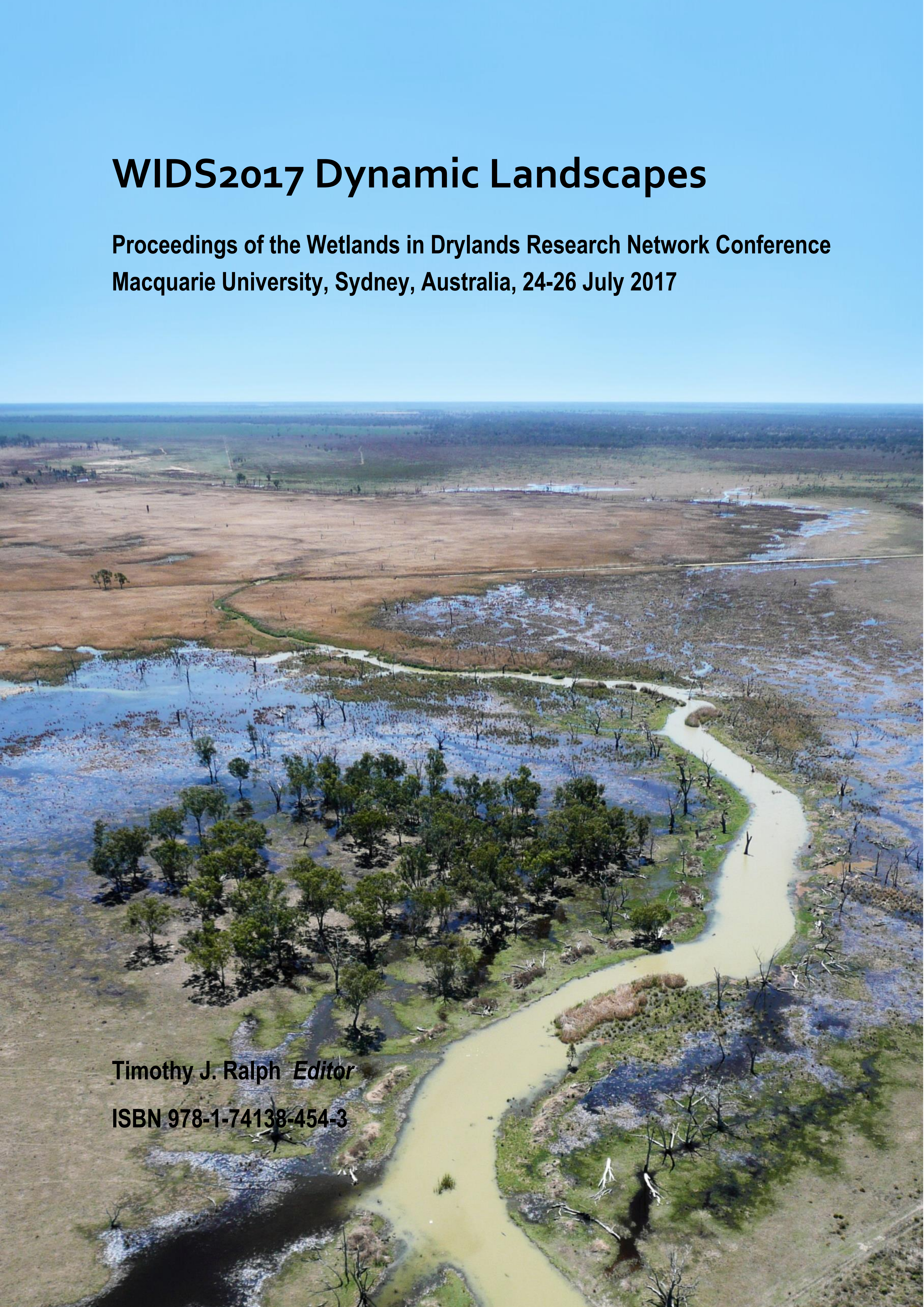
WIDS2017 Dynamic Landscapes

Proceedings of the Wetlands in Drylands Research Network Conference

Macquarie University, Sydney, Australia, 24-26 July 2017



Timothy J. Ralph ***Editor***

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WIDS2017
Wetlands in Drylands Research Network Conference

wetlandsindrylands.net • #WIDS2017MQ

Cover image: Willancorah Swamp in the Macquarie Marshes, NSW, Australia. Photograph: Tim Ralph.

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WIDS2017 Dynamic Landscapes

Welcome to WIDS2017! This is the second meeting of the Wetlands in Drylands (WIDS) Research Network, following on from the inaugural meeting at Parys, South Africa, in November 2014.

The WIDS Research Network is a collaborative international initiative to promote the science and management of these important landscapes and ecosystems. We encourage and value participation by researchers, students, practitioners, managers, landowners, traditional owners, and all other stakeholders and community members.

The theme of WIDS2017 is *Dynamic Landscapes*, since WIDS typically have highly variable and changeable responses to external controls as well as internal forms and processes. Over three days, keynote presentations, panel discussions and group workshops will be structured around seven themed sessions focussed on hydrology and geomorphology, biogeochemistry, ecology, socio-cultural perspectives, sensitivity and resilience, links between science and management, and outlooks for the future.

The aims of WIDS2017 are to:

1. Promote WIDS research, conservation and management;
2. Continue to build a collaborative international community with active partnerships;
3. Discuss past and current successes in research, conservation and management;
4. Identify knowledge gaps and needs for applied research;
5. Establish a baseline of research, conservation and management actions and opportunities to guide future research projects and programs.

Session introductions and keynote lectures will focus on key concepts and pressing issues, as well as syntheses of key ideas and activities based on the experiences of the invited speakers. Panels, workshops and poster sessions will provide forums for discussions on the talking points and ideas raised in the session introductions and keynotes. We will identify and consider past and current successes and future opportunities, assess knowledge and information gaps, and discuss needs for further applied research on WIDS. Ultimately, we would like to promote new and existing research, management and stakeholder/community partnerships with a view to future activities and outcomes.

For more information about the WIDS Research Network, please visit wetlandsindrylands.net.

Enjoy your time at WIDS2017, and at Macquarie University.

Tim Ralph

July 2017

Wetlands in Drylands RESEARCH NETWORK

Sponsors

The following sponsors are gratefully acknowledged:

Macquarie University Research Development Grant project 'Sediment and carbon in wetlands in drylands: understanding long-term biophysical change in iconic ecosystems' (9201501517)

Department of Environmental Sciences

Oceania Chapter of the Society of Wetland Scientists

Australian Research Council project 'Remaking Wetlands in the Murray-Darling Basin, 1800 to the Present' (DP160103152)

Conference Venue

WIDS2017 will be held on Level 8 of Building E7A (12 Wally's Walk), in the Faculty of Science and Engineering at Macquarie University, Sydney (North Ryde campus, map grid reference N20).

An interactive campus map, parking map, and guides to the location and facilities can be found at: http://www.mq.edu.au/about/contacts-and-maps/maps

Programme

Day 1 • Monday, 24 July 2017	
8:30	Registration open
9:30	**Welcome and Acknowledgement of Country** Speaker: Phil Duncan
9:40	**Opening address** Keynote speaker: Lesley Hughes
9:50	**Introduction** Speaker: Tim Ralph
10:00	**Keynote address: Global challenges facing wetlands in drylands** Keynote speaker: Stephen Tooth
10:30	Morning tea
11:00	**Session 1: Hydro-geomorphological dynamics of wetlands in drylands** Chair: Michael Grenfell Keynote speaker: Mirela Tulbure
12:30	Lunch
13:30	**Session 2: Biogeochemical dynamics of wetlands in drylands** Chair: Patricia Gadd Keynote speaker: Spike McCarthy
15:00	Afternoon tea
15:30	**Poster Session 1 and student 3-minute talks (3MT)** *Sponsored by the Oceania Chapter of the Society of Wetlands Scientists (SWS)*
17:00	Day 1 close

Day 2 • Tuesday, 25 July 2017	
8:30	Registration open
8:50	**Introduction** Speaker: Tim Ralph
9:00	**Session 3: Ecological dynamics of wetlands in drylands** Chair: Peter Gell Keynote speakers: Phumelele Gama and Denise Schael
10:30	Morning tea
11:00	**Session 4: Sensitivity and resilience of wetlands in drylands** Chair: Kirstie Fryirs Keynote speaker: Max Finlayson
12:30	Lunch
13:30	**Session 5: Science and management for wetlands in drylands** Chair: Samantha Capon Keynote speakers: Tim Hosking and Peter Berney
15:00	Afternoon tea
15:30	**Poster Session 2** *Sponsored by Australian Research Council project 'Remaking Wetlands in the Murray-Darling Basin, 1800 to the Present' (DP160103152), CI Dr Emily O'Gorman*
17:00	Day 2 close

Day 3 • Wednesday, 26 July 2017	
8:30	Registration open
8:50	**Introduction** Speaker: Tim Ralph
9:00	**Session 6: Indigenous knowledge and management of wetlands in drylands** Chairs: Emily O'Gorman, Emilie Ens Keynote speakers: Danielle Flakelar, Phil Duncan
10:30	Morning tea
11:00	**Session 7: Future outlooks for wetlands in drylands** Chairs: Tim Ralph and Stephen Tooth
12:30	Lunch
14:00	Day 3 close

Wetlands in the Panhandle region of the Okavango Delta, Botswana. Photograph: Tim Ralph.

