering carbon farming were related to economic risk and perceptions of incongruity with existing enterprises. Complexity and uncertainty were also barriers, as well as perceived negative social and environmental outcomes (for example, increased absenteeism and increased monocultures of Invasive Native Scrub). It was found that most stakeholders reported poor access to quality information, with aggregators and carbon service providers being key conduits for information. This research points to a need for clearer information on economic risks and advantages, as well as opportunities for capitalising on payments for co-benefits, as pathways for increasing uptake. Two focus group discussions following these surveys will elicit advice on the types of information and functions the tool could accommodate, as well as the best mode of delivery.

Evaluation of the Forage-Livestock Balance policy in grassland management in China

Dr. Xiaoyong Cui[1, 2], Mr. Tong Li[1]

[1]*University Of Chinese Academy Of Sciences, Shijingshanqu, China,* [2]*CAS Center for Excellence & Innovation in Tibetan Plateau Earth System Sciences , Chaoyangqu, China*

Biography:

Xiaoyong CUI got his Ph.D. in Soil Science and Plant Nutrition from Chinese Agriculture University in 1997. Then he started to research plant physiology and ecosystem mass cycling of grasslands in China from temperate steppes in Inner Mongolia to alpine grasslands on the Tibetan Plateau. He spent two years in Institute of Botany of CAS as a post-doc, and 3 years in Institute of Environmental Studies in Japan. Currently he is a professor of Ecology in University of Chinese Academy of Sciences, focusing on belowground ecological processes in relation to C, N, and P transformation and ecosystem management.

Grassland has critically important ecological and economic values while overgrazing and climate change have caused grassland degradation. The implementation of rational policies may mitigate the negative effects or even improve grassland ecosystem health. The 'Forage-Livestock Balance' policy refers to balancing the relationship between forage productivity and grazing consumption of grassland. It was recommended in Inner Mongolia as a pilot program in the year of 2000. In 2005 Ministry of Agriculture implemented this policy in all the natural grassland regions in China. However, the theory and methodology of 'Forage-Livestock Balance' has been under debate since the proposal of this policy. A lot of studies have been conducted to explore the scientific basis, to develop the methods, to evaluate the effects, and to discuss the challenges of this policy to promote grassland protection and local people livelihood.
In this paper, we analyzed the concept and theory of 'Forage-Livestock Balance', pointing out the ignorance of the highly dynamic nature of climate in grassland regions. The officially proposed method of determination livestock quantity was compared with local practices and real livestock numbers from household surveys to test the implementation of this policy. The change of income and livelihood of herdsmen were studies in typical areas, together with grassland quality. The challenges of harmonization of the 'Forage-Livestock Balance' policy with new policies, including modified Grassland Law and separation of land tenure, right of operation, and right of contracting were discussed.

Aligning Rangeland Management Values / Achieving Shared Values across the Pastoral/Desert Interface

Mr Chris Curnow[1]
[1]*Rangelands NRM, Perth, Australia*

Biography:
Since 2014 Chris is Program Manager (Deserts & Pilbara), Rangelands NRM. Has 28 years engaging land managers and communities for socio-economic and environmental outcomes. He has worked all over the Americas, including six years with Amerindian communities in Latin America collaborating with NGOs and governments on environment and development projects that align with indigenous values. Since 1990 in the rangelands of western NSW with the Soil Conservation Service, he delivered rangelands extension services to pastoralists. He was secretary for the Organising Committee for the 7th ARS Conference, 1992. 2003-2013 Chris was WWF-Australia's Program Manager – SW Australia Land Manager Engagement.

- WA Pastoralists and Traditional Owners both manage land across the pastoral/desert interface.
- Cooperation across the pastoral/desert interface historically minimal.
- Geophysical boundaries and cultural divides pose challenges in achieving collective impact.
- Intentional investment with Aboriginal rangers and pastoralists showed that collaboration was beneficial.
- It has allowed for increased connection to Country, the opportunity for the growth of inter-generational cultural knowledge transfer and reduced threats to beef production enterprises.

The Western Australian rangelands are massive with low population densities. In order to have impact collaboration essential across geophysical boundaries and cultural divides. Historically, cooperation across the interface is minimal, resulting in neglected fire regimes and uncoordinated responses to large feral herbivores. Lack of support for once shared values of country between pastoralist families and descendants of Aboriginal stockmen families. Desert land owners (now largely exclusive native title) have uncertainty around offending pastoral neighbours with their desire to return right way fire to neighbouring landscapes; and that some pastoralists feel the desert has low value and is full of risk to their enterprises.

Rangelands NRM began collaborations along the pastoral/desert interface to encourage new conversations around fire and camels. Collaborations allow sharing of traditional heritage and values, which can benefit management of pastoral leases. Both parties found collaborations to be beneficial and a win-win situation for both.

Connection to Country and cultural revival is also allowing Elders to utilise ranger programs for inter-generational cultural knowledge transfer. This has instilled renewed confidence in the younger rangers, who can now act with cultural authority when it comes to speaking to pastoral neighbours about the values of their lands.

With these connections done the right way, the avenues are open for rangeland pastoralists and desert Traditional Owners to forge productive partnerships for themselves.

Traditional burning and contemporary risk management in the Kimberley

Mr Glen Daniel[1], Mr Rhys Swain[2]

[1]Department of Fire and Emergency Services, Perth, Australia, [2]Kimberley Land Council, Broome, Australia

Biography:

Glen Daniel manages the planned burning assurance program for the Department of Fire and Emergency Services. He has previously held operational and planning roles in land and fire management with the Department of Biodiversity, Conservation and Attractions and its predecessor organisations.

Rhys Swain is the Senior Fire Officer for the Kimberley Land Council and works with Aboriginal groups across the region to plan and implement burning for cultural, environmental, bushfire risk and carbon abatement outcomes.

Recent decades have seen the widespread reinvigoration of traditional burning practices by Aboriginal people in the Kimberley. Indigenous rangers combine traditional knowledge with modern technology, using planned fire to reduce the likelihood of large wildfires. While this has resulted in positive cultural, environmental, economic and bushfire risk outcomes, it has also created the challenge of maintaining consistent standards for burning conducted across a vast and diverse region.

As the peak Indigenous body in the Kimberley, the Kimberley Land Council (KLC) has an important role to play in meeting this challenge. The KLC works with Native Title Prescribed Bodies Corporate and Aboriginal people to plan and conduct land management activities, including burning. They provide training and mentoring, facilitate access to equipment and maintain policies and procedures to promote the safe and effective use of planned fire.

To ensure these arrangements appropriately manage the risks associated with planned burning, the KLC engaged the Office of Bushfire Risk Management (OBRM) to undertake an assurance review of planned burning conducted by native title groups in the Kimberley. OBRM is part of the Department of Fire and Emergency Services' Rural Fire Division, tasked with supporting continuous improvement in the management of risks related to bushfire prevention in Western Australia.

OBRM endorsed the KLC's policies and procedures as being aligned to the Australian standard for risk management in 2018 and is now engaged to review their application during operations. OBRM visits burns that are planned, in progress or completed and provides feedback on how risks are being managed or where improvement may be required. This drives continual improvement, including providing for collaborative actions on issues that are relevant to multiple groups.

This presentation describes the KLC's journey through OBRM's assurance program, highlighting the benefits to the organisation and to fire management in the Kimberley and beyond.

Watching the grasses grow: using UAVs and satellites to monitor rangeland species composition

Ms Milou Helene Dekkers[1], Dr Simon Quigley[1], Dr Peter Scarth[2], Dr Peter O'reagain[3], Prof Dennis Poppi[1]
[1]Univeristy of Queensland - School of Agriculture and Food Sciences, Gatton, Australia, [2]Univeristy of Queensland - School of Earth and Environmental Sciences, St Lucia, Australia, [3]Department of Agriculture and Fisheries, Charters Towers, Australia

Biography:
Milou H. Dekkers, completed her BSc Animal Science in The Netherlands where she worked for 3 years in Process Management. In 2007 she moved to Australia to study her first MSc. in Natural Resource Management and in 2010 she completed her second MSc in environmental management. Milou has been working in the field of animal research for over 11 years and has been conducting her PhD Part-time since 2016. She is very passionate about Australia's Natural Resources and hopes that her PhD research will assist in a more sustainable future for the Australian Rangelands.

Rangeland monitoring methods traditionally involve intensive and time consuming fieldwork. New sensing technologies (e.g. drones, satellite imagery) have the ability to rapidly collect large data sets at relatively low cost. These data are operationally used for greenness and cover analysis but due to the complexity of grass phenological response, the classification of individual species remains a challenge.

This paper reports on new research using unmanned aerial vehicles (UAVs) with a multi-spectral camera to monitor the temporal reflectance changes of four grass species (Bothriochloa pertusa, Bothriochloa ewartiana, Heteropogon contortus and Aristida sp.) common in rangelands of north Queensland. Grass seed was collected from Wambiana Station, Charters Towers, QLD and stored for six months to break dormancy. Seed was sown in pots (290 x 290 x 400 mm) containing Brigalow or Box soil and irrigated daily until all grasses reached a minimum height of 150 mm. A calibrated Parrot Sequoia multispectral camera was used to capture daily images of germination and seedling growth. The pots were then allocated in a randomised block design with each grass species-soil type combination subjected to different simulated rainfall (high or low) and grazing pressures (high, low or no grazing) (n=4 replicates/combination). A DJI Phantom 4 Advanced UAV fitted with the multispectral camera was then used to capture daily high-resolution images of the grasses for 140 days.

An automated workflow was developed to extract the multispectral response of each experimental pot from the imagery to link the phenological response to the simulated grazing and rainfall combinations. Early results indicate substantial spectral variability within species. However, several species combinations may be identified under certain rainfall and grazing regimes. If this technique is found to be successful, it would be a new means to monitor changes in pasture species composition on these rangelands.

Trade-offs regulate the effects of woody removal on biodiversity and ecosystem functions in global rangelands

Ms Jingyi Ding[1], Prof David Eldridge[1], Dr. Samantha Travers[1], Dr. Manuel Delgado-Baquerizo[2]
[1]*School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, Australia,*
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Biography:
Jingyi Ding is a PhD student in arid zone ecology who explores the structure and function of woody plant communities in drylands. She uses meta-analysis and field surveys along climatic gradient to reveal how the woody plant dynamics varies in drylands and the effectiveness of removing woody plants in rangeland management.

Woody plant encroachment is a major land management issue. Managers often remove woody plants in an effort to reinstate grasses and restore ecosystem functions, but few studies have assessed the role of woody plant removal on ecosystem functions and biodiversity at global scales. We collected data from 146 global studies, and evaluated how and why different woody plant removal methods affect biodiversity (plant and animal diversity) and ecosystem functions (plant productivity, hydrological function and soil carbon) across global rangelands. Our results indicate that the effectiveness of removal is strongly context dependent, varying with the specific response variable, removal method, and traits of the target species. We showed that 1) across all methods, removal significantly increased grass biomass and groundstorey diversity only; 2) physical, chemical and multiple removal methods increased the response of grass and total groundstorey biomass, but burning reduced the response of animal diversity and soil carbon; 3) the effectiveness of different treatment methods declined with time since removal, particularly for grass biomass and hydrological function; 4) removing taller or pyramid-shaped woody plants increased soil carbon, but reduced groundstorey and animal diversity; and 5) environmental context (e.g. aridity and soil texture) indirectly regulated the effectiveness of removal by influencing plant-soil traits associated with allelopathy and root type. Our study demonstrates that a one-size-fits-all approach to removal of woody plants is unlikely to be effective, and that consideration of woody plant identity, removal method, and environmental context is critical for the removal outcomes. This knowledge is fundamental for maintaining rangeland biodiversity and ecosystem functions as we move towards a drier and more variable climate.

Corresponding to David J. Eldridge

Assessing the effectiveness of kangaroo management through total grazing pressure fencing

Mr Brian Dohnt[1], Mr Russell Grant
[1]*Western Local Land Services, Cobar, Australia*

Biography:
Brian Dohnt has 37 years practical experience working in the fields of fire management, land management, biosecurity and environmental management.
Presently he provides advisory services to landholders in the Western Division of NSW with a focus on managing total grazing pressure fencing incentive projects. Visiting landholders throughout this region has provided Brian with a great insight on the impact of high total grazing pressure and the value of appropriate fencing as a management tool for improving land condition.

The use of pasture rest periods and rotational grazing as a means to improve landscape condition was suggested as early as 1901 in a Royal Commission to inquire into the condition of the NSW Western Division. However, the effective control of total grazing pressure to achieve pasture rest still eludes most landholders this region due to the mobility of kangaroos, unmanaged goats and to a lesser extent rabbits.

Over the past decade, mesh products such as Hingejoint™ have increasingly augmented traditional pastoral fencing approaches in order to control goats and provide partial exclusion of kangaroos. This "total grazing pressure" (TGP) fencing is of standard 1.2 meter height and not the exclusion fencing adopted for wild dog control.

How effective is TGP fencing in managing kangaroos? This paper provides a preliminary assessment of the effectiveness of TGP fences for kangaroo management through camera monitoring of animal responses to the infrastructure.

- Eleven motion-sensing cameras were deployed at sites along two fencelines on the boundary of a Hingejoint™-fenced paddock over a period of several weeks.
- The analysis of images indicated that while kangaroos continuously investigated and patrolled the outside of the fence, very few instances of jumping were recorded.
- Jumping events appeared to coincide with other stimuli such as vehicle movements.

Kangaroo pressure on TGP fencing increases under prolonged drought conditions and some landholders seek means to increase the effectiveness of the barrier. Options could include fence extenders or various means of enhancing fence visibility, similar to the use of fladry to deter wolf predation trialed in North America.

The monitoring was repeated following the installation of reflectors on the fence to investigate if enhancing visibility could improve kangaroo exclusion.

- Image analysis suggests that there was no apparent change in kangaroo behavior regardless of the presence of these enhancements.

Queensland Rangelands Policy Dialogue

Dr Geoffrey Edwards[1]

[1]*The Royal Society of Queensland, Godwin Beach, Australia*

Biography:

Dr Geoff Edwards is qualified in ecological science and public policy. He worked in parks and Crown land administration in Victoria and Papua New Guinea. He was a local government Councillor for six years in Victoria. From 1991-2006 he served in Queensland's Department of Lands/Natural Resources as Manager, Land and Regional Planning, with responsibilities for a range of aspects of land policy. After a stint in 2007-8 as CEO of South West NRM in Charleville, he retired from the Department of Mines and Energy in 2011. In June 2013 he was elected President of The Royal Society of Queensland.

The Royal Society of Queensland collaborated with AgForce and NRM Regions Queensland in a two-day dialogue to examine Rangelands policy, on 1, 2 July 2019. Attendance was by invitation, to ensure that the participants were largely policy-aware individuals.

Building on a 2018 paper, From Red to Green to Black, the Dialogue aimed to identify current condition and trends and to examine how to transition from the present fractured condition to a sustainable one.

Western Queensland has the most variable climate in the world and the variability is increasing.

Rural debt per unit of commodity production is increasing. Rural economic policy portrays failure of a pastoral enterprise as a consequence of personal inadequacy – “blaming the victim”. But the income received from commodities remains disconnected from the domestic cost of production.

Rural Queensland is depopulating and townships are hollowing out. Properties in western Queensland are being bought for their carbon credits, destocked and left vacant. Yet the landscape needs more people (fencing, pest control, erosion control, etc.), not fewer. Carbon credits are focused on trading in measurable carbon stocks, yet it is not stocks that energise a landscape, but carbon flows.

The agents of coordination, community support and translation of scientific knowledge to pastoralists are not funded to perform these support functions adequately: NRM regional bodies, CSIRO and the ABC are all being starved.

The overriding consensus was that given climate change, business as usual will not be possible in the Queensland Rangelands and a major transformation is inevitable. But there is no roadmap of how to transition to a new, unknown future.

The consensus is being written up as a Queensland Rangelands Declaration for presentation to governments and public advocacy. The meeting endorsed a subsequent initiative to re-run the Dialogue on a national stage in collaboration with national bodies.

Analysis of the rangeland goat industry as a complex social ecological system

Mr Marwan El Hassan[1]

[1]*Australian National University - Fenner School Of Environment and Society, Canberra, Australia*

Biography:

Dr Marwan El Hassan recently finished a PhD on the management of rangeland goats as a social ecological system. He is currently working as a systems research scientist in the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) and is also affiliated with the Fenner School of Environment and Society at The Australian National University. Marwan's research interests include the application of systems thinking and resilience theories, as well as approaches like human ecology, behavioural change and adaptive pathways to better understand complex issues around social ecological systems and create partnerships between various stakeholders for collaborative management of their systems

Goats have always been controversial in Australia, and there are two competing paradigms around them: pest and resource. While they can contribute significantly to damaging grazing pressure if left unmanaged, goats simultaneously constitute adaptive tools for rangeland producers during hard times, including drought, and support an industry that relies on harvesting wild goats for 95 per cent of the supply to lead the world in goatmeat exports. This research investigated how the rangeland goat industry—as a complex social ecological system—behaves and how to sustainably manage it. I described and assessed the system and its social, ecological and institutional components, drawing on a framework adapted from human ecology and integrated with principles from resilience thinking. I focused on the western rangelands of New South Wales, where most of the goat population and many key stakeholders in the system are. I also analysed inter-scale dynamics and how this affects the behaviour of the focal system. This is necessary in light of uncertainties and possible future shocks to this system, mainly by climate change and market drivers. Based on these analyses:

- I argue the need for a paradigm shift towards collaborative management of rangeland goats for the mutual benefit of conservation and pastoral industries, whereby goat harvesting becomes the tool of choice for management, rather than a purely financially driven activity.
- I provide the tools for stakeholders in goat management, through clear feedback-guided analysis and models, to come together and form partnership platforms to manage the system. These models constitute a transdisciplinary shared language that facilitates collaboration towards adaptive goat management.
- These findings and tools can assist stakeholders in identifying and bridging the gap between the current, unsustainable state, and an agreed future resilient state of the goat system. This project is a first step towards achieving this desirable goal.

The challenge of community perceptions of the Australian cattle industry: Exploring industry perceptions of the past, present and future

Taylah Faulkner[1], G Bradd Witt[1]
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The Australian agricultural sector is undergoing constant change. A key sustainability challenge for the sector, and particularly the cattle industry, is meeting community and consumer expectations of its environmental performance. This research explores industry perspectives of community expectations and how it is adapting to changing perceptions. It identified opportunities and challenges that have emerged in light of perceived social change, in order to inform and guide improvements in industry environmental performance. This research drew on rich insights provided from 17 in-depth, semi-structured interviews with key informants who have diverse and extensive knowledge and experience in the Australian cattle industry. These interviews provided insight into how the industry perceives its environmental performance. The key findings from the research indicate that there is no universally accepted industry-level understanding of community expectations for environmental performance, demonstrated by diverse internal perceptions. The industry is attempting to respond to changes in community expectations; however, due to a limited industry understanding of what those expectations are, it is uncertain whether those responses have been effective in meeting community expectations. Additionally, this research identified some significant challenges to aligning industry activities with community expectations. These included:

- Organisational culture;
- Communication within the cattle industry and externally to the community;
- Community education on industry practices;
- Diverse environmental values across individuals in the cattle industry; and
- The divide between rural and urban communities.

The Australian cattle industry recognises the challenges in meeting community expectations for environmental performance. However, the industry appears to be taking action to address community expectations of environmental performance, and, with effective collaboration within the industry, it is possible to overcome this challenge to achieve sustainability in the Australian cattle industry.

The synergistic effects of afforestation and check-dams on sediment trapping on the Loess Plateau

Dr. Xiaoming Feng[1], Dr. Bojie Fu[1], Mr. Qinglong Liu[1]

[1]*State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-environmental Sciences, Cas, Beijing, China*

Biography:

Research Professor with the research fields ecosystem restoration and afforestation, ecosystem service tradeoff in dryland, the ecological application of remote sensing.

Soil erosion represents a major environmental threat to ecosystems. Effective sediment trapping relies on the cooperation of multiple soil erosion control measures. However, findings on the synergistic effects of multiple soil erosion control measures are still lacking, in particular on a large spatial scale. This study provides a first attempt to analyze four decades of data from the 1980s to the 2010s on the Loess Plateau. The analysis combines the spatial investigation of check-dam construction in gullies, afforestation on hillslopes and station-observed sediment yield within the evaluation framework of the Water and Tillage Erosion Model/Sediment Delivery Model (WATEM/SEDEM). The results indicate two periods of effective sediment trapping on the Loess Plateau in the last four decades: 1980s-1990s and 2000s-2010s. Check-dam construction was the main driver of reduced sediment yields before the 1990s. Massive afforestation played an increasingly important role beginning in 1999. The synergistic effects of afforestation and the construction of check-dams in the period from the 2000s to the 2010s not only include the effective trapping of sediment but also improvements in the resistance of ecosystems to climate change. These results improve our understanding of the synergistic effects of multiple soil erosion control measures on sediment trapping. The findings support a rational collocation of different soil erosion control measures to support comprehensive management in erosion-prone regions.

What can WARMS tell us about White Grass (Sehima nervosum) in Kimberley pastures?

Mr Matthew Fletcher[1], Mr Andrew Craig[2], Ms Kathryn Ryan[1]

[1]Department of Primary Industries and Regional Development, Kununurra, Australia, [2]Formerly, Department of Agriculture and Food, Kununurra, Australia

Biography:

As a Development Officer I spend much of the northern dry season monitoring grassland sites of the Western Australian Rangeland Monitoring System (WARMS) across the Kimberley. The information produced is invaluable when assisting land managers to make sustainable use of their pastoral resources. I work with Rangelands NRM, support MLA EDGE workshops, encourage water ponding to increase rangeland productivity and condition and talk one-on-one with managers about their pastoral business. My main interest is working with land managers to align stock numbers and available feed to maximise long-term enterprise returns.

What was found?

Information from the Western Australian Rangeland Monitoring System (WARMS) suggests that there has been an increase in the average frequency of white grass (Sehima nervosum) on Kimberley pastoral lands since monitoring began in 1994. White grass is a perennial tussock grass that also occurs in the Northern Territory and Queensland.

Why is the observed trend potentially important?

White grass is considered to be of limited nutritional value, having relatively low protein content and palatability, although it has good soil-stabilising properties. If white grass has been increasing in abundance at the expense of other more valuable perennial grasses, this would be a negative trend from a production perspective. On the other hand, if pastorally less desirable grasses have been replaced by white grass, this could be considered a positive trend.

What's happening with other important co-occurring perennial grasses?

Frequency changes in other important perennial grasses present at sites where white grass has been recorded were investigated. It was found that, overall:

- Black spear grass (Heteropogon contortus) frequency also increased
- Ribbon grass (Chryspogon fallax) and bundle-bundle grass (Dichanthium fecundum) frequencies remained relatively stable
- Feather top (Aristida inaequiglumis/ A. pruinosa) frequency decreased

Discussion

At this stage there is no evidence to suggest that the apparent increase in white grass frequency is associated with reduced frequencies of more desirable pasture species, but it is important that we continue to monitor the situation.

There is no obvious or simple explanation for the general increase in white grass frequency that has been observed. One possible contributing factor is the good run of seasons experienced in this region since the mid-1990s.

Nudging the narrative: Heading in the "right direction"

Dr Margaret Friedel[1, 2], Mr John Brisbin[3]

[1]CSIRO Land & Water, Alice Springs, Australia, [2]Research Institute for Environment and Livelihoods, Charles Darwin University, Alice Springs, Australia, [3]Northern Gulf Resource Management Group, Mareeba, Australia

Biography:

Marg is an Honorary Fellow with CSIRO Land & Water and a Professorial Fellow at the Research Institute for Environment & Livelihoods at Charles Darwin University in Alice Springs. She joined CSIRO Alice Springs in 1974 to research the ecology and management of arid rangelands and since then has explored aspects of range assessment, rehabilitation, tourism, land use planning, policy development and invasive plants. Having retired in 2010, she enjoys writing about rangeland management and engaging with practitioners. She joined the Australian Rangeland Society in 1975 and was made a Fellow of the Society in 2017.

There are few certainties on the journey towards environmental, economic, social and cultural sustainability in rangeland use. Change, inevitably, will occur through some combination of chance, intent, and timing. Given this inherent complexity, what can rangelands practitioners do to "nudge" the system in the right direction?

First, the question of a right direction. This is a matter of judgement, open to contest, and subject to continuous revision. Our consensus at any given time comprises the cultural narrative. Laws, policy, and the power of the economy are potent drivers of the current narrative.

- What would it take to shift the rangeland narrative in Australia toward a more abundant and resilient state?

- We suggest that this new narrative begin with a "custodial reciprocity with the land", reflecting an indigenous sense of cultural connection and obligation.

We review the perspectives of pastoralist Bob Purvis (1986), linguist MK Turner (2010) and historian Bruce Pascoe (2014) for supporting and critical views.

What of the nudge? Failure of politicians and the general public to engage with rangelands can be dispiriting. Fred Chaney (2015) remarked "As yet no political party has embraced the need for serious changes in the way government itself operates in remote Australia". He notes: "Policy for remote Australia needs to be … "custom-built" to meet its specific circumstances and needs".

- Given decades of absentee leadership from above, we propose Leith et al.'s (2017) approach for shaping and accelerating grass roots leadership, based on genuine collaboration and acceptance of diverse value systems.

For example, the Ten Deserts Project is achieving indigenous-led conservation through multiple organisations, industry and government working together. We are seeing the public mind shift towards support for climate change action and the Uluru Statement from the Heart. With sufficient determination and insight, we suggest positive change is possible.

A strategic and collaborative approach to managing the national icon

Ms Fiona Garland[1, 2], Mr Russell Grant[2]
[1]*Western Local Land Services, Bourke, Australia,* [2]*Kangaroo Management Taskforce, Bourke, Australia*

Biography:
Fiona Garland has been working with Western Local Land Services since January, 2014 across a number of different community engagement roles. With a background in education and communication Fiona has developed a strong passion for communicating rangeland issues and narratives to the rest of the population. Since July 2018 Fiona has worked in a Kangaroo Management role at Western Local Land Services aimed at supporting the Kangaroo Management Taskforce achieve their goals of improving kangaroo management to achieve better outcomes for landscapes, production and kangaroo welfare.

The Kangaroo Management Taskforce (KMT) was formed in 2016 after a workshop in Cobar focusing on the impacts that large boom and bust cycles in kangaroo populations were having on landscapes, pastoral production and animal welfare in Western NSW. The Taskforce is unique in that it has broad representation from most of the key stakeholders who have an interest in the sustainable management of kangaroos. Representation includes relevant government agencies, welfare organisations, the commercial kangaroo industry, a kangaroo harvester, Aboriginal communities, landholders, Landcare, and both landscape and kangaroo ecologists. The group has been meeting regularly via night-time teleconferences for nearly 3 years to try and find solutions to the complex and fraught issue of kangaroo management. The dedication and persistence of this group of mostly volunteers finally resulted in funding support from Local Land Services in July 2018 which enabled a Project Officer to be employed to support the KMT pursue their goals of improving kangaroo management to achieve better outcomes for landscapes, production and kangaroo welfare. Since that time the group has produced a Strategic Plan. Underpinning this the Taskforce is developing a public website, a range of films, fact sheets and other resources; is working with NSW Government Agencies to help develop a Regional Research Trial; and supporting the implementation of a Kangaroo Symposium at the ARS Conference in 2019 amongst other things. Although the Taskforce began with a Western NSW focus, it soon became clear that issues related to managing our national icon are relevant to ALL Australians, particularly in sheep zone rangeland environments. This presentation will tell the story of how a group of passionate volunteers from Western NSW have been delicately navigating the needs of a diverse range of stakeholders to develop a Strategic Plan for improving management of Australia's well-loved national icon.

Global rangeland systems at threat under climate change and variability

Ms Cecile Godde[1], Dr Randall Boone[2], Dr Andrew Ash[1], Dr Katharina Waha[1], Dr Lindsay Sloat[3], Dr Philip Thornton[4,5], Dr Mario Herrero[1]

[1]Csiro, St Lucia, Australia, [2]Colorado State University, Fort Collins, United States of America, [3]University of California Irvine, Irvine, United States of America, [4]CGIAR Research Programme on Climate Change, Agriculture and Food Security, Nairobi, Kenya, [5]International Livestock Research Institute , Nairobi, Kenya

Biography:

Cecile Godde is a Food Systems Scientist at CSIRO Agriculture and Food. Her recent work has focused on assessing the impacts of climate change and climate variability on grazing systems through modelling. She is also interested in the drivers and trade-offs of grazing systems dynamics, the relationship between livestock systems and biodiversity, and soil carbon sequestration potential to mitigate climate change.

Rangelands are one of the Earth's major ice-free land cover types. They provide food and support livelihoods for millions of people worldwide in addition to delivering important ecosystems services. However, rangelands are at threat under climate change, although the extent and magnitude of the potential impacts are poorly understood. In particular, declines in vegetation biomass and fluctuations in grazing availability are of concern for food production and may change ecosystems integrity and functionality. In this study, we use a global rangeland model in combination with livestock and socio-economic datasets to identify where and to what extent rangeland systems may be at climatic risk.

- Overall, mean herbaceous biomass is projected to decrease across global rangelands between 2000 and 2050 under RCP 8.5 (-4.7%), while inter- (year-to-year) and intra- (month-to-month) annual variabilities are projected to increase (+21.3% and +8.2%, respectively).

- These averaged global estimates mask large spatial heterogeneities, with 74% of global rangeland area projected to experience a decline in mean biomass, 64% an increase in inter-annual variability and 54% an increase in intra-annual variability.

- Half of global rangeland area is projected to experience simultaneously a decrease in mean biomass and an increase in inter-annual variability - vegetation trends both potentially harmful for livestock production. These regions comprise 376 million people and 174 million ruminant Tropical Livestock Units.

- Moreover, the rangeland communities currently the most vulnerable (here, with the lowest livestock productivities and economic development levels and with the highest projected increases in human population densities) are projected to also experience the most damaging vegetation trends for livestock production.

Although the capacity of rangelands to adapt is highly complex and edged with large uncertainties, risk analyses such as these can be used to target technical and institutional options to facilitate pastoral system resilience and adaptation under climate change.

Investigating the complexity of natural resource-based enterprise development in remote Australian Aboriginal communities

Mr Julian Gorman[1], Dr Penny Wurm[1], Dr Sivaram Vemuri[1], Dr Chris Brady[2], Associate Professor Yasmina Sultanbawa[3], Dr Melissa Bentivoglio[4]

[1]Charles Darwin University, Darwin, Australia, [2]Northern Land Council, Darwin, Australia, [3]University of Queensland, Brisbane, Australia, [4]Thamarrurr Development Corporation, Wadeye, Australia

Biography:

Julian has spent 20 years in the Northern Territory of Australia as a researcher and lecturer with the Charles Darwin University. 7 years of this were on secondment with the Northern Land Council.as a Wildlife Enterprise Development Facilitator. His area of expertise is natural resource management and sustainable use of wildlife to improve Indigenous livelihoods. He is currently enrolled in a PhD investigating Kakadu Plum (Terminalia ferdinandiana) as an Indigenous agribusiness for northern Australia. Julian is now working at Massey University, New Zealand lecturing in Resource and Environmental Planning and conducting research in the field of horticulture.

Across the world's rangelands, livelihoods of millions of people are dependent on customary and commercial use of wildlife. Many Australian Aboriginal communities aspire towards natural resource-based enterprise but seldom are in a position to identify, plan and develop these opportunities. However, their customary knowledge of wildlife may have many commercial utilisations which if realised could contribute to their livelihoods and ability to remain living on their country, providing valuable natural and cultural resource management and supporting the resilience of the rangelands. Over the last 15 years, the Indigenous people of the Thamarrurr Region of the Northern Territory have been building an enterprise based on wild harvest and value adding of Terminalia ferdinandiana (Kakadu Plum) products. This research has documented the progress of this enterprise and identified the actors and factors that have contributed to the development of its value chains. It identifies a trend in historical, legislative and institutional arrangements driving business development which have been primarily based on social instead of economic criteria. This research has documented the progress of this enterprise and identified the actors and factors that have contributed to the development of its value chains. It identifies a trend in historical, legislative and institutional arrangements driving business development which have been primarily based on social instead of economic criteria. This has resulted in business decisions being made independent of market signals resulting in fragmented and inefficient value chains and a tyranny of failed enterprises. Aboriginal communities have complex social, cultural and political influences and if businesses are to succeed they need to be economically sustainable and developed in an appropriate cultural framework. In turn this will provide the much-needed longer term social benefits.

RaPP Map: vegetation cover and productivity in support of soil conservation and livestock production

Dr Juan Guerschman[1], Dr John Leys[2], Dr Michael Hill[1,3], Dr Randall Donohue[1], Dr Luciana Porfirio[1], Dr Jasmine Howorth[4]

[1]CSIRO, Canberra, Australia, [2]NSW Office of Environment and Heritage, Gunnedah, Australia, [3]University of North Dakota, Grand Forks, USA, [4]Australian Bureau of Agricultural and Resource Economics, Canberra, Australia

Biography:

Juan Guerschman is a Senior Research Scientist with CSIRO. His research focuses on the calibration and application of a regional carbon cycle model, and the integration of remote sensing and ground-based observations through model-data assimilation for the analysis of carbon dynamics of tropical savannas. He has played a leading role in developing and evaluating methods to use satellite observations in hydrological and land management applications. Juan has also been actively involved in developing algorithms for estimating vegetation cover from remotely sensed data across rangelands and croplands and applying these estimates to deliver timely information for better management of these environments.

The Rangeland and Pasture Productivity (RaPP) Map (http://map.geo-rapp.org) is a tool that delivers public online access to datasets of vegetation and soil cover and forage productivity. It provides global monthly coverage of these data (2000-present) from the MODIS satellite with 500 metres resolution. The "fractional cover" dataset estimates cover of: photosynthetic vegetation (PV), non-photosynthetic vegetation (NPV) and bare soil (BS). The sum of PV and NPV equals to Total Vegetation Cover which, in areas with sparse or no tree cover is equivalent to the ground cover. A similar dataset is also available from the Landsat and Sentinel2 sensors, courtesy from the Qld JRSR Program. The RaPP Map tool also includes ancillary layers which can help interpreting the time-series remote sensing data, including land use and land cover, soil and physiography, livestock statistics among others.

RaPP Map helps regional natural resource management organisations: 1) view and report on ground cover change, 2) plot time-series of average mean ground cover and forage productivity for an area, 3) understand the decile ranking of the ground cover level for the month by comparing it to the same month in other years, and 4) understand how many percentage points the ground cover level is above or below the long term mean for each pixel. The tool can also be used by industries and policy makers to inform them of ground cover change and will provide the basis for the Department of Agriculture' reporting on improvements in resource condition at the national level.

Future developments proposed include:

Training for natural resource management organisations in the use of the tool

Improvements in the tool to facilitate ground cover target setting

Improving the validation of the remote sensing datasets by collating existing field measurements

Developing a net primary productivity product for the herbaceous and woody component of vegetation

Mapping livestock grazing distribution for Australia during European settlement -1790-1980

Mr Scott Irvine[1], MR J Carter[2]

[1]Queensland Department of Environment And Science, Brisbane, Australia, [2]Remote Sensing Centre Queensland Department of Environment and Science Ecosciences Precinct , Dutton Park , Australia

Biography:

Scott Irvine is currently a senior scientist with the Queensland Department of Environment and Science, working with Grazing Land Systems team at Dutton Park. He has been employed by the Queensland Government in various geographic and scientific roles since 1995. First employed as a land resource officer, Scott has since extended his work experience into soil science, vegetation management, geographical information systems and grazing research, throughout Queensland along with his personal interest in history.

Analysis of historical livestock grazing maps can provide insights into the long term environmental impacts of grazing upon different landscapes in Australia's rangeland regions.

Since 1790, a number of colonial/state agencies have been describing the numbers of cattle, horses and sheep, providing a record of the introduction and spread of the pastoral industry throughout Australia. By capturing the spatial extent of the districts at the time of the livestock recording, along with data estimates of water availability and vegetation density, an estimate of grazing distribution can be derived.

To account for livestock number change at local statistical areas over time, it was necessary to determine the incremental changes in statistical boundaries and spatially distribute stock according to the statistical area that was described in the historical record. This was achieved by applying a stock distribution model (SDM) in order to calculate an estimated yearly stocking density within each statistical district. This work has been completed for Queensland for livestock records from 1860. Recently, livestock numbers for Northern Territory and Western Australian (from 1829 to 1960) have been captured to expand the analyses.

The SDM has now been enhanced to include water source information. Water source information was able to be modified to show pre-European water sources as well as dating subsequent post-European water improvements. Date omissions within the groundwater data and water surface improvements have been statistically added.

In the absence of other data, these methods are likely to present a more accurate representation of stock movement and subsequent grazing distribution during the pastoral development period. These stocking densities have been standardised across the mapping units allowing for the AussieGRASS (Australian Grassland and Rangeland Assessment by Spatial Simulation) model to represent grazing impacts between years 1790 1981 for all Australian rangeland regions.