Abstracts

A comparative analysis of classification methods for burn scar mapping in wetlands

Mackenzie L.C. Austin, Hsing-Chung Chang, Kerrie M. Tomkins and Timothy J. Ralph

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This project explores the role and history of fire in the Macquarie Marshes and Gwydir Wetlands in New South Wales with two key objectives; to compare the spectral indices and classification methods that can be utilised for burn scar mapping, and to understand the behaviour of vegetation regeneration and regrowth in post-fire wetland ecosystems, namely the rate of regeneration and its relation to variables influencing burn severity, such as wetland moisture content. The methodology consists of multiple stages, the first of which includes performing spectral indices such as the normalised vegetation differential index (NDVI) and NDVI-Difference, burned area index (BAI), and the leaf area index (LAI) using satellite imagery. These processes measure the red and near-infrared light reflected from a sensed surface, which can be used to calculate green vegetation cover and density, which will allow for the detection of the large vegetation losses caused by bushfires. These outputs will then be classified by different classification methods such as neural networks (NNs), support vector machines (SVM) and random forest (RF) to determine the accuracy of the delineation between 'burned' and 'unburned' pixels, with a comparative statistical analysis performed to ensure accurate results. Finally, these outputs will be sequenced to form a time-series analysis, highlighting vegetation regeneration over time.

Temporal change in the vegetation communities in the Macquarie Marshes, a wetland in the drylands of NSW

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The vegetation communities of wetlands in drylands are comprised of species that require water from rivers (via flooding) to be available during some or all their lifecycle. Vegetation communities of wetlands in drylands are arranged in complex spatial patterns that can change over time. Water availability is the key driver of vegetation community structure and composition. We mapped the vegetation communities of the Macquarie Marshes at three times in the last three decades; 1991, 2008 and 2013. We investigated the change in spatial area of vegetation communities and compared the condition and extent of the communities at these three times. We found that there was a trajectory of change from better condition of communities in 1991 to displacement by terrestrialisation of wetland communities (2008), to a recovery of some areas of the Marshes through greater availability of water from natural flooding and managed environmental water delivery (2013).

Exploring capabilities of network flow programming for development of environmental flow management strategies

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Current management of regulated river basins has resulted in significant ecological changes in wetlands including the Macquarie Marshes. Water planners and managers use river basin models to evaluate different water management strategies. In the case of the Macquarie River basin, an IQQM model has been developed to emulate a hydrodynamic model of the Macquarie Marshes - it produces time series data in daily time steps of inflow, outflow, flow paths, storage volume and inundation areas of ecologically important areas of the marshes. However, a significant shortcoming is that the Macquarie Valley IQQM model is limited to modelling the ecological responses to hydraulic relationships from pre-determined water management strategies – the ecological state of the Marshes does not affect water management strategies in real time.

The network flow program WATHNET5 is a water resource modelling program that can simulate, optimize and calibrate water resource systems. Of particular interest is the multi-objective optimization capability in WATHNET5, which is currently utilised by the urban water sector to develop water resource management strategies for urban water supply. Our long-term goal is to develop a WATHNET5 model of the Macquarie Valley to simulate real-time feedback of ecological responses for the determination of management strategies for environmental flow releases and to use multi-objective optimization to explore optimal trade-offs.

In working towards this goal, we have had to ascertain whether a network flow program such as WATHNET5 can emulate wetland hydrodynamic flow relationships and the river basin upstream of the Marshes. This contribution reports on this task showing that WATHNET5 more reliably emulates wetland hydraulics than IQQM and can satisfactorily emulate key features of the Macquarie river basin using a much simpler model than IQQM. This paves the way to simulate wetland management rules that respond in real-time to the state of the wetland and to explore the utility of multi-objective optimisation for identifying optimal trade-offs between the competing ecological (and irrigator) demands for water within the Macquarie Valley.

Indigenous engagement: incorporating indigenous values and knowledge into meaningful partnerships

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[3]CSIRO, Member of the National Indigenous Advisory Council.
[4]Productivity Commission, Member of the National Inquiry into Australia's Water Resources.

Aboriginal people attach enormous cultural and spiritual significance to our cultural landscapes. In the Aboriginal world view, people and Country (including lands, wetlands, waterways and seas) are interdependent entities that are intrinsically linked in the landscape. This means that there is no separation of nature and culture. The health and wellbeing of Aboriginal people is directly influenced by both the health of the environment and the degree to which Aboriginal people can be actively involved in caring for it. Wetlands that are on our Country are our supermarkets and our learning centres.

As first people of Australia, Aboriginal people have inherent rights that were never traded or given away. These inherent rights are recognised in a wide range of International, Federal, State and Territory Government instruments that afford Aboriginal people ownership and custodial interests in Country and recognises including their unique responsibility to care for their communities, cultural landscapes, biodiversity and places of particular cultural significance.

Ongoing access to Country and its resources is essential so Aboriginal people can continue cultural practices, maintain links with the land and care for Country. Aboriginal communities can retain and obtain valuable knowledge and skills through being proactively involved in environmental management and conservation. People can benefit from Aboriginal people's knowledge, relationships and cultural and environmental practices and protocols that are alive and vibrant in the Aboriginal communities.

The unique position of Aboriginal people in our culture and history must be acknowledged and recognised, there needs to be a strong committed to the genuine recognition of the truth of Australia's history, the disadvantage that Aboriginal people continue to face today must be addressed by engaging Aboriginal communities in economic, environmental and conservation projects.

A key component of this process is to ensure that Aboriginal communities and individuals have access to economic, social, environmental and conservation opportunities. If genuine access to relevant information is given to Aboriginal community and adequate explanation of the likely impacts (positive or negative) of change upon Aboriginal people is explained, then the likelihood of successful and ongoing engagement with Aboriginal communities is greatly increased.

Meaningful engagement with Aboriginal people requires innovation and particularly patience. Organising and facilitating meetings for key proponents and Indigenous people and communities don't come without some distinct challenges, but through maintaining a very strong focus and articulating policies and processes that are beneficial for all parties has been a foundation of success. Ensuring positive feedback and engaging in a transparent, accountable and culturally appropriate manner is fundamental to laying the platform for strong partnerships with Indigenous people and their communities.

Semi-automated delineation of reticulate channel networks in low-gradient floodplain wetlands using LiDAR-derived DEMs

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The study of catchment drainage networks and river channel delineation using Digital Elevation Models (DEMs) has been the focus of many studies, both domestically and internationally. However, little attention has been given to the mapping of complex reticulate channel networks that characterise many low-gradient floodplain wetlands in the drylands of Australia, and elsewhere around the world. This ongoing pilot study has identified and mapped the drainage network present in the Macquarie Marshes, New South Wales, to better understand the channel hierarchy, patterns of flow dispersal, channel morphology and connectivity within this system. Several different tools

commonly used to derive drainage networks using DEMs in Geographical Information System (GIS) software packages, such as ArcGIS, GRASS GIS and SAGA GIS, were applied to a high-resolution DEM of the Macquarie Marshes derived from Light Detection and Ranging (LiDAR) data obtained by the NSW Office of Environment and Heritage. The outputs were compared to determine which method offered the most accurate channel network and provided the most efficient technique for further morphometric and pattern analyses. It was found that methods that did not require DEM-filling prior to flow direction and accumulation modelling and that took multiple flow directions into account offered the most accurate channel networks in this system and were more computationally efficient.

Sensitivity and resilience of wetlands in drylands

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The concepts of sensitivity and resilience of ecosystems have been much discussed and at times without a common understanding or agreement about what was meant. I see this as largely a definitional issue and not one that should delay our discussions on changes in wetlands in drylands. With this in mind I turn to what some issues in these highly variable wetlands and look at change within a contemporary timescale and how some of the species respond, and how they may respond under further pressures from changes in our land and water management and climate. This in effect introduces a wide range of drivers that have and continue to impact on the ecological processes that shape the character of these wetlands. The questions then become ones of how vulnerable are these wetlands to such pressures, and how well can we interpret such change? In other words, how much do we know about them? We tend to have more information on some of the vertebrate populations that inhabit them, for at least some of their life cycles, but possibly not enough information about how those that are most prevalent in the dry periods shape the conditions of the ecosystems. Hence, how do we contend with the dryness when looking at these wetlands? This extends further to how do the plants that characterise the wet phase survive the dry, or otherwise establish when it is wet, and does the loss of dry phase vegetation have an effect? Seedbank analyses can tell us something about this. Then we have the swing between saline to fresh conditions, and the microphytes that may well be the forgotten but critical part of the system. Also, the organisms that thrive in the sediments, under some conditions. We can argue whether the systems are sensitive and also about where the resilience comes from, all while keeping in mind that these are highly variable in space and (short) time and by size. Can we therefore conceptualise that in general models or do we need to be more specific, or treat them more individualistically?