By mapping the historical grazing distribution, impacts of recorded droughts and recovery can be ascertained and further examined.

Peer to peer forage budgeting in the Upper Burdekin Rangelands

Mrs Heather Jonsson[1]

[1]*Dalrymple Landcare Committee Incorporated, Charters Towers, Australia*

Biography:

Heather Jonsson is the Landcare Coordinator for Dalrymple Landcare Committee (DLC) taking up the position in September 2018.

Heather has a strong rural background having grown up on the family farm and cattle properties in Far North Queensland. After leaving home she worked as a governess on cattle stations in the Gulf Country and the NT.

Heather's interests in grazing and land management stem from supporting her husband in working on properties especially in this extended drought period.

She is passionate about listening and talking with graziers to best support them while focusing on sustainable grazing practices.

Peer to peer forage budgeting in the Upper Burdekin Rangelands

Heather Jonsson (A), Bob Shepherd (B)

(A) Dalrymple Landcare Committee Inc (DLC); PO Box 976 Charters Towers, Qld 4820

(B) Department of Agriculture & Fisheries; PO Box 976 Charters Towers, Qld 4820

Poor management of stocking rates has a direct correlation to land degradation which is one of the main contributors to poor quality runoff water. As the seasons are highly variable, stocking rates require regular adjustment. If the country is set stocked for an average season, it will be overstocked in 50% of years. This style of management causes land condition to slide to category B. Failure to adjust stocking rates on degraded country increases the frequency of overstocking to 70 to 80% of years, with feed shortages, high mortalities and high supplementary feeding costs incurred almost annually.

Forage budgeting is a critical tool in northern Australia to ensure adequate end-of-dry season pasture cover levels are retained. High pasture cover promotes rainfall infiltration and good pasture growth the following season. An objective method of determining dry season stocking rates based on available feed in April or May, sets the property up for a dry season that is low stress for the people, finances, land and cattle. It allows for the planned marketing of cattle and the adoption of a wide range of land management practices.

The concept of basing dry season stocking rates on an annual forage budget has been promoted for several decades. However uptake by industry has been poor. Facilitating a peer to peer forage budgeting service by the Dalrymple Landcare Committee based in Charters Towers, has increased the adoption.

This paper highlights the evolution of this free service, grazier participation and benefits for the whole beef business, including herd performance, and environmental & financial outcomes.

Community based monitoring for tracking biodiversity change in Rangelands

Mr Michael Kelly[1], Dr Eren Turak[1, 2]

[1]NSW Department Of Planning Industry And The Environment, Parramatta, Australia, [2]School of Biological, Earth and Environmental Sciences, UNSW, Australia , Kensington, Australia

Biography:

Eren Turak is currently Principal Scientist at NSW Department of Planning Industry and Environment. He has a BSC and MSC from Macquarie University and PHD from University of Technology Sydney. His PhD research was on Biological Classifications of the Rivers in NSW. He has been working as a scientist for the NSW Government since 1994, His responsibilities included: a State Wide Biological Monitoring Program for Rivers; Environmental Monitoring Assessment and Reporting Framework for OEH; new tools and methods for freshwater conservation planning; a biodiversity monitoring strategy for the Gondwana Rainforests World Heritage Area; community based biodiversity monitoring in semi-arid NSW

Sustainable management of Australian rangelands relies of a capacity to measure system-level changes in biodiversity at local to sub-continental spatial scales. This requires both a suitable conceptual framework and solutions to the formidable resourcing problem. We trialed a new approach that addresses both these challenges in an indigenous-managed Reserve in Semi-Arid NSW. The conceptual framework includes Essential Biodiversity Variables (EBV) and Response Pressure State Benefit RPSB) models at the scale of individual properties. This enables biodiversity monitoring to be focused on local needs while measuring outcomes in a common currency across Australia and globally. To address the resourcing challenge we focused on community-based monitoring. We constructed the RPSB models around the primary management intervention which in this case is Aboriginal Cultural Burning. The next step was to select EBVs that need to be measured and to identify which species assemblages and individual species should be monitored to measure these EBVs. Then we developed tools and methods that would enable non-expert community members to make spatially and temporally precise biodiversity observations. The primary tool was a reserve-specific app that allows the generation of rapid species sighting records. The tool also combines traditional ecological knowledge with techniques such as species habitat suitability models and helps to build local capacity in biodiversity monitoring. We then adapted widely used monitoring techniques and protocols so that they can be used by non-experts. This led to new methods of visual searches, video surveillance, and acoustic monitoring. The new methods were developed by actually doing monitoring. As a result since November 2017 over 2000 sightings of birds, reptiles and mammals were made in the reserve including many threatened species. Now these tools and methods are also being applied in other rangeland reserves and properties.

Strategies for improving Chinese degraded grasslands

Professor David Kemp[1], Professor Jianping Wu[2], Professor Fujiang Hou[3], Professor Guodong Han[4], Professor Yingjun Zhang[5], Professor Xiangyang Hou[6]

[1]Charles Sturt University, Orange, Australia, [2]Gansu Academy of Agricultural Science, Lanzhou, China, [3]CPAST, Lanzhou University, Lanzhou, China, [4]College of Grasslands, Resources & Environment, Inner Mongolia Agricultural University, Hohhot, China, [5]Dept Grassland Science, China Agricultural University, Beijing, China, [6]Institute for Grassland Research, Chinese Academy of Agricultural Science, Hohhot, China

Biography:

David Kemp has spent much of his career working on improved management of grazing systems, mostly in higher rainfall zones of NSW. An aim has been to work with what is there. Early this century he was invited to develop a program with leading Chinese grassland scientists to improve their grasslands. That work has been highly successful, culminating in him being given several awards including a Friendship Award by the Chinese Government.

China has ~400m ha of grazing lands, a similar area to that used in Australia, but 90% of Chinese grasslands are degraded to varying degrees. This results in low productivity, very low herder incomes (among the poorest in China, at less than $US2/person/day) and considerable environmental problems, especially more frequent dust storms and silt in major rivers. Since 1950 the average stocking rate of grazing animals has increased four-fold across China. Most of the grazing lands are in the north and west, where there is only 3-5 months, above freezing and rainfall varies from 50-500mm, falling mostly in summer. These areas include the Mongolian, Tibetan and Loess Plateaux, the Gobi desert and Alpine areas. Rehabilitating these grasslands and improving herder incomes has become a major focus of the Chinese Government. Early this century the Australian Government through ACIAR commenced a major program designed to devise strategies for improvement. A range of studies were done to better understand the system and then test options. These studies included herder surveys, modelling options, field experiments in grassland management and farm demonstrations. This paper outlines the main strategies that emerged to reduce stocking rates, improve herder household incomes and help grasslands recover. These strategies are now included in national policies and grassland improvement programs.

Parks Victoria partner with farmers to conserve native grasslands

Ms Jacqui Knee[1], Mr Ben Hodgens[1]
[1]*Parks Victoria, Echuca, Australia*

Biography:
Jacqui's career interest is managing natural resources (land, water and biodiversity) to sustain both agriculture and the environment. To date, this includes working with farmers and agricultural industries in areas such as on-farm nutrient management, reducing carbon footprint and efficient use of water.

Ben has worked in field of native grassland conservation for the past 10 years. Having started his career working in the Western Basalt Plains Grasslands of south west Victoria, Ben is now employed by Parks Victoria to manage a range of conservation grassland projects in the state's Northern Plains Grasslands.

Parks Victoria partner with farmers to conserve native grasslands
Jacqui Knee and Ben Hodgens, Parks Victoria
Parks Victoria (PV) works in partnerships with farmers to achieve conservation outcomes on public native grassland reserves in northern Victoria.
PV manages 6,853 hectares (ha) of native grasslands on the Patho and lower Avoca Plains in northern Victoria. These grasslands are some of the last remaining remnants and are protected at a federal level as a threatened ecosystem under the Environment Protection and Biodiversity Conservation Act 1999. They are home to fauna and flora species that are unique to these grasslands, such as the critically endangered Plains-wanderer.
The grassland reserves were previously farming properties, where grazing and cultivation took place. The presence of agricultural plant species requires PV to actively manage these grasslands. Grazing is the main method used and PV contracts farmers to provide grazing services.
Managing these native grasslands is complex. As well as achieving the desired outcomes from good grazing management, PV also needs to consider:

- Managing reserves ranging from 10 to 3,000 ha interspersed across the landscape
- The variation in quality of grasslands
- The strong community interest
- Working with 12 farmers contracted to graze the grasslands; who all have their own business demands and knowledge of how to manage native grasslands.

Therefore, PV found it is important to work in partnership with contracted farmers to manage these grasslands and achieve the desired conservation outcomes required.
PV recently ran a process to contract famers to provide grazing services. This presentation will describe this process, including:

- Addressing the complex management aspects, including community interest
- Being clear about what Parks Victoria wanted to achieve with grazing
- Looking for the mutual benefits the contractual arrangements have for both PV and farmers

Influencing Policy and Management of Water in Western NSW - "Pumped", a case study

Mr Terry Korn[1]

[1]*Australian Floodplain Association, Canberra, Australia*

Biography:

Terry Korn is president of the Australian Floodplain Association whose membership consists primarily of floodplain graziers from the Murray Darling Basin. But it also has diverse community membership ranging from shire councils, tourist organisations and Local Aboriginal Land Councils. Terry has worked as a beef cattle advisory officer, led NSW Agriculture's vertebrate pest management program and been an executive director in NSW National Parks and Wildlife Service overseeing 70 percent of western NSW. He has worked in the Murray Darling Basin since 1974, retired in 2006 and was awarded the Public Service Medal in 2007.

The Murray Darling Basin (MDB) accounts for 40%of Australia's agricultural production. Stretching over four states and the Australian Capital Territory it covers about 1 million square kilometers, much of which is rangelands.

It contains major river systems, extensive floodplains, 30,000 wetlands, 16 of which are Ramsar listed and over 100 of which are nationally important for wildlife. These wetlands, rivers, floodplains and unflooded rangelands support diverse and long standing agricultural, social, cultural and ecological systems which bind communities.

The millennium drought highlighted the parlous state of the rivers, floodplains, wetlands and the communities they support, resulting in the $13 billion MDB Plan being developed and approved by parliament in November 2012. The intent was to re-balance the system by transferring water from irrigation production to the environment over a ten year period without undue negative impact on the social and economic values of basin communities.

After five years of implementation non-irrigation groups felt the Plan was not going to deliver the expected outcomes of healthy rivers and floodplains or care for non-irrigation communities in western NSW because of poor policy, poor policy implementation and political influence. It was decided that change could only be brought about by employing a targeted legal and media strategy involving specialist lawyers and investigative journalists, who could demonstrate to the broader public major deficiencies in law, policy and implementation.

This presentation reports on (1) how the ABC Four Corners show "Pumped" of 24 July 2017 significantly altered government attitude, behaviour and policy, thereby leading to greater optimism for improved outcomes for river, floodplain and community health in western NSW rangelands; (2) describes the key elements of a successful media strategy and (3) encourages those involved in contentious rangeland management issues to use strategic media as a tool to influence policy.

Preparing for drought: what the farmers say

Ms Jennifer Laffan[1]

[1]*Nsw Department of Primary Industry, Redfern, Australia*

Biography:

Jennifer Laffan has written about a broad range of agricultural topics. The publications are published by NSW Department of Primary Industries both as hard copies and on-line. Research is based on current practice or recently published work. This presentation is based on interviews with producers who have thoughtfully prepared for drought throughout NSW and Southern Queensland. It is based on the advice they offer for future dry conditions.

Preparation for dry times and survival through them has not been well documented. There are many useful publications about managing for drought and recovering from drought but once the drought breaks there is a tendency to move on and not record successful measures that people put in place before the drought. This study is about preparing for drought. Many consider that drought is expected as one of the risks to agricultural production. Although such conditions are never welcome, it makes good business sense to prepare for the calculated risk. The concept of drought is not the same to everyone: it can differ according to severity; frequency; days or years of dry time; industry; growing season; ambient temperature. Twenty-five producers from widely distributed areas throughout New South Wales and south west Queensland were interviewed about their drought management strategies. Production included the following enterprises: grazing; cropping; dairy. Although individual circumstances and locations differ, there are common themes that evolve: livestock selection and management; soil moisture content assessment; ground cover as a priority; need for climate forecasting; water storage; goal setting; financial opportunities and management; mental and physical health of all involved; benefit of community involvement. In addition, it was often common to realise the need to make tough decisions such as breaking away from traditional family or location management practices or selling seed stock. However, it can be difficult to be objective when formulating the plan. Preparation for drought is best undertaken in normal times.

Modelling the current and potential spread of the exotic grass Bothriochloa pertusa throughout sub-coastal Queensland

Miss Gabrielle Lebbink[1], Dr Rod Fensham[1, 2], Dr John Dwyer[1]
[1]*University Of Queensland, St Lucia, Australia,* [2]*Queensland Herbarium, Mnt Coot-tha, Australia*

Biography:
I enjoy a challenge and have therefore focused my career towards trying to address some of the intricate and interrelated threats to our natural environment. At the end of 2016 I completed my honours degree at the University of Queensland, where I investigated plant species responses to soil properties and fire history in semi-arid savanna. In January 2017, I commenced my PhD program, which is focused on determining the factors which influence the spread and impact of the invasive grass species Bothriochloa pertusa. My ecological interests are varied, but I am particularly drawn to rangeland and plant ecology.

Managing the spread of invasive species is an important priority in the Australian rangelands. The invasive exotic grass species Bothriochloa pertusa was first introduced in the 1930's into eastern Queensland to be trialed as a pasture and lawn grass species. Since its introduction B. pertusa has naturalised and is thought to have spread widely throughout Queensland. Current estimates of its spread are undetermined; however its presence is widespread, spanning from south-west of Mackay to north of Charter Towers. The species has been associated with significant declines in floristic diversity, particularly of native perennial grass species. It is thought to be moderately beneficial as a pasture grass in low fertility soils, however its inherently low biomass and drought tolerance reduces it production value and in areas where it outcompetes more desirable pasture species has been associated with significant production declines. Using information on the current and historical distribution of B. pertusa we aim to map and analyse its spread throughout the Burdekin region of Queensland and investigate trends in B. pertusa density across ranges of environmental, climate and soil predictors. Finally, using this data alongside phenological attributes of the species we aim to formulate habitat and climate suitability models to predict areas vulnerable to future invasion. This research will be integral for managing the species current and future spread and to minimise negative impacts on floristic diversity and livestock production.

Monitoring Australia's rangeland vegetation under climate extremes using multi-satellite observations

Mr Song Leng[1], Prof Alfredo Huete[1], Dr James Cleverly[1]
[1]*University of Technology Sydney, Sydney, Australia*

Biography:

Song Leng is a third-year PhD student at the University of Technology Sydney, and he has a research background in remote sensing, landscape ecology, phenology and monitoring extreme drought/wet events. As a member of the Ecosystem Dynamics Health and Resilience research group led by Professor Alfredo Huete, Song is currently focused on phenology dynamics of dryland vegetation under climate disturbances across central Australia using multi-scale satellite observations coupled with eddy covariance tower flux measurements.

Extensive areas of central Australia are exposed to highly variable and extreme climates with prolonged droughts and intense rainfall pulses. An exceptionally 'big wet' event occurred in central Australia during 2010-11, triggering a huge vegetation response that was largely responsible to a large global land carbon sink anomaly. This was repeated with another extreme wet pulse during the 2016-17 monsoon season in central Australia, with a larger intensity than 2010-11. We investigated the response of two major biomes (Mulga woodland and Hummock grassland) to these two extreme wetness events and characterized their spatial-temporal traces in greening and drying utilising multi-satellite observations of (1) solar-induced chlorophyll fluorescence (SIF), as a proxy for photosynthetic activity, (2) enhanced vegetation index (EVI), as a proxy for surface chlorophyll or greenness, and (3) soil moisture derived from the Soil Moisture Active-Passive (SMAP) sensor. We evaluated the impacts of extreme wetting and drying events on the spatial patterns of greening and photosynthetic rates and ecosystem functioning for the two major biome types. Our results show:

- Both Mulga woodland and Hummock grassland displayed irregular seasonal patterns and high inter-annual variability largely regulated by hydro-climatic conditions;
- Mulga was generally more responsive to extreme wet and dry events compared with Hummock, although in the 2010-2011 big wet, both biomes were highly responsive;
- Extreme wet events altered the phenological response of both Mulga and Hummock land cover types;
- Soil moisture derived from the SMAP mission was shown to be a more valuable controlling variable of vegetation responses under climate disturbances.

Satellite observations of greenness and photosynthesis enable an improved understanding of rangeland vegetation dynamics over dry and wet periods and can advance our ability to detect ecosystem alterations under future changing climates.

Vegetation cover targets for sustainable land management

Dr John Leys[1], Dr Juan Pablo Guerschman[2], Ms Jasmine Howorth[3]
[1]Office Of Environment And Heritage, Gunnedah, Australia, [2]CSIRO Land and Water, Black Mountain, Australia, [3]Australian Bureau of Agricultural and Resource Economics and Sciences , Canberra, Country

Biography:
John Leys is a Senior Principal Research Scientist and a Senior Team Leader – Knowledge Services with the Office of Environment and Heritage based in Gunnedah, Australia. John is Australia's leading researcher in agricultural wind erosion and dust storms. John started his career with the New South Wales public sector with the Soil Conservation Service of New South Wales in 1981. Since then he has worked with various New South Wales government natural resource management agencies and landholders with the aim of improving agricultural land management practices that will reduce soil erosion and dust storms.

Maintaining vegetation cover is key for sustainable rangelands. In dry times, cover is decreased, and dust storms and rainfall events erode soil. The climate, the fertility of the soil and land management practices all influence how much vegetation cover is left on the ground. But how much vegetation cover can be reasonably expected to be maintained in droughts?
The National Landcare project is working with all NRMs to develop regionally specific vegetation cover targets. The targets are designed to be improvement targets; that is, can we maintain more vegetation cover in the next dry spell than we did in the last one. We use remote sensed fractional cover time series data, that is freely available via the GEOGLAMM RAPP and VegMachine web pages, to develop targets from paddock to continental scale.
We suggest that the target should be "To manage total fractional cover so it does not drop below the 10th percentile of the area exposed to erosion for the last 18 years of monthly records". The logic is that most erosion occurs in drought, or when drought breaking rains occur. The aim is to "improve" the amount of vegetation cover retained in each successive drought. So, for the Australian continent, this would mean having greater than 61% of the landscape protected from wind erosion.
The benefits of improved land management practices can be quantified using vegetation targets. Demonstrating improvement in vegetation cover during droughts will clearly demonstrate that rangelands are being sustainably managed.

A review on the grassland management rules and programs in Inner Mongolia, China

Dr Ping Li[1], Prof David Kemp[2]
[1]*Institute Of Grassland Research, Chinese Academy Of Agricultural Sciences, Hohhot, China,* [2]*Charles Sturt University, Orange, Australia*

Biography:
Dr Ping Li (PL) is an agricultural social economist at Institute of Grassland Science, Chinese Academy of Agricultural Sciences. Originally trained in grassland resources management, she has worked over 10 years in grassland science. Her current research interests include the impact of grassland policies on herders and grassland ecosystem, herders' decision making, et al. With a research background of both natural science and social science, Dr Ping Li is inclined to treat human-livestock-grassland as a whole community and study the interaction among them. She has worked on several multidisciplinary projects investigating the mechanism and drivers of the herders' decision-making.

The recorded history of grassland management in Mongolia plateau is over 4000 years. Although the grassland management strategies have changed significantly, the review on the history of grassland rules and programs is helpful for improving the current and future grassland policy. The history of grassland management policies in Inner Mongolia was summarized based on a timeline. The main information obtained were:
(1) The grassland protection concept has developed from the original primitive fire forbidding and wild animal protection to the modern legislation which regulates the use of grassland resources and property rights.
(2) Seasonal migrations were the main method used in grassland management to avoid nature disasters and go through the harsh winter before the establishment of the PRC in 1949.
(3) During 1949 and 1980, improving animal production to feed the population was the main target of the government, which has led to an increase in livestock number while a decrease in grassland quality and quantity. Consequently, the Grassland Law was issued in 1985 and the grassland was contracted to households to avoid the "tragedy of the commons". However, environmental problems like sand storm and soil erosion became more serious before the end of last century.
(4) In recent 20 years, the grassland management goals of China have changed from animal production to combination of economic and ecological goals and then the currently ecological priority, which can be seen from the projects and rules that were carried out ever since.

Spatio-temporal monitoring of grassland degradation in the Qinghai-Tibet Plateau over past 3 decades

Ph.d Wenjun Liu[1]

[1]*Institute of Remote Sensing and Digital Earth, Chinese Academy Of Sciences, Beijing, China*

Biography:

Ph.D in ecology, research on how climate change induced precipitation regime changes and extreme precipitation events affect CO2 and H2O fluxes exchange in the semi-arid grassland, and current research focuses on monitoring grassland degradation in Tibetan plateau by building comprehensive remote sensing indices

Alpine grassland is the major ecosystem in the Qinghai-Tibet Plateau (QTP), accounting for 60% area of QTP. Due to climate change and anthropogenic activities, diverse forms and differing intensities of grassland degradation have been reported in several regions of the Plateau, explicit monitoring is crucial to analysis the temporal and spatial variations of grassland degradation for both researchers and policy makers. In this study, 27-year long-term AVHRR and MODIS data were used to developed grassland degradation classification indices based on net primary productivity (NPP) and fraction vegetation coverage (FVC), two most important indicators for grassland ecosystem quality and functioning. The result of this study indicated the both the area and degree of degradation were significantly decreasing and improving for the whole QTP and sub six eco-geographic region over three periods (1990-1999, 2000-2009 and 2010-2017). The degradation area of grassland was 1,096,866 km2, accounting for 80.90% of the entire grassland during 1990-1999, slightly, moderately, and severely degradation accounted for 19.37%, 25.59% and 55.05% of degradation grassland, respectively. During 2000-2009 and 2010-2017 period, degradation area reduced to 453,156.69 km2 and 266,036.31 km2, respectively, and severely degradation degree area were also decreased to 4.3% and 7.28%, respectively. The general situation was improving, however the improve in some area such as south Qinghai and North Tibet was still limited, which need more attention

Cascade framework coupling suppliers and beneficiaries of soil erosion control services in a semiarid watershed

Dr. Yu Liu[1]

[1]*Institute of Geographical Sciences and Natural Resources Research, Chinese Academy Of Sciences, Chaoyang District, China*

Biography:

Yu Liu is a full-time staff of Institute of Geographical and Natural Resources Research, CAS, and a staff of Chinese Ecosystem Research Network (CERN) Secretariat. Dr. Liu is experienced in soil erosion and ecohydrological monitoring and modeling, and application of remote sensing for ecosystem observation and assessment. Recently, he focused on the linkage between landscape pattern dynamic and sediment flow at scales range from hillslope to watershed in semiarid environment on the Loess Plateau, with the consideration of interactions between landscape pattern and processes.

Cascade framework coupling suppliers and beneficiaries of soil erosion control services in a semiarid watershed

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Soil erosion control services (SECS) are fundamental ecosystem services for human beings. Since spatial decoupling among SECS donating areas and beneficiaries are common, delivering ES through some service carrying media is common. Previous SECS assessments mainly count the benefits derived from on-site soil erosion prevention, or preventing the in situ soil loss. The off-site benefits usually are estimated by multiply the capacity of SECS provision by spatially consistent allocation coefficients of land use/cover types. Overestimation, item omission, and disability in catching the spatial heterogeneity of SECS lead to great uncertainties. In this study:

- A cascade concept adopting sedimentological connectivity was develop for evaluating soil erosion control services flow between suppliers to beneficiaries for a semiarid watershed on the northern Loess Plateau in middle Yellow River basin in China.
- Both the on-site soil erosion prevention and sediment delivery over landscape were integrated into the SECS quantification by referring to the methodology of WATEM/SEDEM, which potentially reveal the sedimentological connectivity over landscape.
- A monetarized valuation of SECS delivered to local communities was evaluated by employing a land-use-based replacement cost technique and taking the land units as SECS receiver and conveyer.

This approach illustrated is helpful in understanding and coupling the supply of soil erosion control services with the benefits of local communities, and thus, improves the evaluation of SECS.

Assessing Critical Natural Capital in Ecologically Fragile Areas: Land Use Scenarios Based Analysis

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[1]*Research Center for Eco-environmental Sciences, Chinese Academy Of Sciences, Beijing, China,* [2]*University of Chinese Academy of Sciences, Beijing, China*

Biography:

Dr Yuanxin Liu is a post-doc in ecology at Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. His primary research topics include ecosystem service assessment, soil and water conservation, and landscape ecology.

Abstract: Many ecologically fragile areas face challenges around meeting the needs of society development and maintain natural capital. Land use policy and management changes can alter critical natural capital with a socio-natural system. The Qinghai-Tibetan Plateau (QTP) is a source of many of Asia's major rivers and is the largest high-altitude grazing region in the world. Grasslands on the plateau, where pastoral practices date back at least 8800 years, cover about 1.33 ×106 km2, accounting for almost 60% of the QTP and 30% of grasslands in China. The QTP provides abundant critical natural capital (CNC), but it is a typical ecologically fragile area. It is important to understand the spatio-temporal variations of CNC in QTP, modified by land use policy and management. In this study, we adapted a biophysical approach to quantitatively assess 4 CNC functional components, including carbon capture, soil protection, water and nutrient retention, and habitat provision, from 2000 to 2015. Firstly, the spatial patterns and temporal trends of CNC were mapped. Secondly, according to the 16-year land use change and the demand for land use management, we set up different scenarios and analyzed the changes of CNC. Finally, corresponding land use planning measures are proposed to provide methodological support for government decision-making and sustainable development in ecologically fragile areas. Moreover, our method for assessing the relationship between land use planning and critical natural capital can be easily adapted to other large-scale ecologically fragile areas.

Keywords: critical natural capital, ecosystem services, land use management, land use scenarios, Qinghai-Tibetan Plateau

Herders' preference for different grassland management policy in Mongolia

Enkh-Orchlon Lkhagvadorj[1], Duinkherjav Bukhbat[2], Lkhagvadorj Dorjburegdaa[3], emeritus professor Jeffrey Bennett[1]

[1]Australian National University, Canberra, Australia, [2]University of Queensland, Brisbane, Australia, [3]Mongolian University of Life Sciences, Ulaanbaatar, Mongolia

Biography:

Enkh-Orchlon is a PhD candidate at the Australian National University focusing on agricultural and development economics in Mongolia.

Herders' preference for different grassland management policy in Mongolia
Enkh-Orchlon Lkhagvadorj, Duinkherjav Bukhbat, Lkhagvadorj Dorjburegdaa, Jeff Bennett

After the transition to market economy in 1990 livestock numbers have increased tremendously. This has led to grassland degradation due to overgrazing in the central regions of Mongolia. The lack of regulations and high occurrence of natural disasters known as dzud (harsh winter) have led the herders to struggle. With no social safety nets in place herders are turning to maximize the herd size in order to overcome the risks. This paper discusses the results of research that studies the preference of herders for different grassland management options. Choice modelling design is used in the questionnaire to present different policy attributes and options for the herders. Livestock tax is used as a payment scheme to reveal the willingness to pay for the attributes. Contingent behavior analysis is also employed to study how the herders would respond to the changes in policy options presented. The results reveal that herders are willing to pay for better market access, lower interest rate for credit and for others to decrease their livestock numbers. On the other side credit size and infrastructure and communication were found to have insignificant results.

Vegetation change and its hydrological consequences in African savannas

Dr. NAN LU[1], Linhai Cheng[1], Zhuonan Wang[2]

[1]Research Center for Eco-Environmental Sciences, Chinese Academy Of Sciences, Beijing, China, [2]School of Forestry and Wildlife Sciences, Auburn University, Auburn, USA

Biography:

Dr. Lu Nan is currently an associate professor in the State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-environment Sciences, Chinese Academy of Sciences. Her research interests include ecosystem hydrological process, plant-water relationship in arid and semi-arid regions, ecosystem service, process, mechanism and assessment.

Vegetation structure is closely associated with hydrological cycles. In this study, vegetation change in African savanna areas were analyzed by using VCF, NDVI and LULC data. The relative changes of the fractions of tree, grass, shrub, crop and other land types were firstly separated and then the data layers were combined with a dynamic land ecosystem model (DLEM). The analyses were conducted at 0.5°×0.5° spatial resolution. Our main findings are: 1) the fractions of vegetation have changed significantly in the savannas regions of Africa during 1992-2015; 2) significant increase in tree cover was dominant in the northern area and significant decreasing trend in tree cover with increasing shrub or grass cover occurred in the southern area; 3) the contrasting pattern was mainly related to the change of fire regime and clear cutting besides the direct influences of climate; 4) woody encroachment into grassland in the northern savannas led to more biomass accumulation but decreased water yield (WY), which was unfavourable for water related ecosystem services; 5) tree cover reduction in the southern area increased WY in the study period but resulted in large carbon loss. Ecosystem management in different savannas should fully consider the driving forces and trade-offs of ecosystem services to maintain the structure and functioning of this particular ecosystem type.

Natural Resource Management can make an important contribution to Disaster Resilience in Rangelands Regions

Mr Andrew Maclean[1], Dr Gabriel Crowley[2], Ms Anne Alison[1], Ms Pru Wharton[1], Mr Steve Cobbin[1]
[1]Southern Gulf NRM, Mount Isa, Australia, [2]Cairns Institute, James Cook University, Cairns, Australia

Biography:
Andrew Maclean is the CEO of Southern Gulf NRM, the regional natural resource management body for the Southern Gulf region in north-west Queensland. In this role, Andrew leads a team of staff developing and implementing projects to support the sustainable management of the extensive rangelands of the region, which are mostly managed for beef production. In prior roles, extending over 30 years, Andrew has held diverse senior roles in heritage and protected area management, native forest management, biodiversity, biosecurity and fire management.

A monsoon trough over the Southern Gulf region of north-west Queensland in early February 2019 generated intense rainfall over a period of several days. Major flooding affected 457 rangelands grazing properties in the Southern Gulf region, extending over 69,000 km2 and caused major mortality in the regional beef and sheep herd. Flooding also caused major damage to fencing, caused extensive erosion and has stimulated widespread germination of noxious weeds.

The disaster prompted a strong response from disaster management agencies working at the local, regional, State and National levels. Governments have now committed $242M to disaster recovery programs for the Southern Gulf and other regions affected by the disaster.

In the days immediately following the floods, Southern Gulf NRM developed and communicated an NRM-based response strategy. This identified four interlinked high-level outcomes: (1) farm business and community resilience; (2) landscape recovery; (3) resilient management practices; and (4) assessment, planning and monitoring. Each of these outcomes align with the long-established role and capability of Southern Gulf NRM.

Some preliminary observations about the 2019 flood disaster from a natural resource management perspective are:

• Best practice natural resource management plays a positive role in building and maintaining producer, community and landscape resilience to the impacts of flooding

• The regional flood recovery program provides an opportunity to build resilience and support preparedness for future flooding events – it can and should be more than just a restoration program

• The scale and remoteness of the grazing enterprises in the region demands that disaster preparedness needs to be planned and implemented at the individual property scale; disaster preparedness planning potentially integrates well with other aspects of NRM-driven property management planning

• Natural resource management organisations and approaches could contribute more to coordinated disaster preparedness and response activities if they were more completely recognised in disaster management arrangements – this is especially important in rangelands regions were underlying institutional capacity is sparse

Widespread adoption of digital technology in rangelands agriculture will need establishing regional innovation platforms

Dr YIHEYIS MARU[1]

[1]*CSIRO, Land and Water, Canberra, Australia*

Biography:

Dr Yiheyis Taddele Maru is a senior systems research scientist at CSIRO. He has veterinary medicine and rural development background. Since joining CSIRO in 2002, he has been conducting research for resilient and sustainable development of remote regions in Australia as well as systems research for food security and agricultural development in sub-Saharan Africa. His current research focus include:

1) Developing agricultural innovation systems informed partnership models for improved animal health surveillance and biosecurity systems in Australia

2) Mainstreaming resilience, adaptation and transformation pathways in the design and implementations of interventions for sustainable development in regional Australia and developing countries

Rangeland agriculture (including pastoralism) can significantly benefit from wide adoption of digital and digitally enabled biological technologies such as sensors, drones, big data and genomics. Digital agriculture is expected to substantially:

a) Improve productivity, profit and generate new products,

b) Build resilience to a variety of stresses and shocks,

c) Help meet dynamic customer expectations, industry standards, regulatory requirement and stewardship obligations.

Known for its poor soils, harsh and variable climate, rangeland Australia provides the opportunity to develop and test digital technologies by national and international entrepreneurs. Digital agriculture in Australia is, however, in its infancy and faces significant challenges, which are more pronounced in the rangelands.

These include lack or limitation in:

a) Internet connectivity and coverage,

b) Digital literacy,

c) Clear value proposition to farmers and pastoralists,

d) Trust and confidence on ownership and confidentiality of data, and

e) Data regulation and governance.

Given these challenges, traditional transfer of technology through the persuasive efforts of extension agents will not work for most digital technologies. Furthermore, unlike conventional technology, the development and use of most digital technologies will require building close and sustained working relationships and trust among farmers and entrepreneurs and digital data analysts. Informed by Agricultural Innovation Systems (AIS) approach, we propose forming regional innovation platforms in the rangelands for digital innovation. We make this proposal drawing from our current successful application of AIS approach in improving partnership and surveillance of exotic animal diseases in Australia. An innovation platform is a partnership among stakeholders for effective interaction to understand needs, share knowledge, learn together, promote trust and coordinate efforts at different scales for innovation. In AIS, innovation is not only developing the technology but also putting it in use to generate value by simultaneously addressing the multiple capacity, trust and institutional and infrastructural challenges.

Working together for research success: The CRCNA's role in forging partnerships across northern rangelands

Mr Jed Matz[1], Councillor Peter Long
[1]*Crc for Developing Northern Australia, Hermit Park, Australia*

Biography:
Jed has had over 20 years of experience providing policy, strategy and operational leadership in Australian Agriculture.
He has worked with the Department of Primary Industries and Resources SA, as an English teacher in Japan and with the South Australian Farmers' Federation representing the interests of Sheepmeat, Cattle, Wool, Poultry and Pork Producer and as the Policy Director and CEO of the Cattle Council of Australia.
In 2017 he was appointed as the inaugural CEO of the CRC for Developing Northern Australia (CRCNA).

Developing strong partnerships between researchers, industry, communities and governments is crucial for building resilient rangelands across Australia. Short-term research collaborations may deliver against specific program objectives, but this can often fail to address much broader capacity-related issues which are impeding future development or progress. Australia's rangelands have experienced several stop-start, but often positive approaches to supporting researchers working with industry and communities (and vice versa). These relationships, however, are fundamental to achieving long-term social, economic and environmental outcomes. They are also crucial to build the trusted science needed to help tackle big policy-based challenges.

This presentation aims to highlight the success or otherwise of past approaches, while also providing an overview the work that the Cooperative Research Centre for Developing Northern Australia (CRCNA) is doing across the northern rangelands such as : (i) brokering research collaborations between industry, researchers and governments; (ii) investing in projects which can help challenge the status quo, particularly around production system and supply chain developments, models for Traditional Owner-based business development, and new health service delivery models. The research will have a direct impact on the long-term sustainability and prosperity of rangeland environments and communities across northern Australia. Building strong partnerships across industry, Traditional Owners, government and business is ensuring maximum "buy-in" and emerging as a long-term strategy to implement the outcomes of the research. The lessons learned in the north are important and transferable to the broader rangeland context.

Importantly, the presentation will highlight these long-term and strategic approaches of the CRCNA and its role in working across the Australian Government and Western Australian, Northern Territory and Queensland jurisdictions to build stronger and impact-focused research partnerships which aim to tackle some of the most important and ongoing conflicts which persist across the rangelands including environmental, indigenous and development considerations.

Grazing with rest: what we know and where to from here?

Dr Sarah McDonald[1, 2], Ms Rachel Lawrence[2], Dr Romina Rader[2]

[1]NSW Department of Primary Industries, Trangie, Australia, [2]University of New England, Armidale, Australia

Biography:

Sarah is a research officer at NSW Department of Primary Industries, working in pasture and rangeland systems. Specific research interests include sustainable land management, particularly in arid/semi-arid environments, and the integration of production and ecological outcomes in agricultural systems.