A Wayilwan perspective on enhanced management of wetlands in drylands

Danielle Flakelar

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How does sharing degrees of power with landless descendants, also known as Aboriginal Traditional Owners, better serve the wetlands in drylands? Wayilwan people, using the 'Empowerment model', are taking their place at the environment water planning and management table to voice their

priorities for natural and cultural outcomes of wetlands in drylands. Wayilwan people are the traditional owners of the Macquarie Marshes and the floodplains area in north-western NSW. They are using their knowledge, cultural obligations and responsibilities to guide them in finding solutions to the current and future water management issues as they arise.

Notwithstanding the recent history of dispossession and displacement from their traditional country, Wayilwan people have been active in reconnecting, reviving and renewing their natural and cultural knowledge and practices of country for generations. Furthermore, they are negotiating agreements for management of environmental water in the Macquarie Marshes in partnership with government agencies.

More recently Wayilwan people have been developing their scientific and technical knowledge and understanding of the current water management regime that affect the Macquarie Marshes. With these combined traditional and contemporary knowledges and experience they are challenging the current environmental water management principles and practices within the Macquarie Marshes, along the waterways and throughout the floodplain.

Wayilwan people do not have a dedicated seat on the Environmental Flows Reference Group (EFRG), but this has not hindered them to be involved in environmental water management of the Macquarie Marshes. Since 2007, there has been an active Wayilwan representative on the EFRG, who was firstly encouraged to support the decisions made by stakeholders and government representatives.

Now however, Wayilwan people have determined their purpose using the "Quadruple Bottom Line" as a contemporary measurement to strive for resilience across their homelands. They challenge long held attitudes and behaviour that has seen the over-extraction and diversion of water from the waterways and marshes for agricultural and farming purposes. They provide constructive advice and expect decision making to reflect the long term natural and cultural outcomes of the Macquarie Marshes, not just short term economic and environmental benefits.

Empowerment isn't easy though, because it requires government agencies especially water license holders to be committed to continuous Traditional Owner development in science and technology. It means fostering an environment of trust between stakeholders and helping each other to learn from combined their successes and failures. There are five key elements that Wayilwan people have used to empower themselves at the Drylands in Wetlands Research Network conference in 2017.

Ecological dynamics of wetlands in drylands: resilience and adaptation

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Semi-arid and arid regions are usually dominated by a few, large, perennial fluvial ecosystems and a multitude of ephemeral rivers and wetlands of varying sizes (<0.001 ha to >10 000 ha) and variable hydroperiods (days to months). The highly dynamic nature of ephemeral wetlands and the rapid response of their biota make them both interesting, on an ecological and biodiversity level, and challenging, on a management level. Aquatic biota in dryland regions have evolved strategies for survival and persistence through naturally variable climatic conditions. The precise attributes that make biota resilient and persistent in these dynamic habitats make designing and developing wetland health biomonitoring tools for management very difficult. In order to use the information

that aquatic biota can impart regarding the health status of a wetland, it is critical that a basic understanding of their dynamics in different wetland types, under various periodicities and hydroperiods is established and developed. From recent field data, we now know that there are significant differences between some wetland types in terms of aquatic flora and faunal composition. This knowledge is important when characterizing successional changes in aquatic biota, in order to relate these shifts to natural abiotic changes and/or anthropogenic perturbations. Clearly our understanding of wetlands in drylands and their ecological role in the landscape is still developing with a number of unanswered questions. For example, how much do we know about the community successional patterns of wetlands in drylands around the world? Is our knowledge regionally, locally or project based? And if so, how can we extrapolate regional or local knowledge into generalisations that can help in regions where there is little or no data to make informed decisions regarding the management of wetlands elsewhere? In this session, we will share our understanding from a South African perspective with regard to the dynamics of ephemeral wetland ecosystems.

Rapid analysis of soil carbon in wetlands, using Laser Induced Breakdown Spectroscopy (LIBS)

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Measuring soil carbon stores and fluxes is important for our ability to understand ecosystem health and carbon sequestration. Soil carbon can be measured in a range of ways, most usually and simply by loss on ignition (LOI) at temperatures from 375 to 850 °C and durations from 0.5 to 16 h, with the application of a conversion factor to convert LOI to organic carbon. The lack of a standard method is not the only complexity; the loss on ignition metric is prone to error as waters of formation are lost from hydrated minerals including salts, clays and other minerals. In field measurements of soil carbon are now possible using Laser Induced Breakdown Spectroscopy (LIBS). Measurements are fast, inexpensive and have reasonable accuracies. Here, we present a measurement program for soil carbon from a wetland in semi-arid central NSW, and we will highlight some of the advantages and pitfalls of using LIBS for measurement of soil carbon.

Contemporary fluvial charcoal supply to floodplain wetlands of the Macquarie Marshes, NSW, Australia

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Fire plays a pivotal role in modifying and shaping the Australian landscape, including floodplain wetlands, which respond dynamically to flooding, fire and geomorphological changes. Buckiinguy Swamp, a key ecological asset in the Macquarie Marshes, has experienced numerous fires in the past. For example, a total of 32 fires occurred in the period 2004-2014 within a ~10 km^2 zone in and around the wetland, as shown on contemporary satellite imagery (Geoscience Australia Sentinel Hotspot data). However, the volumes of charcoal produced in situ by local fires and that supplied to the wetland from the upstream catchment (i.e. not representative of local fires) are unknown. This

study assesses the fluvial input of macroscopic charcoal (>125 µm) associated with sediment from upstream to disentangle these two major sources of charcoal. Sediment was collected from synthetic grass mats that were deployed in the wetland for 7 months to establish the contemporary charcoal flux to Buckiinguy Swamp. Preliminary results show that charcoal counts were highest at site B4 and consistently lower at the three other sites. Sites B1, B2 and B3 appear to yield a consistent fluvial charcoal signal. Charcoal found at B4, near the outlet of the reed bed and with the lowest volume of deposited sediment, may have been remobilised and redeposited from nearby in the wetland, rather than being supplied from upstream. The results showed that B2 and B3 near the terminus of Buckiinguy Creek had the highest volume of deposited sediment (0.74 to 0.98 kg m^{-2}). The amount of charcoal and sediment deposited near the channel and on the adjacent floodplain was highly variable, probably due to flow attenuation by vegetation (e.g. *Phragmites australis* and *Paspalum distichum*) and differential patterns of sedimentation. The findings from this study will help to provide a baseline charcoal flux (i.e. a background fluvial deposition rate) for Buckiinguy Swamp, which will be used to separate the in situ and fluvial charcoal signal from sediment cores and to determine the historical charcoal signal related to local fires preserved in the wetlands.

Eco-morphodynamics in non-perennial rivers: challenges and opportunities

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Geomorphological analyses are often applied in river management to provide a frame of reference for the state of the physical fluvial habitat template. Recognising that this reference state is neither singular, nor static in its characteristics, processes and behaviour, it is common to evaluate the historical range of variability (HRV) of a river or reach of interest. Common approaches to documenting the HRV involve combinations of i) time-series historical image analysis, ii) reconstruction of past environments using field morphological and stratigraphic surveys, supplemented by chronologies of geomorphic change, and iii) type i and ii analyses of geomorphologically-equivalent systems in 'better' condition, to apply space-for-time substitution. These approaches, although well-grounded in observation, may be subject to underdetermination, and can lead to a wide range of incompatible hypotheses. However, they may be valuably supplemented by morphodynamic modelling of the potential range of variability (PRV) in habitat characteristics, given specified historical, prevailing, or likely future flow/sediment feeds. This poster presents an example of such an approach applied to a large non-perennial river system in South Africa, and illustrates some of the challenges that must be addressed for the successful application of eco-morphodynamics in non-perennial rivers. These challenges include i) selecting or developing a modelling framework that is sympathetic to environments with highly variable flow/sediment feeds (at times approaching hyper-concentration), complex and poorly-sorted particle mixtures, patchy and dynamic roughness and bed sediment thickness characteristics ('rivers' that are for the most part networks of 'wetlands in drylands'), and large differences in the inlet and outlet fluxes of water due to transmission losses, ii) accessing field flow and sediment transport data for model calibration and confirmation in rivers that may experience no flow for several concurrent years, and iii) defining, in consultation with ecologists, and extracting from model output, geomorphological metrics of physical habitat quality and diversity, such that changes in geomorphology may be translated into the ecological terms that typically form the basis of river management practice. Examples of such metrics are provided.