With purported benefits of improved animal production and ecosystem health, interest and adoption of grazing systems incorporating periods of planned rest (rest-grazing) has grown rapidly in recent decades. However, published research has revealed contrasting findings and the value of these systems is often debated. This presentation outlines key results from a systematic review into the ecological, biophysical and animal production effects of incorporating rest into Australian livestock production systems. Data from 68 studies comparing rest-grazing and continuous grazing systems were analysed, with the majority of studies reporting either equal or greater ground cover, biomass and livestock production per hectare under rest-grazing. Only 12 studies compared rest-grazing with ungrazed systems, with the majority revealing reduced ground cover, biomass and tree regeneration under rest-grazing. Overall, this review highlighted a lack of research in arid and semi-arid areas, along with little research focusing on animal (native mammal, reptile, bird, insect), plant diversity or functional diversity measures. Only a small proportion of studies considered the effect of rest-grazing on both ecological and production outcomes simultaneously. In addition, the majority of research undertaken in Australia has studied short-term effects of rest-grazing systems on a small scale that is not reflective of 'real-life' management, and few have examined effects of systems with long rest relative to graze times or the use of more tactical cues to determine when rest and graze events occur. Future research should seek to address these gaps in order to improve our understanding of the benefits and trade-offs of different grazing systems and to develop grazing management strategies that promote both ecological and production outcomes.

Sustainability Initiatives at Ayers Rock Resort

Ms Mandy McLeod[1]

[1]*Voyages Indigenous Tourism Australia, Yulara, Australia*

Biography:

Mandy McLeod is the Environmental Officer for Voyages, Ayers Rock Resort in the central desert region of the Northern Territory. With tertiary qualifications in environment management, Mandy is committed to improving environmental outcomes by reducing resource use and waste production, protecting native species, and engaging with both the workforce and the wider community through awareness and education. Mandy has over 20 years' experience in managing environmental issues across large complex organisations, including in the timber, and infrastructure industries, pulp and paper manufacture.

Ayers Rock Resort is situated adjacent to the dual UNESCO World heritage listed Uluru Kata Tjuta National Park in the central desert region of the Northern Territory. The Resort is located on more than 10,000 ha of land, the majority of which is unfenced, and has very little human interference apart from the township, remote dining sites and fire trails.

The Resort hosted more than 365,000 guests in 2018, and also manages the township of Yulara with a population of over 1,400 residents. Due to its remote location a number of services usually seen within larger population centres, such as an industrial laundry, waste facilities, service station and supermarket are on site.

Many sustainable initiatives have been undertaken by the Resort over time, including:

o construction of the Tjintu solar field in 2016, designed to produce up to a minimum of 30% of the electricity consumption of the Resort, thus reducing reliance on fossil fuels;

o instigation of a ban on plastic bags in 2005 from the supermarket with a reduction of 465,000 plastic bags/year consumed, and in 2019 a project to remove all single use, non-recyclable plastics wherever possible;

o recycling which commenced in 2000, initially of cardboard and then expanded over time to include glass, aluminium, cooking oil, car batteries, E Waste (2017), and small batteries and light bulbs in 2019.

An ongoing threatened species monitoring program is now in its 19th year the longest running in the Central desert area.

Many of these initiatives and projects are well ahead of policy both at a national and territory/state level and are being undertaken in a remote location. What are the implications for the future of policy making and implementation for remote areas?

Low volume, high concentration splatter gun technology – a useful tool for 'opening up' dense bellyache bush (Jatropha gossypiifolia) infestations?

Hayley McMillan[1, 2], Shane Campbell[2, 3], Dannielle Brazier[3], Clare Warren[3]

[1]Department of Agriculture and Fisheries, Agri-Science Queensland, [2]School of Agriculture and Food Science, The University of Queensland, [3]Department of Agriculture and Fisheries, Tropical Weeds Research Centre, ,

Bellyache bush (Jatropha gossypiifolia L.) is a highly toxic perennial Weed of National Significance capable of forming dense infestations within rangeland areas of northern Australia. This study aimed to determine if the high efficacy obtained using splatter gun technology on isolated bellyache bush plants could also be achieved if dense infestations were treated. The efficacy of three herbicides at two rates each (metsulfuron methyl - Brushoff® (1, 2 g product L-1), aminopyralid/metsulfuron methyl - Stinger™ (2, 4 g product L-1) and triclopyr/picloram/aminopyralid - Grazon™ Extra (35, 50 mL product L-1)) was tested against an untreated control treatment. In a dense infestation (~25,000 mature plants/ha) located in North Queensland, twenty-one 5x5 m plots were set out using a randomised complete block design with three replications. Herbicide treatments (that included 2 mL L-1 of the non-ionic wetter/spreader/penetrant Pulse® (Nufarm)) were implemented in March 2019 using a gas powered 'Forestmaster' applicator (N.J. Phillips®) set to deliver 50 mL shots via a stream splatter nozzle. The aim was not to saturate foliage but to apply 'splatters' of mixture across the entire plot at the recommended application rate of 10 mL/m2 of canopy cover (see Grazon™ Extra label). Plant health and mortality were monitored at 0−1, 1−2, 2−3, 3−4, and 4−5 m from the spray front. Five months after treatment, ≥85% of plants treated with herbicides containing metsulfuron methyl (Brushoff® and Stinger™) were either dead (~35% of plants) or largely desiccated (~60% of plants), with no regrowth present. Triclopyr/picloram/aminopyralid (Grazon™ Extra) appeared ineffective, with regrowth present on ≥83% of plants five months after treatment. Under these conditions, no significant rate response or effect of distance from the spray front was evident five months after treatment ($p>0.05$). These preliminary findings suggest that splatter gun technology may be a useful tool for 'opening up' dense bellyache infestations for follow up control.

Living Earth Australia: Land cover mapping to inform decision-making in Australia's rangelands

Dr Christopher Owers[1], Professor Graciela Metternicht[2], Professor Richard Lucas[1], Dr Peter Bunting[1], Dr Daniel Clewley[3], Miss Belle Tissott[4], Mr Sean Chua[4], Dr Ben Lewis[4], Mr Norman Mueller[4]

[1]Department of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, United Kingdom, [2]School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, Australia, [3]Plymouth Marine Laboratories, Plymouth, United Kingdom, [4]Geoscience Australia, Symonston, Australia

Biography:

Graciela Metternicht is Professor of Environmental Geography at the UNSW Sydney, with over 20-year experience in remote-sensing based landscape analysis of semi-arid landscapes. She has conducted research on rangelands degradation for the Government of Western Australia and currently advices the UN Convention to Combat Desertification, and the UN Global Environmental Facility on matters of land degradation and sustainable land management. She has a special interest in applications of geospatial technologies for environmental management and sustainability

Identifying the state and condition of Australia's landscape through continuous monitoring is paramount to a sustainable approach for managing our natural resources. Reliable, standardised, continental-scale mapping of land cover and its change over time and space facilitates decision-making by providing information to implement and assess management practices addressing challenges unique to the Australian rangelands. Digital Earth Australia (DEA), developed by Geoscience Australia, offers a framework for continuous land monitoring using earth observation data to produce a range of open access land products targeted to decision makers, practitioners and scientists. Living Earth Australia builds on this innovative framework to generate land cover maps and change classification based on the Food and Agriculture Organisation (FAO) Land Cover Classification System (LCCS).

This study generated FAO LCCS level 3 classification, differentiating eight (8) key land cover types over the Australian continent: aquatic and terrestrial (semi) natural vegetation, cultivated and managed terrestrial and aquatic vegetation, artificial and natural (bare) surfaces, and natural and artificial water bodies. Annual summaries of Environmental Variables (EVs) within DEA were used to derive five input layers required for the classification, including Fraction Cover, Water Observations from Space (WOfS) and surface reflectance Median Absolute Deviation (MADs). This novel approach facilitates routine, multi-temporal generation of land cover maps at high (<=30m) spatial resolution using a consistent and internationally recognised taxonomy. Moreover, land cover maps provided by Living Earth Australia can be integrated with environmental management frameworks such as DPSIR (Drivers-Pressures-States-Impacts-Responses) for reporting change in the rangelands to support effective and timely decision-making.

Remote Sensing for landscape monitoring in Queensland

Mr Andrew Morgan[1], Ms Deanna van den Berg[1], Ms Lisa Collett[1], Mr Dan Tindall[1,2], Mr Neil Flood[1,2], Ms Fiona Watson[1], Ms Caroline Teutsch[1], Ms Dan Wu[1], Ms Jane Bryden-Brown[1]

[1]Department of Environment and Science - Queensland Government, Dutton Park, Australia, [2]Joint Remote Sensing Research Program, Brisbane, Australia

Biography:

Andrew Morgan is a scientist within the Queensland Government's Remote Sensing Centre, in the Department of Environment and Science, Brisbane, Australia.

The Queensland Government has a long history of using earth observation for its rangeland monitoring programs. Satellite and airborne imagery has been integral to the State-wide Land and Trees Study (SLATS), ground cover, and fire scar monitoring programs for observing and recording changes in Queensland's vegetation. These programs are built on archives of historical data requiring a high performance computing environment and include data from active and passive sensors at a range of spatial and temporal resolutions. As more data becomes available from a range of sensors, many at higher temporal and spectral resolution than previously available, these programs and the products generated by them are continuously improved and refined to meet user demands.

A new program of work is currently being undertaken in Queensland to enhance SLATS and provide information on woody vegetation extent and dynamics across the state, including its extensive rangeland environments. The program is building on the extensive legacy and continuity of the Landsat archive, while maximising new technologies such as the European Space Agency's Copernicus program and very high spatial resolution and high temporal frequency data such as Earth-i and Planet.

As part of this program, research and development has focused on producing spatial datasets describing woody vegetation extent. A relatively new computer vision approach was applied to very high resolution (1m) imagery with a streamlined editing framework to enable efficient production of accurate, highly detailed maps of woody extent. The computer vision approach uses existing woody vegetation extent data sets to train a model that analyses the data on multiple spatial scales to produce predictions which is then applied to very high resolution imagery. Editing the machine learning outputs presents its own set of challenges due to the complexity and diversity of Queensland's vegetation types and landscapes.

What happens after you cull a kangaroo and leave it to rot?

Dr Thomas Newsome[1], Emma Spencer[1]
[1]*University of Sydney*

Biography:
I am a Lecturer (Academic Fellow) at The University of Sydney. I hold a courtesy faculty position within the Department of Forest Ecosystems and Society at Oregon State University, and an Affiliate Assistant Professorship within the School of Environmental and Forest Sciences at The University of Washington. My research addresses how species respond to human-induced changes to the landscape. I am particularly interested in how humans, predators and scavengers shape and drive ecosystem processes.

When an animal dies, its carcass becomes a food resource for vertebrates, invertebrates and microbes. Uneaten carcass remains decompose, returning nutrients to the soil, which influences localised plant growth. But despite these events being integral to the structure and function of all ecosystems globally, we lack an understanding of the dynamic processes that occur in, on, and around carcasses, and whether they are changing in a human-dominated world. In this talk, I will present results from a study that has monitored vertebrate and insect use of over 150 kangaroo carcasses across three different eco-regions in Australia. I will show how different factors such as season, habitat, and scavenger diversity can influence carcass decomposition rates. I will also outline the extent to which carcasses can become a hub for invasive vertebrate and insect pests that threaten biodiversity and/or agricultural productivity, such as red foxes, feral cats, feral pigs and European wasps. The results provide insights into the ecosystem services that scavengers provide in terms of their ability to rapidly consume dead animal material, but also the ways in which carcasses can facilitate invasive pests. The research also uncovered how carcasses can be used as a tool by land managers to assess ecosystem structure and functioning by evaluating scavenger diversity and measuring carcass decomposition rates. I will therefore outline how this can be effectively achieved. Although death is a natural part of the web of life, our results highlight (1) the ways in which humans have modified critical ecosystem processes around carcasses, (2) that land managers need to more broadly consider the ecosystem effects of undertaking culls and leaving carcasses to rot in-situ, and (3) that we need to increase our understanding of the dynamic processes that occur in, on, and around carcasses.

Natural Capital Accounting: supporting rangeland producers to balance production and the environment

Ms Susan Ogilvy[1], Dr Dionne Walsh[2], Dr Kathryn Ryan[3]

[1]ANU Fenner School of Environment & Society, Canberra, Australia, [2]NT Department of Primary Industry and Fisheries, Darwin, Australia, [3]WA Department of Department of Primary Industries and Regional Development - Agriculture and Food, South Perth, Australia

Biography:

Sue is completing PhD research at the Fenner School of Environment & Society ANU. Her research explores how ecosystems can be included in the international accounting standards for corporations. She has published in environmental accounting and food security literature as well as in general literature exploring the opportunity to support sustainability-conscious markets to establish a virtuous cycle of causally linked improvements in environmental and economic performance of livestock producers. Her most recently completed project investigated the comparative profitability of grazing farms with better environmental performance and profitability in the sheep-wheat belt.

Title: Natural Capital Accounting: supporting rangeland producers to balance production and the environment

Abstract

Increasing consumer anxiety about environmental issues is motivating investment by governments, investors, financiers, insurers and sustainability-conscious brands to incorporate environmental performance and biodiversity conservation in their investment, lending and sourcing decisions. The formal frameworks of natural capital accounting allow these users to measure, verify, compare and communicate environmental performance of agricultural producers. They use the information to assess and compare the profitability, dependability and sustainability of the natural resource base and whether it is generating the environmental and conservation outcomes required to maintain their social licence to operate. Outside of the agricultural value chain, natural capital accounts can provide information for governments to assess the magnitude of any financial disadvantage producers may experience if they were to increase environmental performance. Recent research suggests that leading producers may already be capturing the information required for natural capital accounting. Good practice management of rangelands for livestock grazing already describes methods for measuring ecosystem condition and assessing whether they are being used in an environmentally sustainable way. These measures are congruent with the formal accounting frameworks for national accounts and corporate accounts of individual entities. Our presentation demonstrates the incorporation of these measurements that underpin good practice management into formal natural capital accounts and a statement of ecological position. We discuss how this may enable rangeland producers to prepare and use natural capital accounts to demonstrate their environmental-economic credentials and communicate opportunities for public investment to increase environmental and biodiversity outcomes. If widely implemented, natural capital accounts would provide valuable input to corporate and government policies to support producers to generate the environmental performance and biodiversity conservation services increasingly expected by society.

How many sheep does a kangaroo make?

Dr Lester Pahl[1]

[1]*Department of Agriculture and Fisheries, Queensland, Toowoomba, Australia*

Biography:

Has researched the interactions between herbivores and pastures in the rangelands for the Department of Agriculture and Fisheries for over 20 years. But still trying to answer basic questions such as what impact do kangaroos have on livestock production.

The extent that kangaroos substitute for sheep and thus contribute to total grazing pressure (TGP) has been conveyed in dry sheep equivalents (DSEs). As the maintenance energy requirements of marsupials is known to be 70% that of placental mammals like sheep, a kangaroo has often been considered to be 0.7 of a DSE. More recently, Munn et al. (2013) and Munn et al. (2016) found that the field metabolic rates of kangaroos are only 0.45 that of a same-sized Merino sheep, and thus a kangaroo is 0.45 of a DSE. Furthermore, Grigg (2002) argued that a kangaroo may only be 0.15 of a DSE, due to their smaller size relative to sheep. On the basis of these findings these authors propose a much lower contribution of kangaroos to TGP.

However, a herbivore's energy requirements do not faithfully predict the amount of forage they consume daily, as the latter varies with forage quality, digestive systems and selective foraging capabilities.

Based on measured daily dry matter intakes, a kangaroo consumes 0.7 that of a same-sized sheep when fed a high quality diet such as Lucerne, and 0.9 that of a same-sized sheep when fed low quality straw. However, given that on average kangaroos may be 30% smaller than sheep, an average-sized kangaroo is more likely to represent 0.6 of an average-sized Merino sheep.

A DSE of 0.6 for kangaroos may better represent their contribution to TGP and the degree they may reduce the livestock carrying capacity of properties. However, the latter will depend on the extent kangaroos eat the same forages as livestock.

Rangeland goat production in western NSW: Where are they now?

Mr Mitch Plumbe[1], Mrs Trudie Atkinson[2], Mrs Gemma Turnbull[1]

[1]Western Local Land Services, Broken Hill, Australia, [2]NSW Department of Primary Industries, Trangie, Australia

Biography:

Mitch Plumbe is Senior Land Services Officer – Agribusiness, with Western Local Land Services. Mitch is based in Broken Hill where he has worked in rangeland grazing for the past 4.5 years. Prior to this he completed a Bachelor of Rural Science (Hon 1) at the University of New England.

The report 'Rangeland goat production in western NSW: Where are they now?' was published in February 2019 as a review of enterprise case studies developed by NSW Department of Primary Industries (DPI) in 2012. Eight pastoral businesses from across western NSW were interviewed in order to develop case studies that provide insight into the development and evolution of managed and semi-managed rangeland goat enterprises.

The transition of rangeland goats in western NSW from pest to managed enterprise has received much attention in recent years, following the record prices received for goatmeat in 2017. This study identifies the factors that contributed to individuals making a transition into managed goats as well as the evolution of the industry over the past five years.

A prominent theme that emerged from this study is that rangeland goats provide a profitable alternative to more traditional livestock enterprises. Depending on management practices, goat enterprises can also exhibit benefits such as reduced labour requirements, reduced input costs, and improvement in environmental condition. Increases in environmental health are associated with the tendency for goats to graze in a more dispersed fashion and browse a wider range of vegetation than traditional livestock. A critical aspect of successfully managed goat enterprises is the establishment of fencing infrastructure that allows for the controlled grazing of livestock and management of Total Grazing Pressure (TGP).

Seven recommendations are made in the study, including the following (in no order):

- Uptake of enterprise benchmarking across the industry
- Development of rangeland adapted Boer goats
- Industry promotion and extension of best practice management
- Prepare for and respond to the risk posed by wild dogs
- Further explore and promote the control options for Invasive Native Scrub (INS)

Individual rights and CPR: Based on the case study of grassland co-management in Qinghai-Tibet Plateau

Mr. Yingjun Qi[1], Prof Wenjun Li[1]
[1]*Peking University, Beijing, China*

Biography:
Yingjun Qi is the PhD candidate in College of Environmental Sciences and Engineering in Peking University and his supervisor is Prof. Li who is faculty in in Peking University in China. His research focuses on the grassland management pattern and the evolution of herders' individual grassland rights.
Wenjun Li the dean of the Environmental Management Department of the College of Environmental Sciences and Engineering in Peking University. Her research focuses on grassland management and animal husbandry development in China, with particular attention to the institutional changes in grasslands and their impact on grassland ecology and the livelihoods of herders.

Individual rights and CPR: Based on the case study of grassland co-management in Qinghai-Tibet Plateau
Yingjun Qi and Wenjun Li
Peking University, Beijing, China

Abstract： In China, with the marketization of pastoral areas and the development of pasture animal husbandry, it has become a trend to clarify and strengthen herders' individual grassland rights. Traditional CPR property rights theory does not focus on the evolution path of common resources and the importance of individual rights. Thus, this paper takes the two kinds of individual grassland rights formed spontaneously in the Qinghai-Tibet Plateau as an example to compare and analyze the influence of the different individual rights, and discusses the relationship between individual grassland rights and common property rights of grassland under the grassland co-management from the perspective of resource system and resource unit. The research finds that, compared with the individual grassland contracted operation right, the individual grazing quota right does not destroy the integrity of the grassland ecosystem, but maintains the grassland co-management mode, which has more advantageous in relieving the grassland grazing pressure, improving herders' livelihood asset level and reducing the production cost of pasture animal husbandry. Under the grassland co-management mode, individual grazing quota right is based on the grassland resource unit, common property right is based on the grassland resource system. The grassland grazing quota right is embedded in the grassland common property. Clarity of individual grazing quota right not only can strengthen cooperation between herders and community, but also can guarantee the continuity and effectiveness of collective action under grassland co-management mode.
Keywords: Resource unit, Resource system, Grassland grazing quota rights, Common property rights, Qinghai-Tibet Plateau

Learn from the past, Use the best, Adapt the rest: Insights from Alinytjara Wilurara region

Ms Kristy Richards[1], Ms Leah Feuerherdt[1], Mr Michael Haynes[1]
[1]*Alinytjara Wilurara NRM Board, Ceduna, Australia*

Biography:
Kristy was appointed to the Alinytjara Wilurara NRM Board in April 2016. Kristy was raised in the Yalata area on the sheep station called Colona Station. Kristy is of Wirangu, Kokatha, Mirning, Anangu, and Adnyamathanha decent, and she represents the Aboriginal Lands Trust (Aboriginal Regional Authority) on the Alinytjara Wilurara NRM Board.
Kristy's families have strong ties to the Alinytjara Wilurara Management Unit, and her family membership spans from Ceduna (Far West Coast Traditional Lands), west to Yalata, north to Maralinga, and across to Tjuntjuntjara in WA. She has a great understanding, and has worked closely with the Board, on several projects that relate to the engagement of the Anangu women.
Kristy would like to encourage and support the work of the Alinytjara Wilurara NRM Board, and ensure that practices and staff are culturally supported in their understanding of cultural and heritage responsibilities. She has an understanding of culture and NRM practices that have been passed down to her through generations, and she has a strong connection with her people from the Far West Coast to Oak Valley, and Western Australia.

The Alinytjara Wilurara (AW) region is home to ~3000 Aboriginal people who have lived in this rangelands region for thousands of years. The region that was once marked 'nothing' on early settler maps, and that many non-Aboriginal or urban people still consider to be a harsh and unforgiving landscape. Yet Aboriginal people have lived successfully here for a long time, and the majority of the region is recognised as freehold Aboriginal Land under Land Rights Acts. These Land Councils, and other native title holders in the region, work closely with the Alinytjara Wilurara Natural Resources Management Board to ensure natural resources are healthy and thriving. The AW NRM Board is comprised of all Aboriginal members from the AW region. The Board's aims are to increase awareness of the AW region and work in partnership for healthy people and country. One of the Board's guiding principles is to learn from the past, use the best and adapt the rest. This presentation will be delivered by an Aboriginal Board member, and share insight into how they've adapted and innovated to thrive in this rangelands region, and how all rangeland land managers can learn from, and with Aboriginal people, to continue to look after the precious rangelands regions of Australia. We plan to challenge and perhaps even shift perspectives of conference attendees!

The value of Aboriginal heritage as a cultural ecosystem service in the rangelands of NSW

Mr Mal Ridges[1]

[1]*Office of Environment & Heritage (NSW)*

Biography:

Mal Ridges began his career as an archaeologist whose PhD focused on mapping Aboriginal site distribution. In 2001 he began working in systematic conservation planning and developing methods for integrating natural and Aboriginal heritage. This resulted in the Aboriginal Sites Decision Support Tool (ASDST), which has assisted quantification of the cumulative impact on Aboriginal Heritage, and its conservation status in NSW. Since then his research has focused on how landscape planning can support Aboriginal cultural continuity and how the concept of healthy culture can be used as a planning objective.

Cultural ecosystem services is a new concept emerging from the Millennium Ecosystem Assessment in 2005, and has only become prominent in academic literature since 2010 (cf synthesis by Milcu et al 2013). Since being identified, the emerging challenge has been how to value cultural ecosystem services. Several recent studies have highlighted the value of heritage preserved in natural landscapes as an important tangible asset enabling the values of aesthetic appreciation and sense of place identified as cultural ecosystem services. Most of these studies have focused on agricultural heritage. However, little research has been undertaken to understand the extent, significance or value of Indigenous heritage in Australian rangelands. For Aboriginal people, connection with their heritage is an important part of maintaining identity, facilitating cultural continuity, and supporting health and well-being. This paper reviews the Aboriginal heritage present in the rangelands of NSW; the contribution it makes to the Aboriginal heritage of NSW; and its conservation status. The analysis is used to highlight the significant role rangelands in NSW have to Aboriginal people's ability to appreciate, connect with, and utilise their heritage. When coupled with recent research on the value of participating in cultural practice for Aboriginal people's health and well-being, the cultural service provided by Aboriginal heritage offers a significant contribution to how we value the cultural services provided by Australia's rangelands. The paper concludes by suggesting that heritage is an under-explored cultural ecosystem service of Australian Rangelands, and warrants more systemic, national, investigation.

Good dog, bad dog; how we manage predators for conservation and production outcomes

Dr Renee Rossini[1], Ms Tanya Pritchard[1], Ms Felicity Shapland[1]
[1]*Queensland Trust for Nature, Brisbane, Australia,* [2]*The University of Queensland, St Lucia, Australia*

Biography:
Renee Rossini is an ecologist working in the applied sphere for the Queensland not-for-profit QTFN, and as an academic and teacher for The University of Queensland. She has a strong history of working in rangelands, in central Queensland studying groundwater and native grasslands in national parks, and now in an organisation that works to flagship grazing and conservation outcomes in southeast Queensland.

As ecologists for the Queensland Trust for Nature we are in a unique position – we manage landscapes for biodiversity outcomes and threatened species persistence, but on some properties, we also ensure our management complements a productive grazing enterprise. This leaves us in a unique position, as conservationist and grazier, to test and comment on the age-old and ongoing dingo/wild dog debate in Australia. Across the globe, academic ecologists argue that predator-friendly management is imperative for conservation outcomes, whilst productive landscape managers hold that predators threaten the sustainability of their livelihoods. In this talk, we present data from 5-years of management and research on our properties in south-east Queensland. We will discuss how we have grown to position dingos/wild dogs in our management ethos, how their numbers have fluctuated on our reserves, the effects that has had on other introduced predators and native wildlife, and how their management affects us financially and particularly in regard to our grazing enterprise. In doing so, we present our perspective on how rangeland managers can contribute to the divisive dingo/wild dog debate in Australian and integrate this academic affair into organisational philosophy and on-ground management.

Madden-Julian Oscillation influence of phase on rainfall and intraseasonal dry spells: Halls Creek case study.

Miss Kath Ryan[1]

[1]*Department of Primary Industries & Regional Development, Kununurra,*

Biography:

Kath's role includes analysis and interpretation of field and laboratory results in a broad range of regulatory assessments, including clearing inspections (vegetation and soils), long term rangeland condition trend monitoring, and rangeland condition inspections on pastoral leases. She has been instrumental in the development and delivery of a broad range of extension tools including Kimberley rangeland condition guides, rangeland plant identification factsheets and fire management information for the Kimberley, Pilbara and Shrublands of WA. Kath is the department representative in the Northern Australia Climate Program.

Climatology (historical weather observations) together with the Madden-Julian Oscillation (MJO) index forecast and seasonal outlooks can be useful in northern rangeland management decision making. Climatology can provide long term 'best-bet' dates for wet season onset, green date, production point and end of growing season: these can be used in combination with seasonal outlooks to inform decisions about wet season stock movement, fire management, weed control, joining windows, adjusting stocking rates, labour hire, supplementation, etc.

The MJO is likely to influence rainfall at Halls Creek in phases 3, 4, 5, 6 and 7 during the northern wet season. Summary statistics of rainfall figures from 1974-2017 at Halls Creek show that phases 5 & 6 are most likely to coincide with rainfall.

The MJO also influences 'dry' periods during the northern wet season in phases 8, 1 and 2 (Wheeler et al. 2009). Phase 2 is least likely to coincide with rain at Halls Creek. 'Rainfall effective for plant growth' (50mm or more over 3 days with follow-up rainfall two weeks later) occurred at least once in 27 of the 42 years in the sample and in most phases of the sample period, but never in phase 2. The 23 years where 'effective rainfall' was not recorded at Halls Creek tracked along with years of near or below median rainfall.

Other major drivers of rainfall at Halls Creek include El Nino and La Nina patterns, the Indian Ocean Dipole and regional soil moisture during the dry season (Sur 2018).

Further analysis: regional drivers of 'unseasonal' rainfall; revision of thresholds for 'rainfall effective for growth' at Halls Creek; and, the length of time that the MJO remains in phases 4, 5 and 6 may correlate with the amount of rainfall received (i.e. increased length of time 'stalled' may lead to increased rainfall); .

Social acceptability of control practices for non-domestic herbivores in the southern rangelands of Australia

Dr Katrina Sinclair[1,2], Dr Allan Curtis[2], Dr Ronald Hacker[3], Ms Trudie Atkinson[4]

[1]NSW Department of Primary Industries, Wollongbar, Australia, [2]Graham Centre for Agricultural Innovation, Charles Sturt University, Wagga Wagga, Australia, [3]Ron Hacker Rangeland Consulting Service, Tenambit, Australia, [4]NSW Department of Primary Industries, Trangie, Australia

Biography:

Katrina is a social researcher experienced in qualitative approaches to examining the social dimensions of agriculture. She is currently leading a component of a multi-disciplinary project, Increasing livestock production by integrating tropical pastures in farming systems. Recently completed projects include the social acceptability of pest animal management in meeting TGP targets and understanding landholders' perspectives on the NSW cattle Tick Program.

Total grazing pressure is a key driver of productivity in livestock systems in the southern Australian rangelands. Grazing pressure from kangaroos, unmanaged goats and feral pigs (the focus species) must be managed as well as grazing impacts of livestock. There are control practices available to pastoralists to manage kangaroos, goats and pigs but these practices must be socially acceptable if the red meat industry is to maintain its social licence. This presentation draws on data from twenty-four semi-structured interviews with key industry stakeholders. Interviewees included pastoralists, a veterinarian, a sporting shooter, government agents (policy, NRM and agriculture), academics, animal welfare and animal protection advocates, a wildlife conservationist, red meat industry stakeholders, kangaroo meat processors and an indigenous representative.

Commercial shooting was the most acceptable practice for managing kangaroos with a much lower level of acceptance of non-commercial shooting. A trap yard (at a water point) was the most acceptable control practice for unmanaged goats with shooting least acceptable. Ground shooting, trapping and 1080 baiting were the most acceptable practices for controlling feral pigs with dogging least acceptable. Judgements about the acceptability of practices used by pastoralists to control kangaroos, unmanaged goats and feral pig populations were influenced by interviewee's attitudes towards particular species. For example, interviewees distinguished between managing native wildlife and "feral" animals, and between managing "resource" animals and "pest" animals. Actions to manage kangaroo populations are more contentious than efforts to control goats and pigs.

A key finding is that whatever practice is being considered, those responsible must be able to justify the need for population control, and demonstrate that the practices will not cause unnecessary "pain, distress or suffering".

Culling kangaroos presents an unexpected threat to native ground-nesting birds

Ms Emma Spencer[1], Dr Alex Kutt[2], Professor Chris Dickman[1], Dr Thomas Newsome[1]
[1]*The University of Sydney, Sydney, Australia,* [2]*Bush Heritage Australia, Melbourne, Australia*

Biography:
Emma is a PhD student working with the Global Ecology Lab (GEL) at the University of Sydney. She is currently studying carrion and scavenger ecology, with a focus on vertebrate and arthropod use of carcasses and the cascading impacts of this resource on soil nutrients and plant growth, and on predation risk for small mammals and ground-nesting birds.

Carrion is a nutrient-rich resource that is utilised by a variety of vertebrate scavengers across the rangelands globally. As many of these scavengers are also predators, there are concerns that carrion produced from both anthropogenic (e.g. pest control and roadkill) and natural (e.g. droughts, floods and disease) sources may bolster predator numbers, and have flow-on impacts to native wildlife and livestock. These impacts may be heightened if exotic predator species are present. Our research addresses some of these concerns, exploring the use of carrion by exotic and native predators and the impacts of carrion on risk of predation to ground-nesting birds in an arid Australian environment. We made use of remote cameras and experimentally placed kangaroo carcasses to compare visitation rates to carrion by different predator species. We also constructed 'fake' bird nests with quail and plasticine eggs in areas where carcasses were present or absent to determine how nest predation was influenced by carrion resources. Our findings reveal that (1) while scavenging was dominated by native species such as wedge-tailed eagles, little crows and Australian ravens, exotic animals including the red fox and feral cat also foraged frequently on carcasses, and, in some cases, continued to visit these resources months after they were first made available, (2) that predation by both native and exotic species on eggs in 'fake' nests was greater in the proximity of carrion resources, and (3) that carrion use and nest predation varied with environmental factors such as tree coverage and season. This study has provided new insights into the role of carrion in Australian food-webs and has indicated that the management of carrion should be given more careful consideration across both conservation and pastoral landscapes.

The Drought Map Sequence viewer: arranging rainfall and pasture maps for explaining drought situations

Mr Grant Stone[1], Mr Matthew Lord[1], Mr John Carter[2]

[1]Grazing Land Systems, Queensland Department Of Environment And Science, Dutton Park, Australia, [2]Remote Sensing Centre, Queensland Department Of Environment And Science, Dutton Park, Australia

Biography:

Grant Stone is the Principal Extension Scientist with the Grazing Lands Systems group within the Department of Environment and Science.

Grant has spent over 40 years involved with rural industries. He was a livestock and property agent for 12 years and has completed the Agricultural Science degree at the University of Queensland.

Over the last 20 years, Grant has worked as a rangelands scientist involving climate and grazing impacts on natural resource systems across northern Australia.

Recent activities include: science communication of climate, pasture and ground cover products for Grazing Best Practice, in rural communities and industries.

Viewing current drought status or retrospective maps (for Queensland) has been possible for some time by visiting the "Drought Declaration" page on the Long Paddock website (https://www.longpaddock.qld.gov.au/drought/drought-declarations/). However, there is often an interest in the contributing factors that are associated with the evolution of a drought situation (i.e. rainfall, pasture growth). Therefore, additional information about current and past factors that impact on regional areas can be helpful in understanding drought conditions.

The new Drought Map Sequence viewer (DMSV) provides arrangements of drought maps along with the suite of AussieGRASS maps for analysing and better understanding current and past contributing factors to the current seasonal conditions (e.g. for drought declaration and revocation). There is one standard screen which relates the most recent drought situation map, along with rainfall and pasture growth percentile maps (for the previous 12, 24 and 36 months). Alternatively, the DMSV can be user defined to select another time period, plus other variables (e.g. soil moisture, runoff), with different time sequences (i.e. monthly, annually). If required, the map selection can then be saved as a PDF document for printing, emailing or presenting.

The Drought Map Sequence viewer is a useful tool to better understanding drought sequences and conditions, especially for assisting in declaration and revocation activities. It can also be used for funding applications, reporting purposes and education activities. The DMSV can used for other Australian states and territories to display the sequences, however, the drought situation map will not appear for non-Queensland views/selections. The viewer can be accessed from the Drought Declaration page on the Long Paddock website (https://www.longpaddock.qld.gov.au/drought/drought-declarations/).

A new tool for assessing pasture growth and resilience risk: The FORAGE "Pasture Growth Alert"

Mr Grant Stone[1], Dr Baisen Zhang[1], Mr John Carter[2]

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Biography:

Grant Stone is the Principal Extension Scientist with the Grazing Lands Systems group within the Department of Environment and Science at the EcoSciences Precinct, Brisbane.

Grant has spent 40 years involved with rural industries. He was a livestock and property agent for 12 years and then completed the Agricultural Science degree at the University of Queensland.

Over the last 20 years, Grant has worked as a rangelands scientist with the Queensland government involving climate and grazing impacts on natural resource systems across northern Australia.

Recent activities include: science communication of climate, pasture and ground cover products for Grazing Best Practice.

The Pasture Growth Alert (PGA) is the latest addition to the suite of FORAGE reports found on the Long Paddock website (https://longpaddock.qld.gov.au/forage/).The 4-page report is sent to the email address of the requesting user as a small PDF file; it provides an assessment of reduced pasture growth and pasture resilience risk for properties located in Queensland. It can be used to assist in stock and property management decisions to increase property resilience to drought and help to identify pasture recovery opportunities by assessing the property for the: last 12 months pasture growth; monthly ground cover percentile and pasture growth outlook for the next 6 months.

The PGA report is site-specific (based on property lot/plan) and timely (pasture growth estimates calculated using latest daily climate data from SILO). It provides information for land managers adjusting property livestock numbers at critical times, such as: the end of the growing season, during the dry season, or waiting for the start of the wet season. A "risk" gauge for reduced pasture growth and pasture resilience (e.g. high or low) is displayed on a "traffic light" indicator figure on the report front page, based on recent and future pasture growth, as well as consideration for ground cover relative to history. Management considerations are given as broad suggestions that change if conditions alter the score – which is derived from a decision tree analysis. Further detail is provided in subsequent pages of the report, such as: pasture growth time series graphs (last 12 months and next 6 months), a satellite ground cover percentile map (for paddock level decision making), and rainfall and pasture growth percentile maps relative to history (for regional context).

The Pasture Growth Alert report is free (Queensland-wide availability); the user can "subscribe" to receive the information on a 1-3 monthly basis.

Understanding percentiles for climate and grazing land management decisions through story-telling animation

Mr Grant Stone[1], Ms Tessie Liddell[2], Ms Fiona McCartney[1], Mr Andrew Grodecki[1]

[1]Queensland Department of Environment and Science, Dutton Park, Australia, [2]Griffith Film School, Griffith University, South Brisbane, Australia

Biography:

Grant Stone is the Principal Extension Scientist with the Grazing Lands Systems group within the Department of Environment and Science.

Grant has spent over 40 years involved with rural industries. He was a livestock and property agent for 12 years and has completed the Agricultural Science degree at the University of Queensland.

Over the last 20 years, Grant has worked as a rangelands scientist involving climate and grazing impacts on natural resource systems across northern Australia.

Recent activities include: science communication of climate, pasture and ground cover products for Grazing Best Practice, in rural communities and industries.