Decline and fall: floodplain wetlands of the Macquarie River are a response to Late Quaternary climate-driven hydrological change

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Rivers in sub-humid to arid lowland basins commonly suffer downstream declines in discharge and channel capacity owing to transmission losses and a lack of tributary inputs. The lower basins therefore have a tenuous dependence on upstream flow contributions for ecological health and the provision of ecosystem services. Palaeochannels of these lowland rivers provide a means of investigating the sensitivity of river response to climate-driven hydrological change. The Macquarie River in the Murray-Darling Basin (MDB) of southeastern Australia today breaks down to form the extensive Ramsar Convention-listed floodplain wetlands of the Macquarie Marshes but around 80 palaeochannels are preserved on the alluvial plain recording the evolution of this distributive fluvial system (DFS). Single-grain optically-stimulated luminescence ages from six conspicuous Macquarie palaeochannels yielded minimum age model estimates ranging from 54 ka to 2 ka and, together with observed cross-cutting relationships, constrain the evolution of the DFS over the last 54 ka up to the formation of the modern river and wetland system. The largest of these palaeochannels (Quombothoo, mean age 54 ka) was 284 m wide, more than 12 times wider than the modern river (24 m) and with 21 times greater meander wavelength. A younger group of palaeochannels, Bibbijibbery (125 m wide, 34 ka), Billybingbone (92 m, 20 ka) and Milmiland (112 m, 22 ka), although smaller, were still much larger than the modern river and continuous all the way to the Barwon-Darling River. The mid-Holocene (5.6 ka) Mundadoo channel was four times wider (86 m) and had meander wavelength double that of the modern river, whose earliest sediments are dated to around 5.2 ka. The morphological changes induced by the decline in river discharge were profound and non-linear. The 5.5 ka transition saw a fundamental change in river behaviour, leading to the formation of the ecologically important Macquarie Marshes but also decreased contribution of water and sediment to the Darling River. This trend is similar in timing and scale to the Gwydir River, with its Holocene wetlands.

Facilitating effective science input for management of wetlands in drylands

Tim Hosking[1] and Peter Berney[2]

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In dryland environments, wetland ecosystems, the adjacent floodplains and the human populations that live there are closely interconnected and can be considered to represent a social-ecological system. Patterns of resource use, particularly water use, affect the ecological, economic and social functioning of these systems. When resource use becomes unsustainable the resilience of the system breaks down and transformation is necessary. The current process of water reform that is taking place in the Murray-Darling Basin has sought to provide greater ecological and economic sustainability in the future to wetland social-ecological systems across the Basin.

Water managers are very much a part of the social sub-system of wetland social-ecological systems. Developing a relationship with the various groups within the community and understanding their values is critical for effective operation as a water manager. The adage “people don’t care what you know until they know that you care” applies. Water reform under the Basin Plan has been driven by science and only belatedly recognized the social dimension of water reform and the need to work with communities in order for them to acknowledge and be guided by research data. Similar relationships between researchers and managers are also likely to help in research making a difference to management actions.

Recent experiences in the Macquarie Marshes where scientists and managers have worked together to enhance the effectiveness of water management include the development of monitoring systems allowing accurate reporting on the outcomes of water management for environmental purposes. Examples include improvements to inundation mapping and flood frequency analysis across the wetland ecosystem. For vegetation, mapping the spatial distribution of plant communities and developing condition measures to assess change in community condition over time have provided evidence to guide future water management decisions. Similarly, during the most recent floods in 2016, close working ties established between colonial waterbird researchers and water managers delivered successful breeding events in the Macquarie Marshes and is continuing to provide ongoing information on waterbird movement post-flooding.

The Basin Plan continues to guide water reform in the Murray-Darling Basin. The development of long-term watering plans represents a mechanism for integrating basin-scale objectives with catchment-scale management goals. Knowledge gaps or deficiencies in the long-term watering plans represent potential fruitful areas for future research.

The geoecology of inland floodplain wetlands: connecting hydro-geomorphic to biogeochemical structure and function

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Inland floodplain wetlands have intricate multi-channelled networks and unpredictable wet and dry phases related to variable hydrological regimes and geomorphic processes such as sedimentation and erosion. Hydrological reconnection of river channels with outer floodplain and wetland habitats initiates mobilisation and transformation of nutrients, carbon and biota in inland floodplain wetlands. Here, we summarise our findings of the wetland responses to environmental water releases that aim to address the ecological needs for inundation. Despite highly variable hydro-geomorphic characteristics, habitat-dependent patterns and processes are evident in relation to mobilisation and transformation of nutrients, carbon and biota in inland floodplain wetlands. Environmental watering strategies that seek diverse ecological outcomes should include the inundation of multiple hydro-geomorphic habitats as an important driver of structural and functional responses in inland floodplain wetlands.

Historical channel change in the Okavango Panhandle, Botswana

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The Okavango Delta in northern Botswana is characterised by ongoing morphological, hydrological, and ecological adjustment and change over seasonal, interannual, and longer timescales. Understanding the natural, historical range of variability in the Okavango is critically important for implementing successful management strategies. The Okavango Panhandle is a ~10 km-wide entry corridor of permanent swamps with a meandering trunk channel that is anabranching in some reaches. By using historical aerial photographs for detailed geomorphological mapping and morphological analysis of channel variables, we investigated the types and rates of change occurring in the anastomosing channels of the Okavango Panhandle. Throughout the second half of the 20th century the main Okavango channel has been progressively losing water to the Filipo channel to the east. Vegetation encroachment into the failing Okavango channel has reduced the channel width from ~40-50 m to ~20 m, whilst the Filipo channel has either remained stable or increased in channel width up to ~55 m. Changes to the water balance between channels is largely manifest in channel width changes, and there is no evidence of discernible lateral channel migration along any of the channels investigated. Given low historical rates of channel migration, meander belts likely take decades to centuries to develop, but given the current rate of vegetation encroachment along the Okavango River, we estimate that the failing Okavango channel may be blocked in various sections and essentially abandoned in the near future. Our findings have implications for the community of Sepopa and local tourism lodges that rely on the failing Okavango channel for water and transport.

Some thoughts on the biogeochemical dynamics of wetlands in drylands (WIDS)

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WIDS generally occur in regions where rainfall<PET, which usually results in a negative water balance. On the other hand, wetland mass balance, which excludes water and considers only particulate and dissolved solids, and solids derived from gases (CO_2 and N_2), can be positive or negative, reflecting net aggradation or degradation respectively. Particulate solids are introduced into WIDS as aerosols (dust) or by fluvial transport. Dust may form an important source of nutrients in some wetlands. It is uniformly deposited over permanently wet areas, but accumulation can become localized, especially in seasonally inundated wetlands, contributing to wetland micro-topography. The total quantity and grain size of fluvial sediment (bedload/suspended load ratio), as well as stream power, influence the character of distributary channel systems in wetlands. The geohydrological structure of WIDS plays an important role in the manner in which physical and biogeochemical processes are expressed. Biogeochemical processes in WIDS differ substantially from those in wetlands where rainfall>PET. They operate alongside and interact with physical processes, all of which contribute to shaping wetland structure and function. Wetland plants and the peat they accumulate constitute an important sediment type, but it differs from clastic sediment because plant growth can interact dynamically with water flow. However, there is little prospect of long term carbon capture in the form of peat because WIDS are prone to desiccation and burning. Precipitation of solutes in WIDS can occur as a result of evaporation, which mainly affects surface water, or transpiration, which affects subsurface water. The geochemical pathways and sequence of precipitation and the varieties of solids formed is determined by the solute composition, especially the relative proportions of Cl^-, HCO_{3-} and SO_4^{2-}, and the molar HCO_{3-} to (Ca+Mg) ratio. Water in which Cl^- dominates precipitate little solid and evolve towards NaCl-rich brines which are toxic to plants. Water dominated by carbonate salts precipitate calcite and dolomite, and toxicity is only attained at extreme degrees of evapotranspiration. Atmospheric carbon is captured by this process but quantities are trivial. Open water evaporation leads to precipitation of solutes around the bases of aquatic plants but prolonged evaporation ultimately leads to NaCl build-up and toxicity, resulting in salt pans. Transpiration occurs as a result of water uptake by plant roots and can lead to the precipitation of carbonate minerals and silica (calc-silcrete) which can result in mound formation in wetlands. Such mounds can become nutrient accumulators due to plant, insect and animal interactions. Mound soil eventually becomes toxic due to accumulation of highly soluble salts (usually NaCl or $NaHCO_3$). Accumulation of solids derived from solute precipitation is probably restricted to WIDS and generally does not occur if rainfall>PET, because of flushing. The microtopography and character of the termini and fringes of WIDS is probably determined by the ratio of rainfall to PET and the chemical composition of the solute load.

Floodplain wetland of the Atuel river system, central-west Argentina

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The Bañados del Atuel (BA) wetland is situated in the lower reach of the Atuel River (AR) fluvial system in central-west Argentina (~36°0´S-67°30’W, ~37°30´S-66°40’W), a complex geological setting including several morphostructural units. The AR (~34°30´S-70°09’W, ~37°30´S-67°00’W) is a tributary of the Colorado River fluvial system and traverses the South American Arid Diagonal (~200 mm/year rainfall). It has a perennial seasonal regime and its flow comes mainly from snowmelt in the Andes Cordillera. At the extra-andean lands, the AR middle reach is a transporting zone formed by a proximal piedmont with alluvial fans, and to the east, by a main trunk stream (MTS) crossing the San Rafael hills, an uplifted tectonic block. Downstream, in the AR lower basin, the MTS bifurcates into a distributary drainage network formed by many meandering streams flowing along the Depresión de la Travesía plain and towards the terminal BA wetland. The goal of this contribution is to analyze the general geomorphological features of the BA wetland. For this purpose, previous studies were reviewed together with the analysis of satellite images and fieldwork consisting in the description of exposed stratigraphic sections and pits.