Using historical climate records and seasonal outlooks are increasingly important for agriculture and natural resource management decision making. To improve the use of this information, land managers need to be able to understand and interpret percentiles, the statistical measure in which climate data and other measures are often calculated and communicated. Unfortunately, percentiles are frequently misunderstood and misinterpreted.

A combined animation and story-telling approach is an innovative way to address such misinterpretations. Animation is often used in the sciences to a diagrammatic effect; as it allows phenomena to be visualised, simplified and annotated. In this instance, an educational animation was employed with a story-telling effect, to positively contribute towards learning outputs and create social change.

A creative collaboration with scientists from the Queensland Department of Environment and Science (DES) and a professional artist through the “Artist in Residence Science program” (AIRS) have used these approaches to create an animation to disseminate scientific information through a character driven narrative. Specifically, to calculate and interpret rainfall percentiles for a grazing enterprise, entitled “Understanding percentiles in climate data: This season might not be as great as you think it is, Jim”. The animation was piloted with a range of potential end users (e.g. extension providers, consultants, land managers), with unanimous positive feedback.

The animation focuses on Queensland rainfall percentiles, however, the statistical information presented in the animation is relevant to anyone who interprets percentiles for a range of purposes (e.g. ground cover measurement, pasture growth). Additionally, it is anticipated that it will contribute to existing literature, educational and communication products to improve land managers’ scientific literacy. The Percentile Animation video can be accessed from the Long Paddock website (https://longpaddock.qld.gov.au), on the AussieGRASS, FORAGE and Rainfall poster web pages.

Substantial gaps between biodiversity hotspots and effectiveness of protected areas on the Qinghai-Tibetan Plateau

Ph.d Xukun Su[1]

[1]*Research Center for Eco-environmental Sciences, Chinese Academy Of Sciences (rcees-cas), Beijing, China*

Biography:

Assistant Research Fellow from State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (RCEES-CAS). I major in biodiversity conservation and landscape ecology.

Human activities such as livestock overgrazing, are the main reasons for the degradation of alpine grasslands and biodiversity loss on the Qinghai-Tibetan Plateau (QTP), China. With an aim toward maintaining sustainable development of alpine grasslands, protected areas (PAs) are important for biodiversity protection and to reduce the negative impacts of human activities. This study was conducted in the east of the QTP to clarify the distribution of plant-based biodiversity hotspots of alpine grasslands and to identify gaps between biodiversity hotspots protection and the effectiveness of PAs. We found that biodiversity hotspots of alpine grasslands were located in Tibetan Autonomous Prefecture of Garzê (TAPG) and the Tibetan Qiang Autonomous Prefecture of Ngawa (TQAPN) in Sichuan Province, and their buffer zones were to the west of the biodiversity hotspots. PAs protected 25.93% (29.09 km2) of biodiversity hotspots and 29.17% (50.36 km2) of their buffer zones, respectively. Therefore, there was a substantial gap between the protection of biodiversity hotspots of alpine grasslands and the effectiveness of the PAs. According to distributions of the biodiversity hotspots and their buffer zones, re-planning the boundaries of the PAs to improve their protection effectiveness would be useful for biodiversity conservation and mitigation of alpine grassland degradation.

Assessing environmental stewardship outcomes - the role of exclusion fences in sheep breeding and wool production

Greg Hosking[1], Mr Richard Thackway[1]
[1]*Fenner School of Environment & Society, Australian National University, Canberra, Australia*

Biography:
Richard Thackway is a landscape ecologist with a research interest in understanding the impacts of land use management decisions. Since the early 1980s Richard has worked in environmental, agricultural and forestry agencies developing several national initiatives and frameworks involving state and territory governments, universities and NGOs and land managers. He is an ANU Honorary Associate Professor, where his research aims to help decision makers improve their ability to monitor and report on the status, and to track and change and trend in ecological function arising from deliberate and inadvertent land management practices. A focus of his current research involves evaluating regenerative landscape management regimes in agricultural and forested landscapes.

Environmental stewardship in Australia's semi-arid rangelands in many ways is confounded by the lack of control over factors outside the control of the land manager, particularly pest animals, which adversely affect reproduction efficiency in the domesticated animals and total grazing pressure. Sheep breeding and wool production have a long history in the rangelands however, in recent years wild dogs, pigs and foxes have taken their toll on lambing rates, and kangaroos and goats have impacted total grazing pressure. As a result, many sheep breeders have left the wool industry for beef cattle. However, the development of exclusion fences that can control total grazing pressure and sheep predators is arguably a "game changer" by enabling land managers to deliver on improved environmental stewardship outcomes and improve sheep profitability. We outline a five-year research project designed to evaluate the outcomes of installing these fences. We use standardized assessment frameworks that include; ecological, production, social and economic criteria and indicators before, during and after establishment of the fences. Nine sheep properties from Longreach to Dalgety were selected as case studies. We present baseline results from 2018 including on-ground control sites, inside and outside the fences, combined with time series remote sensing, are being used to assess changes in ground cover and forage biomass. Bird species are surveyed at the same sites to assess further changes in biodiversity.

Rangeland Rehydration in western NSW: collaborative learning and implementation between land managers, EMU and LLS

Mr Paul Theakston[1], Dr Hugh Pringle[2]

[1]Western Local Land Services, Cobar, Australia, [2]Ecosystem Management Understanding (TM), Alice Springs, Australia

Biography:

Paul Theakston is the Rangeland Rehabilitation Officer with the Western Local Land Services. He has 20 years' experience in the delivery of rangelands management projects and natural resource management policy. He designs and lays out rangeland rehabilitation projects to improve landscape rehydration.
Hugh Pringle (PhD.) is co-founder of Ecosystem Management Understanding(TM). He has extensive experience in rangeland ecology and geomorphology and landscape repair. Hugh has empowered landholders in Australia and southern Africa to strategically repair rangelands.

In past decades, the NSW Soil Conservation Service (SCS) researched and developed many innovative soil conservation techniques for use in western NSW. Currently this corporate knowledge resides in Local Land Services (LLS) as rangeland rehabilitation enjoys a renaissance in the Western Region. The LLS inherited many soil conservation techniques that focused specifically on choosing areas that would respond effectively to soil and water conservation. The Ecosystem Management Understanding (EMU)^{TM} approach was engaged by LLS in 2016 to help build a strategic planning basis for LLS rehabilitation works. EMU brought to the partnership a drainage ecosystem perspective and the idea of repairing critical control points. The number of techniques used by EMU practitioners was relatively small in comparison to the SCS endowment to LLS. Through working together on a succession of projects over three years we have complemented each other's approaches and improved our own methods and the service we provide to landholders. We tell this story through examples of projects and demonstrate the success of a collaborative approach to landscape re-hydration. Land managers are also empowered through this partnership and confidently implement preventative and restorative works on their landscapes.

Identifying policy pathways fit for the Outback

Dr Barry Traill[1,2], Dr Mark Stafford-Smith[1], Ms Kate Forrest[1,3], Mr Jimmy Cocking[1,5], Dr Melodie Bat[1,4], Mr Rod Reeve[1,6], Ms Amber Davis[1,2]

[1]The Outback Alliance, Alice Springs, Australia, [2]The Pew Charitable Trusts, Brisbane, Australia, [3]Rangeland NRM Alliance, Adelaide, Australia, [4]Desert Knowledge Australia, Alice Springs, Australia, [5]Arid Lands Environment Centre, Alice Springs, Australia, [6]Ninti-One Ltd, Adelaide, Australia

Biography:

Barry (B.J.) Traill directs Pew's initiative to bring together Indigenous people, scientists, conservation organisations, industry, and government agencies to conserve Australia's critical natural landscapes and marine habitats. Before joining Pew, Traill worked as a conservation advocate and zoologist for Australian state and national organisations. These efforts include advocating for the inclusion of new areas in the National Reserve System, the funding of conservation management activities, and the creation of sanctuaries for marine life. Traill holds a bachelor's degree and a doctorate in terrestrial ecology from Monash University.

The Outback Alliance is a cross-sectoral group of non-government organisations and individuals who focus on the development, welfare and protection of Outback Australia. It argues that anyone interested in a positive future for the Outback must shift their thinking to understand it from the perspective of the people who live there.

- Its recent publication, Joining the Dots, identifies issues for policy-makers wishing to achieve better outcomes in the Outback around six thematic areas: connection to country with Indigenous peoples; a robust Outback environment; healthy Outback communities that are well serviced; resilient land managers; a better ability for the Outback to contribute to the national economy; and, improved connectivity and digital inclusion for Outback communities.

- Under each of these themes, Joining the Dots identifies some key policy interventions, as well as looking at the systemic links between the policy areas. For example, investing in the capacity of land managers to better adapt to change will help ensure the sustainability both of industries and of environments and communities.

- Locally appropriate and regionally-based delivery is key to developing an integrated and improved approach to rangeland policy. Policy instruments that operate well in populated areas do not necessarily work well in a remote context – for example, effective policy must enable locally responsive economies-of-scope, rather than focusing on economies-of-scale as in more densely-settled areas.

- Similarly, expanding Indigenous Ranger programs and funding for carbon abatement are innovative approaches and economies that value Indigenous traditional knowledge, people and partnerships, and provides effective natural resource management across vast Outback rangelands.

The Outback Alliance aims to help Outback organisations to speak with a consistent voice to policy, and now seeks other interested members who can help extend Joining the Dots into additional themes.

Desert Knowledge Research Institute - enlivening research coordination for desert Australia

Dr Mark Stafford Smith[1], Dr Melodie Bat[2]
[1]*CSIRO, Canberra, Australia,* [2]*Desert Knowledge Australia, Alice Springs, Australia*

Biography:
Dr Mark Stafford Smith is now an Honorary Fellow with CSIRO now based in Canberra, Australia. He has over 30 years national and international experience in drylands systems ecology, management and policy, with senior roles including CEO of the Desert Knowledge Cooperative Research Centre in the early 2000s, and Program Leader of CSIRO Centre for Arid Zone Research in Alice Springs in the late 1990s. During 2013-17, he was chair of the inaugural Science Committee of Future Earth, which aims to coordinate research towards global sustainability worldwide.

- Desert Knowledge Australia has activated its research foundation, the Desert Knowledge Research Institute (DKRI).
- DKRI will serve as a coordinator and facilitator of research, and research collaborations in the desert.
- The opportunity is to refresh our knowledge and understanding of the existing research outputs, and to work together to better meet the research needs of the desert.
- DKRI is actively seeking new research collaborations in the themes of people, place and knowledge.

Valuing Australia's drylands research and practice globally

Dr Mark Staffordsmith[1, 2, 4], Prof Graciela Metternicht[1, 2, 3], Mr Dan Tyson[5]
[1]CSIRO, O'Connor, Australia, [2]GEF STAP, Washington, USA, [3]UNCCD-SPI, Bonn, Germany, [4]Future Earth Australia, Canberra, Australia, [5]Desert Knowledge Precinct, ,

Biography:
Dr Mark Stafford Smith is now an Honorary Fellow with CSIRO now based in Canberra, Australia. He has over 30 years national and international experience in drylands systems ecology, management and policy, with senior roles including CEO of the Desert Knowledge Cooperative Research Centre in the early 2000s, and Program Leader of CSIRO Centre for Arid Zone Research in Alice Springs in the late 1990s. During 2013-17, he was chair of the inaugural Science Committee of Future Earth, which aims to coordinate research towards global sustainability worldwide.

Drylands represent ~40% of the world's land surface and are home to 2 billion people, half of whose livelihoods depend on drylands ecosystem services. Globally, drylands are a significant driver of earth system processes such as the water cycle, carbon storage and atmospheric effects such as dust plumes. They are also a 'canary in the mine' for human disruption, where dependence on ecosystem services means that their peoples are among the first to be widely affected by global changes such as land degradation, climate change and undermined water cycles; hence many of the world's refugee movements are linked to resource pressures in drylands. In the past, their challenging environments made them a source of many social and technical innovations; this continues today, with persisting traditional linguistic and cultural diversity. These realities lie behind the global commitments to the UN Convention to Combat Desertification, the investments by the Global Environment Facility into reversing degradation in drylands, and the activities of many research-practice networks around the world.

This reality also holds in Australia, the continent with the greatest proportion of drylands. As a developed economy in lightly populated drylands, we have made major research and practice contributions globally to drylands agriculture, water management and governance, remote area services, indigenous partnerships, dryland monitoring systems, and 'desert knowledge' innovation. Australia's contributions to international dryland governance and research for development funding has been highly valued, despite recognition and support for this within Australia dropping off markedly in recent years. We argue that it is time for this trend to be reversed, as this is an area of comparative advantage for Australian diplomacy and intervention with huge returns on investment in terms of goodwill, opening of markets and genuine contribution to the maintenance of our common global life support system.

Can fire be used to manage feathertop wiregrass in Mitchell grass pastures?

Dr Dionne Walsh[1], Ms Jane Douglas[1], Ms Gabrielle Penna[2]
[1]NT Department of Primary Industry and Resources, Darwin, Australia, [2]Queensland Department of Agriculture and Fisheries, Brisbane, Australia

Biography:
Dionne has more than 20 years' experience as a researcher and adviser in rangeland management. Her areas of expertise include assessing livestock carrying capacity, monitoring land condition, understanding animal grazing behaviour and advising producers on sustainable and profitable grazing management systems. She has worked with the extensive cattle and sheep industries in South Australia, Western Australia and the Northern Territory. Since 2009 she has led a team in DPIR responsible for delivering grazing land management research, training and advisory services to the NT cattle industry.

Introduction
Feathertop wiregrass (Aristida latifolia) is relatively unpalatable and builds up during runs of good seasons. It has high seed production and can become dominant in overgrazed pastures. Fire has been shown to control feathertop wiregrass in western Queensland. However, success appears to be highly dependent on timing – low soil moisture is needed for several weeks before and after burning. This means that in many parts of northern Australia, the prime time for success coincides with the highest risk of wildfire. Furthermore, producers are wary of burning their best pasture resource in the middle of the dry season.

Methods
The trial site at Newcastle Waters Station (NT) contained a moderate level of feathertop wiregrass together with stands of desirable grasses including curly bluegrass (Dichanthium fecundum) and weeping Mitchell grass (Astrebla elymoides). We used a randomised block design comprising 4 replicates of 3 treatments (Unburnt controls, July 2017 burn & September 2017 burn). Pastures were assessed using the Botanal method. Plant size and seed production measures were also collected from 290 permanently tagged individual tussocks from the species listed above. Soil moisture at the surface and at 15cm depth was measured before burning. The site was completely spelled from grazing for the duration of the experiment.

Results
We found that:
Burning reduced the basal area and biomass of feathertop wiregrass
The fires only killed 1% of the feathertop plants
Burnt plots had lower pasture yields and ground cover overall
No desirable perennial grasses were killed
Burning increased seed production in curly bluegrass

Conclusion
Even under the right soil moisture conditions, it's not a "sure bet" that you will get a good kill of feathertop wiregrass - some years it will work, some years it won't.

“Paddock Power”: unlocking the secrets to sustainable and profitable intensification

Dr Dionne Walsh[1], Dr Kieren McCosker[1]
[1]*NT Department of Primary Industry and Resources, Darwin, Australia*

Biography:
Dionne has more than 20 years’ experience as a researcher and adviser in rangeland management. Her areas of expertise include assessing livestock carrying capacity, monitoring land condition, understanding animal grazing behaviour and advising producers on sustainable and profitable grazing management systems. She has worked with the extensive cattle and sheep industries in South Australia, Western Australia and the Northern Territory. Since 2009 she has led a team in DPIR responsible for delivering grazing land management research, training and advisory services to the NT cattle industry.

Introduction
“Paddock Power” is a new project that will measure the influence of paddock area and distance to water on breeder herd performance, steer live weight gain, mortality rates, operating costs and feedbase management.
Many breeder paddocks in northern Australia are too big and under-watered to achieve optimum productivity. Large, poorly watered paddocks impact on reproduction and profitability: there’s over-and under-utilised feed (depending on distance from water), incomplete musters and limited opportunities to implement herd segregation, controlled mating or tactical pasture management.
Fencing and water development is gathering pace on large properties in northern Australia. However it is very expensive and producers tell us that they need data on potential productivity increases to better articulate the benefits to owners and financiers.
The findings will refine current recommendations on water point spacing and provide better information on where to place new infrastructure to maximise return on investment. The project will deliver a user-friendly “Paddock Power Calculator” for producers to compare the costs of different infrastructure development options, and evaluate their profitability in the context of their specific land types, cost base and livestock productivity.

Methods
By April 2021 we will:

- Collate objective data from existing commercial property records to quantify the potential impact of paddock area and distance to water on reproductive performance and calf wastage.
- Make initial assessments into quantifying the impact of reducing paddock area and/or improving watered area on reproductive performance and calf wastage via trials of commercially managed beef cattle.
- Deliver preliminary recommendations for cost-effectively increasing reproductive productivity via paddock development.
- Complete the development of the “Paddock Power Calculator”, a user-friendly online tool which compares the costs and benefits of user-defined water point and fencing options.

Managing landscape utilisation without more fences - can it be done?

Dr Dionne Walsh[1], Mr Spud Thomas[1], Dr Dean Revell[2], Mr Bruce Maynard[3]

[1]NT Department of Primary Industry and Resources, Darwin, Australia, [2]Revell Science, Duncraig, Australia, [3]Stress Free Stockmanship, Narromine, Australia

Biography:

Dionne has more than 20 years' experience as a researcher and adviser in rangeland management. Her areas of expertise include assessing livestock carrying capacity, monitoring land condition, understanding animal grazing behaviour and advising producers on sustainable and profitable grazing management systems. She has worked with the extensive cattle and sheep industries in South Australia, Western Australia and the Northern Territory. Since 2009 she has led a team in DPIR responsible for delivering grazing land management research, training and advisory services to the NT cattle industry.

Introduction

The first-ever trial of Rangelands Self Herding in the Northern Territory aimed to demonstrate that behaviour-based techniques can be used to establish grazing circuits within a paddock, creating a form of rotational grazing that does not rely on expensive and immovable fencing. We selected a paddock with large contrasts in land condition created by historical grazing patterns. By applying Self Herding techniques, specifically the use of sight, sound and smell signals linked to feed rewards, we aimed to encourage cattle to use areas that had previously been under-utilised whilst reducing the usage of areas that had poorer land condition.

Methods

We used small amounts of feed attractants paired with signals (via a mobile "attractant station") to achieve managed movements of cattle throughout the landscape. Although many producers already move mineral supplements around their paddocks, this method amplifies that approach by offering a variety of attractants using intermittent and unpredictable timing. This has the effect of increasing interest for a broader range of animals in a mob and rewards exploratory behaviours.