The BA wetland is bordered to the west by the late Miocene deposits of the Meseta de Chicalcó and the Pleistocene basalts of the Meseta Basáltica, and to the east by the Desaguadero-Salado-Chadileuvú fluvial system. Southwards, the Neogene Colorado palaeofan constrained the wetland. The low gradient (~0.55 m/km) wetland alluvial plain is built up by fine-grained alluvial sediments (sand, silt and mud), that would have aggraded since the late Holocene, according to the few numerical ages (radiocarbon dating) obtained until now. The wetland fluvial network presents a pattern of channeled and unchanneled landforms (channels, floodplains, marshes and lagoon environments). Numerous channels with distributary pattern are product of nodal/random avulsions. Avulsions seems to have been frequent in the AR terminal fluvial system and contributed to the development of the wetland when the fluvial system was active at full capacity. The transition between channelized flows and non-channelized flow occur in the wetland determining terminal floodout zones (i.e. extensive distributary channels grade distally into sheet flood deposits with poorly defined channels, and floodplains – in the conventional sense of the term – grade into floodouts). The terminal part of the BA wetland corresponds to an endorreic basin – Gran Salitral – that receives water by both groundwater and surficial circulation (e.g. Arroyo Potrol and Arroyo Las Barrancas).

Today, the AR is a misfit fluvial system compared with previous glacial-stage flows. In addition, in the 40s the construction of a series of dams began in the AR transporting reach to produce energy and provide irrigation to the San Rafael city area that turned into an agricultural oasis – with man-made channels – affecting the lower basin fluvial regime and particularly the terminal wetland development. Consequently, the present active surface runoff zone has a minimum expression and is restricted to the Arroyo de La Barda, the only present-day active channel.

Flowing wetlands in the Cape Agulhas region of South Africa

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The Cape Agulhas region is a semi-arid region on the southern-most point in South Africa. The area is a flat, low-lying region that is used extensively for agricultural activities and grazing. Wetlands range in size from small temporary pools, to extensive depressions that are several kilometres in diameter. The hydrology and morphology of these systems are driven by groundwater input from the mountain range in the north, winter rainfall (ca. 400 – 600 mm per annum), and flat topography. The current research aims to assess the extent to which these wetland systems act as a source/sink for sub-surface and surface water in the catchment, and the resulting impact it has on water quality and quantity in the river. Voëlvlei and Soetendalsvlei are two wetlands that have non-perennial inputs and outputs that seasonally connect to the non-perennial Nuwejaars River. Surface water downstream of Soetandalsvlei has a lower pH (7.89), compared to the river upstream (7.90), and the latter is comparable to the wetland itself. A similar pattern was observed with the electrical conductivity (EC). Voëlvlei was more complex, and relationships between the surface water, groundwater and the input/output channel needs to be studied further. Seasonal changes in water quality indicate lower pH values and EC measurements during higher rainfall periods. This coincides with a shift from isolated pools along the river and wetlands, to a dynamic, interconnected system. In addition, the EC varied from 43 – 132 mS/cm among three wetlands associated with the lower reaches of the Nuwejaars River. Therefore, it is essential to understand the complex seasonal and spatial dynamics of these systems across the entire catchment to appropriately manage these water resources in the future. Further research is also needed to understand the extent to which increased unpredictability of rainfall, or shifts in the timing of rainfall, would affect the ability of these wetlands to ameliorate water quality and quantity.

Perched wetlands: an explanation for wetland formation in semi-arid areas

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Over 1700 wetlands have been identified in the Nelson Mandela Bay Municipality (NMBM), Eastern Cape. The average wetland density in the study area is approximately 9 wetlands per 10 km^2. This density is high considering that the NMBM is classified as a dryland (semi-arid area) with evapotranspiration rates being almost three times higher (1800 mm per annum) than the average rainfall in the Municipality (613 mm per annum). This research aims to explain how these wetlands can be prevalent in this semi-arid region, due to the formation of different types of "perches" (i.e. hard impermeable sub-surface layer) on which wetlands can form. The study area is diverse in terms of its climate, vegetation types, geomorphology and underlying geology, and this environmental diversity has resulted in a range of wetland hydrogeomorphic (HGM) types. Previous research in the area has indicated that the majority of these systems are predominantly precipitation driven, with minimal groundwater input that is limited to certain regions. Therefore, the formation of wetlands is facilitated by other environmental processes. Data were collected from 46 wetland sites between 2012 and 2014. These sites were comprised of depressions, wetland flats and seeps that were found within the different environments (geology, climate etc.). Soil core data were also collected at several points at each site. A total of 34 wetlands were perched, with an impenetrable layer within 1 m of the soil. At 14 of the sites a dense clay layer was found, regardless of the surrounding geology and sediment. A calcrete layer was recorded at seven sites that were associated with aeolian deposits in the south-eastern portion of the study area. A shallow bedrock layer was observed at nine sites that were predominantly associated with quartzitic sandstones of the Peninsula Formation. The remaining four sites were comprised of a mix of bedrock and clay perch. Several of the other "non-perched" sites were dune depressions, or could not be classified. In conclusion, this study has highlighted that impermeable sub-surface lenses are a key foundation to the development of a wetland system in some semi-arid areas, regardless of the HGM type and the presence of groundwater.

Tracing ephemeral wetlands along ancient fluvial systems in the drylands of South Africa

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The most pronounced occurrence of ephemeral wetlands (pans) in South Africa is found in the Northern Cape Province, an arid region characterised by low and sporadic summer rainfall (MAP <200 mm) and high evaporation (>2000 mm per year). These pans are either large connected systems or smaller isolated depressions and are believed to be remnants of major historic (Cretaceous) river systems that have been dismembered after extreme aridification and tectonic shifts. Collectively, they cover an area of over 5000 km^2. They have similar bare, flat, shallow, low-elevation surfaces but differ in biological, geomorphological and sedimentological characteristics.

Due to their natural hydrological functioning the pans are subjected to complete desiccation during dry periods, which can last for decades. Consequently, dry pans are often regarded as degraded or lifeless. However, when it rains enough for the pans to hold water, dormant aquatic organisms respond and wetlands are resurrected. The scale of wetness varies over space and time and the unpredictable rainfall regime renders consistent sampling protocols challenging even during wet spells. Therefore, the Northern Cape pans have received little attention in terms of research, and management approaches of pans remain uncertain. By contrast, they are possibly among the most sensitive ecosystems in the region, potentially supporting many species of conservation significance and possibly acting as key stepping-stone corridors in an arid landscape. It is therefore critical to understand their ecological functioning and distribution and to monitor their dynamics.

As a first step towards this, the current study therefore compares the ephemeral pan systems from four geomorphic regions along the two main Cretaceous drainage systems in this province and describes them according to their geomorphological affinities, hydrology, biodiversity and land use.

Wetlands in drylands: the case in Australia

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Wetlands in drylands (WIDS) typically have a negative annual water balance and provide essential biophysical habitats and ecosystem services in moisture-limited landscapes. WIDS are also inherently dynamic systems, since the form and functioning of rivers and wetlands change over time in response to extrinsic controls such as climate, hydrology, and human activities, and intrinsic factors such as sedimentation, erosion, and ecological succession. WIDS have irregular flood, drought and fire regimes that create mosaic-like aquatic ecosystems that often defy simple approaches to conservation and management. For example, changes in the location, extent and integrity of channels in wetlands can lead to significant changes in inundation, aquatic ecosystem responses to flooding, and to flow-on effects for biota, habitats and agricultural productivity. This is certainly the case in Australia, which has rivers and wetlands with some of the most variable hydrological regimes on Earth, that are also heavily relied upon for cultural and ecosystem services. Australia has 906 wetlands in the Directory of Important Wetlands in Australia (DIWA) Spatial Database, of which 65 are also listed under the Ramsar Convention. Approximately 52 % of these DIWA-listed wetlands occur in the drylands (interior) of Australia, many of which are connected to rivers in the Murray-Darling Basin. Australia is moving towards the long-term conservation, management and sustainable use of WIDS through the development of strategies tailored towards holistic and adaptive management of wetlands. Adaptive environmental watering and wetland management plans are being implemented state-by-state in Australia, while broader plans (e.g. Murray-Darling Basin Plan, finalised in 2012) provide a coordinated approach to water use between states. Such plans also set sustainable limits on extraction of surface water and groundwater and support investments and decision-making around water for the environment and water-efficient infrastructure. Although knowledge of the external controls, internal processes, and anthropogenic pressures on and requirements of WIDS is ever-growing, there is still a pressing need for integrated, multidisciplinary research and management to address key threats, thresholds of change, and future outcomes in these dynamic systems.

Aquatic ecosystem metabolism in three distinct hydro-geomorphological zones of the Macquarie Marshes, Australia

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Wetlands are ecologically important freshwater systems that play important roles in global cycling of water, carbon and nutrients. Aquatic metabolism – the balance of gross primary productivity of phytoplankton (GPP) and planktonic respiration (PR) in an aquatic system – underpins healthy food webs and habitats in wetlands. Aquatic metabolism is affected by several factors such as water quality, availability of energy and nutrients, as well as changing biophysical conditions in wetlands. Microbial processes such as planktonic respiration and enzyme activity have received less scientific attention compared to larger wetland biota, despite the fact that wetland ecosystems are dependent on the activity and functional attributes of the microorganisms. To address this knowledge gap, this project will study aquatic ecosystem metabolism and enzyme activity related to functional groups of bacteria in three core hydro-geomorphological zones of the Macquarie Marshes, an iconic inland wetland. Representative soil samples were collected from regularly inundated wetland (Zone 1), rarely inundated wetland (Zone 2), and dryland with non-inundated alluvial soils adjacent to the wetlands (Zone 3). Soil samples were inundated under laboratory conditions in mesocosm for 120 hours and GPP and PR were determined from measurements of dissolved oxygen in biogeochemical oxygen demand bottles. Among the three zones studied, no significant difference was found for the mean GPP but the mean PR differed significantly (one-way ANOVA, $P<0.001$). Tukey HSD test showed that the mean PR in Zone 3 was significantly different (higher) from Zone 1 and Zone 2 ($P<0.05$), but there was no significant difference in mean PR between Zone 1 and Zone 2. These results suggest that inundation has an asymmetrical effect on GPP and PR, and higher net primary productivity (GPP-PR) is likely to be realised in wetland zones. Further work will determine microbial diversity and enzymatic activity in the three zones, as well as dissolved organic carbon and nutrient content, and will assess the relationships between ecosystem metabolism, microbial diversity and nutrient content to understand the functioning of the wetland ecosystem. In doing so, the project will assess how the microbial enzymatic activity can be affected by nutrient availability in the wetlands and whether this is linked to the rates of aquatic ecosystem metabolism.

Vegetation status in freshwater wetlands: an eco-hydraulic model for the Northern Macquarie Marshes

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The Macquarie Marshes is a freshwater wetland located in the terminal floodplain of the Macquarie River, in NSW, Australia. The unique mosaic-like vegetation composition of the marshes is organized

in a collection of reed beds, lagoons, mixed marsh, shrublands, grasslands, and floodplain forests and woodlands. These plant communities are a sanctuary for many species of colonial waterbirds, fish, and other types of fauna such as turtles; and some areas of the marshes have been declared of International Importance under the Ramsar Convention. This research is focused in the northern Macquarie Marshes, where large areas of wetland vegetation were reported to transition to terrestrial vegetation during the millennium drought, with a significant recovery after a few years of record or near record rainfall. We have developed an eco-hydraulic simulation model that couples a quasi-2D hydrodynamic simulations with a vegetation module based on water requirements for various plant associations in the Macquarie Marshes. This approach allows us to determine the condition of the vegetation by considering watering thresholds that have been estimated over a simulation period of 23 years (1991-2013). This contribution presents the definition of the different rules and considerations taken in the development of the vegetation module as well as the latest results.

We can be happy underground: micro-crustacean egg-bank conditions in ephemeral lakes

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Micro-crustaceans form an important part of ephemeral lake food webs, providing food resources to larger aquatic animals including frogs, waterbirds and fish. While most animals have the ability to disperse, micro-crustaceans cannot. Micro-crustaceans are extremophiles; in lieu of active dispersal, they persist in the dried sediments of ephemeral lakebeds by virtue of a resting egg phase. While desiccation-resistant eggs have evolved to survive in harsh conditions, climate change threatens to push environmental conditions beyond the survival capacities of even the most well adapted organisms. Current research often explores the temperature tolerances of micro-crustaceans and their eggs under extreme experimental treatments and in-situ base-line data for these types of experiments are lacking. Our research aims to establish base-line data in order to design experimental treatments that reflect realistic temperature increase scenarios. We have monitored ephemeral lakebed temperatures for 3 months (Jan – Apr 2017) in 3 ephemeral lakes in the Paroo catchment, 130 km north-west of Bourke, NSW. In the height of summer during the hottest part of each day, surface temperatures were significantly higher than atmospheric temperatures, often by 10 °C. During the hottest part of the day, lakebed sediments at 2 cm depth buffered atmospheric temperatures. These results will contribute to the development of base-line data which will be vital when designing experimental treatments that simulate realistic climate change scenarios.

Salt Lakes in the Paroo, northwestern New South Wales

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The central Paroo in northwestern NSW has diverse and numerous wetlands, one distinctive type being saline lakes. These are the best understood as a result of various studies over the last 30 years.

Most formed by ponding due to sanddune movement blocking drainage during the last Ice Age. Presently wind and sedimentation are influencing their form while irregular rainfall determines water presence. Invertebrate diversity is inversely related to salinity though this is varied during El Niño and La Niña years, and by season of fill. Crustaceans are far more tolerant of these variations than insects. The fauna consists of salt tolerant freshwater species, hyposaline, mesosaline and hypersaline species. When the lakes are dry a limited but characteristic terrestrial fauna flourishes. We plan further work on the recent history of the lakes, the hatching of the crustaceans and on food webs.

Global challenges facing wetlands in drylands

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To those unfamiliar with the world's hyperarid, arid, semiarid and dry subhumid regions, the term 'wetlands in drylands' almost sounds illogical, for an overall moisture deficit would not seem to be conducive to sustaining wetlands. In reality, drylands can support diverse wetlands, including features termed floodplains, marshes, swamps, pans, playas and oases. Larger wetlands in drylands tend to be associated with perennial or intermittent river inflows, while smaller wetlands in drylands can be sustained by occasional rainfall inputs or groundwater exfiltration alone. In some dryland settings, numerous small wetlands collectively can cover a large area, and so may take on an importance above and beyond their individual spatial scale. Many wetlands in drylands play a key role in landscape and wider environmental dynamics and also exert a strong influence on human use of these marginal environments. While awareness of the need for science and management of these landscapes and ecosystems is rising, many challenges have to be addressed if we are to ensure their 'wise' or 'sustainable' use.

This presentation identifies some of the key global challenges facing wetlands in drylands. Challenges can be broadly grouped as:

1) Scientific (e.g. a lack of comprehensive inventory, the limited role of geomorphology in research and application, underappreciation of the distinctiveness of wetlands in drylands, critical data gaps including a paucity of late Quaternary chronologies, limited understanding of the role of wetlands in drylands in long-term carbon sequestration);
2) Environmental (e.g. vulnerability of some wetlands in drylands to regional and global climate changes, land use changes and population growth);
3) Sociopolitical (e.g. a possible lack of parity with better-publicised humid-region wetlands work, limited prioritisation of the various ecosystem services provided by wetlands in drylands);
4) Institutional (e.g. a lack of critical mass of researchers, barriers to inter- and trans-disciplinary working).

While some gains in addressing such challenges can be found (e.g. South Africa's 'Working for Wetlands' Programme), further successes are necessary if we are to provide the critical scientific underpinning, management expertise, and political and public goodwill necessary to support the 'wise' or 'sustainable' use of wetlands in drylands. The presentation will end by highlighting how the Wetlands in Drylands Research Network has been contributing to this collective endeavour since its inception in late 2014, and by asking how this meeting can make additional contributions.

Spatiotemporal surface water dynamics at subcontinental scale in a major dryland region

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Surface water is a critical resource in semi-arid areas. In Australia, competing water demands, combined with changes in climate and the way we use our land as well as multi-year droughts, such as the Millennium Drought that ended in 2010, have led to water shortages, particularly in the Murray-Darling Basin (MDB). The MDB is a large (>1 million km^2), semi-arid basin that experiences extreme hydroclimatic variability and competing water demands, of high economic importance given that it accounts for 40 % of Australia's gross value in agricultural production. In this keynote, I will present: 1) the development of a statistically validated surface water and flooding extent dynamics data product (SWD) based on three decades (1986-2011) of seasonally continuous Landsat TM and ETM+ archives and generic random forest-based models; 2) patterns in surface water extent dynamics, and 3) the quantification of key hydro-climatic drivers of surface water extent dynamics.

Investigating (non)equilibrium changes in avulsive channels in floodplain wetlands

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Floodplain wetlands are large and complex fluvial systems with networks of alluvial channels that are affected by human activities and natural processes. Avulsion, the rapid abandonment of a river channel in favour of new one, is one of the most important processes linked to sedimentation and erosion in floodplain wetlands. Avulsion can cause rearrangement of the alluvial channel network, disconnection of parts of the floodplain, and/or abandonment of parts of the wetlands. The Macquarie Marshes are one of the largest freshwater wetland systems in the Murray-Darling Basin, and channels in the Marshes are prone to erosion, sedimentation and avulsion. Channel changes can affect wetland ecology by providing the biophysical template for aquatic and terrestrial habitats, driving wetland succession and renewal, and draining wetlands in some cases. Some sites are also at risk of rapid change due to channel modifications and flow redistribution associated with engineering intervention works. Understanding the balance (or imbalance) between erosion, sedimentation, channel change and flooding is critically important for wetland management.