GPS tracking collars were fitted to 10 heifers in the trial to monitor paddock utilisation patterns in relation to the attractant station and environmental factors such as surface water and burnt areas.

Results

- In the first weeks of the trial the cattle demonstrated a very strong attraction to the historically overgrazed areas of the paddock.
- After initiating Self Herding techniques we were able to attract the cattle away from the overgrazed areas and into other areas of the landscape that were being under-utilised.

More information about Rangelands Self Herding and the Northern Territory trial can be found at http://selfherding.com/ and https://futurebeef.com.au/projects/self-herding-kidman-springs/

Diversifying livestock can improve the functions of grasslands

Professor Deli Wang[1]

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Biography:

Not available

The role of livestock grazing in regulating grassland functions has been studied widely, but the underlying mechanisms how large herbivores like cattle, sheep, and mixed grazing affect the grassland structure or process thereby cascade to grassland functions remains unclear. For this study, we conducted a five-year grazing experiment to test the effects of herbivore species (cattle grazing; sheep grazing and mixed grazing) on ecosystem multiple functions on the five grasslands (meadow, meadow steppe, dry steppe, and desert steppe) in northern China. Our experimental results are as the followings: (1) large herbivore grazing accelerated nutrient cycling by changing the quantity and quality of plant litter, and by deposition of excrement, and by trampling and compacting soil, and herbivore foraging effects might depend on whether herbivores preferentially feed on plants, and also mixed grazing by cattle and sheep was used to enhancing the N availability; further (2) livestock diversification or mixed grazing substantially increased ecosystem multiple diversity (the diversity of plants, insects, soil microbes, and nematodes) thereby improve the multiple functions including plant biomass production, plant leaf N and P, above-ground insect abundance, nutrient cycling, soil C stocks, water regulation and plant-microbe symbiosis. Together, the grazing by diverse large herbivores may improve the grassland functions either by accelerating the nutrient cycling or by increasing biodiversity. This study provides the new insights into understandings of diversifying livestock grazing and grassland management.

Regional NRM investment outcomes for grazing lands in southern inland Queensland.

Armando Apan[1], Professor Geoff Cockfield[3], David Waters[3], Mr Paul Webb[2]
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Biography:
Paul Webb has spent 15 years supporting sustainable agriculture in Southern Inland Queensland. In this time he has worked as a Land and Water Project Officer with the Queensland Murray-Darling Committee (QMDC). QMDC was an NGO largely funded by State and Commonwealth Natural Resource Management programs. In the last three years Paul has had the opportunity to evaluate outcomes from NRM investment. As a research student at the University of Southern Queensland, he has reviewed remote sensing data to determine if ground cover has improved in properties supported by NRM funding.

Australia has invested $10Billion in Natural Resource Management (NRM). A significant part of this investment was through Regional NRM groups aiming to target investment towards regional priorities. Reviews of NRM investment have repeatedly documented activities and outputs but have struggled to demonstrate outcomes.

This study analysed remote sensing data to evaluate outcomes of NRM investment in grazing lands in Southern Inland Queensland. The Dynamic Reference Cover Method (Bastin et al 2012) was adapted (aDRCM) to remove the climate signal from groundcover data. The aDRCM groundcover scores for supported properties were compared with scores for other properties in the Upper Maranoa catchment.

Results showed no significant difference in ground cover in supported properties than in other properties. What was determined, however was that both supported and unsupported properties showed a mild increase in groundcover scores through the NRM investment period.

Interviews with landholders determined that NRM investment impact extended well beyond the listed supported property areas. Landholders also indicated that both within and outside listed property areas, NRM investment was not the only contributor to improved knowledge and grazing land management. This suggests that NRM investment has contributed to improved ground cover across the catchment but that not all the improvements can be attributed to Regional NRM investments.

The ground cover score trends were used to synthesize ground cover layers for several catchment model runs. This will allow an estimate of how improved ground cover has impacted soil loss and stream sediment loads in the Maranoa River.

Paul Webb (ab), Geoff Cockfield (a), Armando Apan (a), David Waters (c)
(a) University of Southern Queensland
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(c) Qld Department of Natural Resources Mines and Energy

A benchmark for stocking rate management in a highly variable climate

Ms Giselle Whish[1], Ms Gabrielle Penna[1], Mr Christopher Holloway[1]
[1]*Department Agriculture and Fisheries, Dutton Park,*

Biography:
Giselle is a senior scientist with Queensland's Department of Agriculture and Fisheries. Her main focus is to develop and implement a simulation modelling program for grazing lands which services the research and extension needs of Queensland. Currently, Giselle's key areas of work include developing and improving property-based grazing land management decision support information; using simulation modelling to assess the impact drought management strategies have on land condition, animal productivity and profitability; and using existing breeder datasets to identify pasture utilisation rates that optimise breeding productivity.

Resting pastures and adjusting stocking rate to match carrying capacity are recommended for managing year-to-year variability in forage supply. Within the Queensland Government Drought and Climate Adaptation Program, grazing benchmark properties are being established to help validate the FORAGE modelling framework. Data from well-managed properties that are in good condition provide a reference for comparison with modelled long-term carrying capacity estimates. We report on the stocking rate strategies used by an experienced grazier for one of these benchmark properties.

Improving the grazing ecosystem through planning, monitoring and managing grazing has been a goal of this grazier for twenty-five years. Stock numbers and grazing pressure are managed to improve grass quantity initially, and then quality, by favouring and encouraging "desirable" pasture species. Short grazing periods are used to minimise preferential selection while still allowing good animal performance, and rest periods are aligned to the growth rate of plants to allow pasture recovery.

Implementation of a "time-controlled" grazing system, where stock are regularly moved through paddocks, provides the flexibility to match utilisation with changes in rainfall, season and pasture. On average, the property receives an annual rainfall of 674 mm but year-to-year rainfall variability is very high (cv 48%). Since 2004, annual stock numbers ranged between 1321 and 2292, with the herd increasing or decreasing up to 38% each year. During this period, paddocks were grazed on average 58 days per year, and stock days per hectare for every 100 mm of rainfall increased from 6 in 2004 to 12 in 2018. Satellite imagery of ground cover enables the health and productivity of this property to be compared with surrounding properties. Over the last 30 years, the number of paddocks across the property with higher ground cover than the surrounding region improved from 39 (1990 – 2009) to 86 (2014 - 2019).

Bio-economic modelled outcomes of stocking rate and drought recovery strategies in the Mitchell grass region

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Biography:

Giselle is a senior scientist with Queensland's Department of Agriculture and Fisheries. Her main focus is to develop and implement a simulation modelling program for grazing lands which services the research and extension needs of Queensland. Currently, Giselle's key areas of work include developing and improving property-based grazing land management decision support information; using simulation modelling to assess the impact drought management strategies have on land condition, animal productivity and profitability; and using existing breeder datasets to identify pasture utilisation rates that optimise breeding productivity.

Extreme year-to-year rainfall variability, long periods of drought, and temporal variability in forage supply pose significant challenges for the sustainable and profitable management of extensive grazing enterprises in Northern Australia. The impact of climate variability on a range of stocking rate and herd management strategies applicable to the Mitchell grass region of central Queensland were simulated by integrating output from the GRASP pasture growth model with the Breedcow and Dynama herd models.

With a safe stocking rate as a base, 'retain core breeders,' 'drought responsive,' and 'fully flexible' stocking rate strategies were simulated (1982-2017) using the GRASP model for a 16,200 ha, predominantly open Mitchell grass downs, cattle breeding property. The strategies varied by the amount stock numbers increased or decreased each year in response to available forage at the end of April. There were no limitations to annual stock changes for the fully flexible strategy. Over the entire simulation period, total annual stock changes could be reduced to a maximum 25% (retain core breeders) or a maximum 75% (drought responsive). Simulated outputs from GRASP were used in the beef cattle herd models to predict herd productivity and enterprise profitability.

Over the 36-year simulation, high annual pasture growth variability (<100 to 4600 kg DM/ha) necessitated the implementation of drought response and recovery strategies for four separate periods. Land condition was maintained or improved when livestock numbers were changed, with some restrictions, in response to pasture availability (drought responsive). A 30-year (1988-2017) economic analysis indicated the drought responsive strategy, when combined with drought recovery options (e.g. the purchase of Pregnancy Tested In Calf (PTIC) cows, trading stock or taking cattle on agistment), was as risky but more profitable (20%, two orders of magnitude, respectively) than the fully flexible and retain core breeders strategies.

Why have a kangaroo symposium at ARS2019? Improving welfare, landscape sustainability & reducing waste

Dr George Wilson[1]

[1]*Australian National University, Canberra, Australia*

Biography:

George Wilson began his interest in kangaroo management in 1970 with the NSW NPWS. He has worked for the Federal Governments in environmental and agricultural public policy, strategic analysis and scientific research. Today as an ANU Honorary Professor, he has a continuing interest in multiple land use, integrating wildlife into agricultural production, population ecology, threatened species management, sustainable wildlife industries, tourism and support for Indigenous communities. His qualifications are MVSc (Univ Syd) and PhD in Zoology (Univ Aberdeen). He is a commercial pilot and aircraft owner with over 4500 hours conducting extensive wildlife surveys.

Kangaroo numbers are declining due to drought and millions are starving. This is not only an animal welfare disaster and an unacceptable national disgrace but is also damaging sustainability of primary production, affecting other biodiversity and potentially threatening the social licence of rangeland pastoral industries. The kangaroo symposium later at this conference will briefly examine causes, issues and consequences and discuss solutions for reducing the chances of a repeat.

Australia's 40 plus million kangaroos are widely distributed and mostly on rangelands used for primary production. The kangaroo industry is contracting and currently taking only 20% of the permitted commercial quota due to actions of industry opponents.

Graziers who are desperate to 'deal with pests' are increasingly using control methods that have poor animal welfare outcomes. Amateur shooting and vermin exclusion fences are erected around clusters of properties to reduce unprofitable grazing pressure.

Shooting by amateurs and letting carcasses lie is both a waste and prevents regulators from assessing how many kangaroos are actually taken. Regulators cannot monitor either shooter accuracy and skill, or compliance with welfare codes.

Better welfare and stable kangaroo populations need a stronger, not weaker, kangaroo industry. Improving quality and marketing kangaroos' natural attributes should increase value and demand and so address several of the issues currently faced by landholders. Meat industry agencies should recognise the considerable natural advantages and adaptations of kangaroos to Australian landscapes. With additional government support, they should invest in integrating kangaroos with conventional livestock production so that landholders have the option of benefiting from kangaroos.

Bringing it all together: big ideas for big change

Mr Peter Schmidt[1], Dalene Wray[2]
[1]"Alawoona", Wyandra, Australia, [2]OBE Organic, Fortitude Valley, Australia

Biography:
Dalene Wray's leadership of a farmer-owned organic beef company has seen OBE Organic emerge as a progressive exemplar for innovation in the organic beef industry and broader red meat industry. She consistently strives to improve the sustainability of OBE Organic and the Australian beef industry by driving change, innovation and digital adoption.

The dominant pastoral industries of the rangelands are arguably facing an existential threat from the emergence of plant and laboratory-based meats, as highlighted by the following:

"Beyond Meat Inc. Inc. raised nearly a quarter of a billion dollars to grow its line of plant-based meats … it closed 163% above its IPO price, making it the best performing first-day IPO in nearly two decades." Marketwatch.com, 6 May 2019.

"Using animals to make meat is a prehistoric and destructive technology. Animal agriculture occupies almost half the land on earth, consumes a quarter of our freshwater and destroys our ecosystems. So we're making meat using plants, so we never have to use animals again." Impossible Foods website, 9 May 2019.

These companies do not want to compete with meat. They want to end animal agriculture, by making products that are functionally the same as meat but are perceived to have less impact.

Ending animal agriculture is a big idea that will have profound impacts globally, and in particular in rangelands where alternative agriculture options are extremely limited.

Confronting this challenge needs big ideas as well – and the big ideas need to work at a small level, so rangelands properties and communities around the world adopt them. Urgently.

This presentation provides a call to action for big thinking and urgent change. To do this we use the quintessentially outback example of OBE Organic, Australia's oldest organic beef marketing company which has sourced organic cattle from the Lake Eyre Basin for over 20 years. It is a practical example of how to use the rangelands' unique attributes to turn this existential threat into an opportunity for rangelands pastoral industries globally. We will discuss:

1. Appreciating our unique rangelands attributes
2. Marketing our unique rangelands attributes
3. Big ideas needed for change at scale.

Global Dryland Ecosystem Programme (Global-DEP)

Professor Zhihong Xu[1]
[1]*Griffith University, Australia*

Biography:
Biography to come

Drylands occupy about 41% of Earth's land area and are home to more than 2 billion people. They are also among the most sensitive and fragile ecosystems on the Earth's surface. Impacts caused by climate change and human interventions simultaneously are felt well on ecosystems and people in and even beyond drylands. Through an integrative approach of biogeochemistry, ecology and sociology, future efforts should explore the links between these impacts and the provisioning of services for human livelihoods in drylands. Such efforts will enhance the monitoring, assessment and management of global dryland ecosystems and be significant for promoting the delivery of Sustainable Development Goals in dryland regions, especially in those developing countries.

The Global Dryland Ecosystem Programme (Global-DEP) is an international cooperation initiative jointly proposed by Prof. Bojie Fu from the Chinese Academy of Sciences and Prof. Mark Stafford Smith from the Commonwealth Scientific and Industrial Research Organization in Australia, with a vision to evolve into a core research programme under the Future Earth initiative. It aims to provide a platform for global research collaboration on dryland ecosystem with its Science Plan that defines key scientific issues and priority areas for future research. It is also highly expected to engage global researchers, practitioners, and policy makers in developing an Action Plan that secures funding for programme implementation.

To define research priorities in the Science Plan, information and knowledge will be integrated under four major themes in accordance with the ecosystem service cascade model, which are: i) dynamics of global dryland ecosystems and their driving mechanisms, ii) changes in the structure and functions of global dryland ecosystems and their effects, iii) changes in the services of global dryland ecosystems and their linkages with human well-being, and iv) dryland ecosystem management and sustainable livelihoods. Finally, research on global dryland ecosystems will be synthesized through conducting meta-analysis of case studies in typical dryland regions around the world to identify their common features and regional differences.

Since 2017, the Global-DEP Interim Scientific Committee, co-chaired by Prof. Bojie Fu and Dr. Mark Stafford Smith, was set up to coordinate the development of the Science Plan, with a Secretariat to provide technical support. Four thematic work groups and five regional work groups were also established between principal investigators from the Chinese Academy of Sciences and their counterparts from the United States, Greece, Senegal, Australia, etc. In October 2018, an international workshop and the first working meeting of the Interim Scientific Committee of Global-DEP were successfully held in Beijing. The overall framework of the Global-DEP Science Plan was discussed and some research priorities were identified preliminarily.

Main tasks for 2019 will be focused on undertaking regional consultation workshops on typical drylands in Central Asia, the Mediterranean Region, Africa, America, and Australia, respectively, in combination with ground surveys and case studies in each region. Through that, it is planned to finalize and launch the Global-DEP Science Plan by the end of 2020.

Promoting ecosystem services for sustainability

Prof. Wenwu Zhao[1], Dr. Siqi Yang[1], Dr. Ting Hua[1]

[1]*Institute of Land Surface System and Sustainable Development, Faculty of Geographical Science, Beijing Normal University, Beijing, China*

Biography:

I am a Professor from Faculty of Geographical Science, Beijing Normal University. My research area are: Land Use and Ecological Process, soil erosion and land degradation, Landscape Pattern and Ecosystem Services, Coupling Human and Nature System for sustainability.

Promoting ecosystem services for Sustainability

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Abstract: The pursuit of human well-being is one of the primary objectives for sustainable development. It is therefore unsurprising if well-being becomes a focus of public policies and interventions, including those on the United Nations 2030 agenda, such as the 17 Sustainable Development Goals (SDGs).The Sustainable Development Goals (SDGs) aim to embrace potential synergies between the environment and human wellbeing. Meanwhile, sound ecological management could identify the pathway on sustaining flows of ecosystem services to humanity. Ecosystem services bridge the natural environment and human well-being, and provide the base for sustainable development. Understanding the relationships between SDGs and ESs (ecosystem services) provides explicit demand of ecological management to support to realization of SDGs. An expert survey on the relationships between 18 ecosystem services and SDGs and the prioritized degrees of SDGs has been processed. Our survey found that continental differences existed obviously in SDG priorities, SDG2 (Zero Hunger) was the most prioritized worldwide goal, and the SDG15 (Life on land) had the strongest correlations with ESs on global scale. Several ESs including education, fresh water, climate regulation, food, water purification, biodiversity and air purification should be paid more focuses for promoting sustainable development. When combined SDG priorities and SDG-ES relationships to derived ES important degrees, water purification could be the most important ES on global and continental scales, and aesthetic value, wood fiber and genetic resources were the less focused ESs. This study triggers understanding prioritized SDGs and relationships between SDGs and ES for further analyze the promoting role of ecosystem services to SDGs.

Evaporation change and its impact factors over the Three-River Headwater region from 1958 to 2018

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[1]*Institute of Remote Sensing and Digital Earth, Chinese Academy Of Sciences, Beijing, China*

Biography:
Ph.D in water resource and ecology, research the methods of surface water and heat flux exchange and evapotranspiration modeling using remote sensing data and meteorological data

Three-River Headwater (noted as TRH hereafter) region is the sources of the Yangtze River, the Yellow River and the Lantsang River, and located in the hinterlands of the Qinghai-Tibet Plateau (QTP), which is particularly sensitive to climate change. In recent years, evaluation of trends in evaporation has been introduced into climate change discussions and evaporation variation has great effect on the hydrological cycle and energy balance. Based on the observed data from 18 meteorological stations from 1968 to 2018 inside the TRH region, temporal variation and spatial distribution of evaporation during the past 60 years was analyzed, and the main impact factors were studied using linear trend estimation and Mann-Kendall abrupt change test. The main conclusions were as follows: 1) Significant annual evaporation increase in TRH hereafter, and the linear change rate was 30.4mm/10a; 2) Seasonal change was obvious and evaporation in summer, fall and winter was increase significant. The max evaporation was present in summer, secondly in spring and fall, minimum in winter; 3) Annual and seasonal spatial changes indicate the northwest was less, the southeast and northeast was more, and climate change rate increased from west to east; 4) Annual evaporation was positively correlated with average temperature, while negative correlations with daily range of temperature and relative humidity. 5) The main reasons of evaporation decline are the rise of average temperature, and the decline of daily range of temperature and relative humidity.

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