This study seeks to investigate drivers of channel dynamics in the Macquarie Marshes. Using cross-section data extracted from a high resolution LIDAR DEM, alluvial channels were classified into two groups: 1. primary channels (width >1 m and depth >50 cm), and 2. secondary channels (width <1 m and depth <50 cm. Bifurcation points were mapped along the primary channels and cross-sections from upstream and downstream of each bifurcation point were assessed for width, depth and area to measure changes in channel capacity. We then calculated the difference between channel width, depth and area for each primary channel and its secondary branches downstream. Our analysis in the southern Macquarie Marshes shows that of 107 bifurcation points on primary channels, 76 %

resulted in an increase of total channel capacity (where the combined capacity of bifurcate channels exceeds the capacity of the primary channel upstream of the bifurcation), 5 % led to a decline in total channel capacity, and 19 % had a combination of increase and/or decreases in total channel width, depth and area. Channels with increasing or maintained capacity can generally be considered to be in dynamic equilibrium in terms of their hydrology and sediment transport efficiency. In places, however, where channel capacity declines or where channels terminate on the floodplain, this is a clear indication of non-equilibrium conditions related to declining hydrological conditions and sediment transport efficiency. Channel metrics will be assessed at bifurcation points on secondary channels in the future and further work will determine the nature of downstream channel change and hydrological declines that drive channel breakdown in these floodplain wetlands.

Keynote Speakers and Session Chairs

Dr Peter Berney

Peter currently works with the NSW National Parks and Wildlife Service in the Northern Inland Branch. This branch contains a number of significant wetland systems including the Gwydir Wetlands, Macquarie Marshes and the Narran Lakes system. While working with NPWS he has undertaken various roles including Regional Ecologist for the Northern Plains Region and more recently Team Leader Fire in the newly formed Northern Inland Branch. Peter's academic background includes a Master's in Natural Resource Management and a PhD in wetland plant ecology. In his PhD Peter studied the interaction between inundation patterns and grazing in plant communities in the Gwydir Wetlands.

Dr Samantha Capon

Samantha Capon is a vegetation ecologist concerned primarily with the ecology and management of riverine and wetland landscapes, especially in drylands and increasingly in human-dominated agricultural and urban regions. Her work aims to inform decision-making regarding water and land management to protect and restore these ecosystems and the range of values they support. She also has strong interests in climate change adaptation and previously coordinated the National Adaptation Research Network for Water Resources and Freshwater Biodiversity, as well as leading the recent revision of the National Adaptation Research Plan for Freshwater Biodiversity. Samantha is currently a Senior Lecturer and Research Fellow with the Australian Rivers Institute and Griffith School of Environment and leads several large, national research projects in addition to teaching plant diversity and community ecology and conservation and supervising a range of student projects. She also has a keen interest in environmental ethics and the philosophy of ecological science, particularly with regards to their role in addressing current global challenges.

Mr Phil Duncan

Phil Duncan is from Moree New South Wales and is a member of the Gomeroi Nation and is an elected leader of the Gomeroi Nation Native Title Claimant Group: his homelands are Moree and Terry Hie Hie. Phil's "Dreaming" is "Boobera Lagoon" and "Songline" is "Garriya". Phil has over 39 years of experience working with Aboriginal people and Government to improve the lives of Aboriginal people through recognition of our rich cultural history, the return of our lands, the improvement of our living conditions and education of our next generation both through his employment and volunteer community work. Phil provides high level policy and strategic advice to key Indigenous Representative Organisations, State and Federal Government Agencies as well as key external stakeholder groups. The strategic advice regards issues of culture and heritage significance, community engagement in on-ground projects, the design, delivery and implementation of programs in partnership with Government, regarding the range of issues required to be addressed, particularly in the area of natural resource management, native fish and water rights.

Dr Emilie Ens

Emilie is a cross-cultural ecologist who has worked with Aboriginal ranger groups and communities in Arnhem Land and northern NSW over the last 9 years to develop cross-cultural approaches to managing and monitoring Country. She works with Elders and young people on a range of projects including: protecting culturally significant wetlands from feral ungulates; monitoring freshwater wetland cultural values and environmental change; and cross-cultural biodiversity surveys. From 2013-2016 she was an ARC DECRA Research Fellow working on cross-cultural wetland protection and monitoring tools in Arnhem Land. She was integral in establishing the Indigenous Ecology group of the Ecological Society of Australia, the Indigenous Biocultural Knowledge (IBK) Working Group of Australia's Terrestrial Ecology Research Network (TERN) and is a member of the IUCN Commission on Ecosystem Management Ecosystems and Invasive Species Thematic Group and Australian Ecosystem Science Council's "Inspiring a Generation" Working Group. In 2014 the IBK Working Group won the Banksia Award for Leadership in Indigenous Sustainability and in 2016 the Ngukurr Wi Stadi Bla Kantri (Study the Country) Research Group she co-leads in SE Arnhem Land was a finalist in the Eureka Prize for Innovation in Citizen Science. Since 2013 she has also been lecturing in Environmental Management at Macquarie University.

Professor Max Finlayson

Prof. Max Finlayson is an internationally renowned wetland ecologist with extensive experience internationally in water pollution, mining and agricultural impacts, invasive species, climate change, and human well-being and wetlands. He has participated in global assessments such as those conducted by the Intergovernmental Panel for Climate Change, the Millennium Ecosystem Assessment, and the Global Environment Outlook 4 and 5 (UNEP). Since the early 1990s he has been a technical adviser to the Ramsar Convention on Wetlands and has written extensively on wetland ecology and management. He has also been actively involved in environmental NGOs and from 2002-07 was President of the governing council of global NGO Wetlands International.

Prof. Finlayson has worked extensively on the inventory, assessment and monitoring of wetlands, in particular in wet tropical, wet-dry tropical and sub-tropical climatic regimes covering pollution, invasive species and climate change. His current research interests/projects include the following:
- Interactions between human well-being and wetland health in the face of anthropogenic change, including global change and the onset of the Anthropocenic era;
- Vulnerability and adaptation of wetlands/rivers to climate change, including changing values and trade-offs between uses and users, considering uncertainty and complexity;
- Integration of ecologic, economic and social requirements and trade-offs between users of wetlands with an emphasis on developing policy guidance and institutional changes;
- Environment and agriculture interactions and policy responses/outcomes, and collaboration between stakeholders and policy-makers;
- Wetland restoration and construction, including the use of artificial wetlands for waste water treatment and the generation of multiple values;
- Landscape change involving wetlands/rivers and land use (agriculture and mining) and implications

for wetland ecosystem services and benefits for local people.

He holds the following associated positions:
- Scientific Expert on the Scientific and Technical Review Panel, Ramsar Convention on Wetlands, Triennium 2016-2018;
- Ramsar Chair for the Wise use of Wetlands, UNESCO-IHE, Delft, The Netherlands (2014-18);
- Visiting Professor, Institute for Wetland Research, China Academy of Forestry, Beijing, China;
- Editor-in-Chief, Marine and Freshwater Research, CSIRO Publishing;

Prof. Finlayson has contributed to over 200 journal articles, reports, guidelines, proceedings and book chapters on wetland ecology and management. He has contributed to the development of concepts and methods for wetland inventory, assessment and monitoring, and undertaken many site-based assessments in many countries.

Ms Danielle Flakelar

Danielle Carney-Flakelar is a Ngiyampaa Wayilwan/Wakka Wakka woman who was raised in her father's family country in Western NSW. Her Wayilwan family and ancestors have lived along the floodplain areas of the Bogan, Macquarie and Castlereagh Rivers including the Macquarie Marshes for thousands of years. Danielle has been a keen representative of the Wayilwan community on the Macquarie/Cudgegong Environment Flows Reference Group (aka Environmental Water Advisory Committee) since 2007. In this role, Danielle has provided advice on the use of environmental water allocation to ensure consideration is given to build and maintain a resilient Natural and Cultural ecosystem. She has challenged the committee to consider utilising e-water for connectivity of waterways throughout the floodplain to enable fish passage and to enhance and sustain native aquatic and terrestrial plants and animals. Danielle's interest in the protection and management of country has led to her completing a graduate diploma in Natural and Cultural Resource Management. Since 2009 she has worked for NSW National Parks and Wildlife Service to provide advice and support Aboriginal Heritage protection and Joint Management on national park estate.

Associate Professor Kirstie Fryirs

Kirstie Fryirs is an Associate Professor in the Department of Environmental Sciences at Macquarie University. Her research focuses on fluvial geomorphology, in particular river evolution, sediment budgets and landscape (dis)connectivity, and human disturbance to rivers. She has also developed frameworks for assessing the physical condition and recovery potential of river systems. She is co-developer of the River Styles Framework and professional training courses. Her research also focuses on how geomorphology provides a physical template for ecosystem function and how science can be better used in environmental management, working closely with a range of government and industry stakeholders. More recently she has led a large research program investigating the geomorphology, hydrology, biology and carbon dynamics of upland wetlands (peat swamps) in Eastern Australia. She has co-written and/or edited three books titled "Geomorphology and River Management" (Blackwell, 2005), "River Futures" (Island Press, 2008) and "Geomorphic Analysis of River Systems" (Wiley, 2013).

Ms Patricia Gadd

Patricia Gadd has a Bachelor of Applied Science (Chemistry) from UTS and has worked at the Australian Nuclear Science and Technology Organisation (ANSTO) in various roles for the last 20 years. She currently operates the ITRAX Core Scanner in the Isotope Tracing in Natural Systems Platform. She has extensive experience in analytical chemistry in the areas of X-ray Fluorescence Spectroscopy (XRF), Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), radiochemistry for Polonium-210 analysis, and Delayed Neutron Activation Analysis (NAA).

Dr Phumelele Gama

Dr Phumelele Gama is a Senior Lecturer in the Department of Botany at the Nelson Mandela University, South Africa. His main research focus over the past 20 years has included microalgal dynamics in temporarily open/closed estuaries and shallow aquatic ecosystems. Presently his research interests have led him to investigate aquatic vegetation and microalgal ecophysiological responses in temporary wetlands, particularly in semi-arid regions of South Africa. He is also conducting experimental research into how algal communities will shift in conjunction with increases in temperatures and nutrient inputs under different climate change scenarios and affect water quality. Dr Gama has supervised a number of postgraduate students and is currently supervising two Honours and three Masters students.

Professor Peter Gell

Peter Gell is a Professorial Research Fellow at Federation University, Australia. His research interests are in the paleolimnology of century-scale sediment records that provide natural baselines for understanding the impact of people and climate change on wetlands. He is a member of the PAGES Scientific Steering Committee and was leader of the PAGES Limpacs working group. He now leads the PAGES Aquatic Transitions working group that synthesizes the timing and nature of human impacts on aquatic systems worldwide.

Dr Michael Grenfell

Michael Grenfell is a Senior Lecturer in Environmental and Water Science in the Department of Earth Science, University of the Western Cape, South Africa. His research focuses on rivers and wetlands in warm semi-arid, sub-tropical and tropical environments. He combines a variety of approaches to study the hydrogeomorphic dynamics of these important systems, including:

- Spatial analysis and modelling using GIS and remotely-sensed data;
- Field and laboratory analyses of morphology, sedimentology, and sedimentary processes;
- Statistical and physics-based modelling of hydrodynamic and

morphodynamic processes.

At present, Michael is leading the fluvial geomorphology component of a large multi-disciplinary project on the environmental water requirements of non-perennial rivers. This work aims to apply physics-based morphodynamic modelling to isolate the hydrogeomorphic conditions necessary to sustain fluvial process-form linkages, and thus the physical habitat template, of non-perennial rivers with highly variable flow-sediment feeds.

Mr Tim Hosking

Tim Hosking is a Senior Wetlands and Rivers Conservation Officer with the NSW Office of Environment and Heritage. A large part of that role is to manage environmental water in the Macquarie catchment in central NSW, with the aim of sustaining the Ramsar-listed Macquarie Marshes and the Macquarie River system. This includes working with the community-government collaborative decision-making committee, assisting complimentary actions, water planning, supporting and partaking in research and monitoring, and communicating - telling the story of the system and the ongoing efforts to maintain it. His academic background is in environmental engineering, natural resources management and planning.

Professor Lesley Hughes

Distinguished Professor Lesley Hughes is an ecologist in the Department of Biological Sciences at Macquarie University and an expert on the impacts of climate change on species and ecosystems. She is the co-convenor of the Terrestrial Biodiversity Adaptation Research Network, Chair of the Tasmanian Climate Action Council and a member of Climate Scientists Australia and the Wentworth Group of Concerned Scientists. Professor Hughes is a Councillor of the recently formed Climate Council, and member of the former federal Climate Commission (Feb 2010-2013). Professor Hughes was also a member of the Expert Advisory Group on Climate Change and Biodiversity for the Australian Greenhouse Office and the Department of Climate Change, and a lead author for the UN's IPCC Fourth and Fifth Assessment Reports. Her research has been published extensively in peer-reviewed journals.

Dr Marc Humphries

Marc is an environmental geochemist who has a particular interest in the geochemistry and geomorphological evolution of wetlands, lakes and estuaries. He has focused much of his research on understanding processes of chemical cycling, nutrient accumulation, and sedimentation in freshwater lakes and wetlands. More recently, Marc has developed an interest in using sedimentary deposits to investigate sea level fluctuations and environmental variability associated with global climate change. He is also interested in the application of stable and radioactive isotopes in understanding aspects of hydrology and sedimentology.

Professor Emeritus Terence McCarthy

Terence McCarthy is Professor Emeritus in the School of Geosciences at the University of the Witwatersrand, South Africa. He has wide-ranging interests spanning the fields of economic geology, environmental geology, geomorphology and geochemistry and has made important research contributions in igneous petrology, the origin and evolution of the Witwatersrand Basin, problems arising from acid mine drainage, and the functioning of the Okavango Delta ecosystem and other southern African wetlands. He is author or co-author of four books and has published over 180 peer-reviewed articles in scientific journals. He is the winner of the Jubilee and Draper Medals of the Geological Society of South Africa and is a Fellow of the Geological Society of South Africa and of the Royal Society of South Africa.

Dr Emily O'Gorman

Emily O'Gorman is an environmental historian with interdisciplinary research interests within the environmental humanities. Her research examines how people live in and understand their environments, with a focus on rivers, wetlands, and climate. Currently a Senior Lecturer at Macquarie University, Australia, she holds a PhD in History from ANU and undertook a postdoctoral candidacy at the Australian Centre for Cultural Environmental Research at the University of Wollongong.

Dr Tim Ralph

Tim Ralph is a geomorphologist with a passion for rivers and wetlands, particularly those in the dry landscapes of Australia and Africa. His research seeks to understand the links between fluvial processes, landform dynamics, soil and water quality, and aquatic ecosystem function within the context of longer-term landscape evolution and environmental change. Tim is currently a Senior Lecturer in the Department of Environmental Sciences, Macquarie University, Australia. Tim was previously a Senior Environmental Scientist at the NSW Office of Environment and Heritage where he helped to integrate river and wetland science with management, working closely with stakeholders.

Dr Denise Schael

Dr Denise Schael is a Research Associate in the Department of Botany at Nelson Mandela University, South Africa. She has over 20 years' experience in aquatic ecology. Her research interests have varied over the years including work on lakes and rivers, but her current research focus centres on using fundamental ecological and landscape processes to inform help management and conservation decisions. Her present research involves investigating the ecological dynamics of different hydrogeomorphic wetland types within semiarid and arid regions of South Africa. This encompasses field work as well as laboratory experiments and modelling. In order to adequately predict changes and ecological shifts with climate change, a basic understanding of how ecosystems currently function is paramount. Empirical experimental evidence of how changing temperatures, inundation periodicities and increased anthropogenic influences affect different trophic levels within the wetland ecosystem is important. Denise supervises Honours, Master's and Doctoral students.

Professor Stephen Tooth

Stephen Tooth is based in the Department of Geography and Earth Sciences at Aberystwyth University, Wales, U.K. His main research interests focus on geomorphology and sedimentology, especially in the drylands of Australia and southern Africa. Particular research themes include: anabranching rivers; floodplains and floodouts; wetlands in drylands; channel-vegetation interactions; bedrock-influenced rivers; controls on gully erosion; long-term fluvial landscape development; palaeoenvironmental change; and the use of drylands on Earth as analogues for Martian surface environments. He is also interested in environmental issues more generally, including current debates about global climate change and the Anthropocene, and in science education.

Dr Mirela Tulbure

Mirela Tulbure is an environmental remote sensing scientist, working at the complex interface of geospatial science, landscape ecology and water dynamics. She has initiated and now leads a number of competitive research projects in applied ecological remote sensing funded by the Australian Research Council (ARC). In addition to receiving an ARC DECRA fellowship in 2014, Mirela is the lead CI on an ARC Linkage in partnership with the Murray-Darling Basin Authority. As a result of this work, she and her team have quantified the high spatio-temporal variability in surface water dynamics in the Murray-Darling Basin and its decline during the Millennium Drought. This work was featured by NASA, became NASA's image of the day (July 2016) and Mirela was awarded a NSW Tall Poppy Award (2015) for this work. Mirela is currently a Senior Lecturer with the University of New South Wales (Sydney), where in 2012 she built the Geospatial Analysis for Environmental Change Lab with funding from the ARC. You can find her online at www.mirela-tulbure.com and follow her on twitter (@MirelaGTulbure).

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3	Exploring capabilities of network flow programming for development of environmental flow management strategies. *Rebecca Carlier*
4	Semi-automated delineation of reticulate channel networks in low-gradient floodplain wetlands using LiDAR-derived DEMs. *William Farebrother*
5	Rapid analysis of soil carbon in wetlands, using Laser Induced Breakdown Spectroscopy (LIBS). *Damian Gore*
6	Contemporary fluvial charcoal supply to floodplain wetlands of the Macquarie Marshes, NSW, Australia. *Bradley Graves*
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