AUTHOR LISTING

ABSTRACTS

ORAL PRESENTATIONS

1

Seeing green: a perspective on the ecology and management. Understanding freshwater connection and disconnection in the genomic age

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The ecological, evolutionary and genetic attributes of species develop within the environmental contexts in which they evolve, and are geared to them. Understanding how species occupy and move around their habitats in space and time is of fundamental interest in ecology. It is also a key platform by which to understand how the projected population persistence of species might change under human impacts, which typically alter population connectivity. In the context of freshwater systems, hydrological connectivity in space and time is a key driver of species ecology and evolution. Human impacts tend to change – increase, decrease and alter the patterns of – hydrological connectivity, as well as the nature and extent of freshwater habitat. Estimating dispersal of organisms can be extremely challenging; genetic techniques, and recently genomic ones, can offer very substantial assistance here. Furthermore, these approaches are the *only* way to understand to what extent evolutionary connectivity (gene flow) accrues from dispersal. Simultaneously, genomic approaches allow us for the first time to make comprehensive assessment of evolutionary history, future evolutionary potential, and to understand the distributions of ecologically important genetic variation that impact population fitness and persistence. In this presentation, I outline some of the key aspects of ecology and evolution that are readily assessed by genomic approaches, with examples taken from current research programs on invertebrate and fish species in the paradoxical, beautiful but threatened Australian arid zone freshwaters, and endangered iconic freshwater fish in eastern Australia.

2

Seeing green: a perspective on the ecology and management of riparian and wetland vegetation in Australia's drylands

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Vegetation in riparian and wetland habitats is widely recognised as a critical component of our riverine landscapes, especially in drylands, supporting diverse biodiversity and a wide range of essential ecosystem functions and services of disproportionately high value relative to the area it occupies. Driven predominantly by hydrology, riparian and wetland vegetation exhibits a great degree of resilience and adaptive capacity to changing environmental conditions. Nevertheless, human pressures from both terrestrial and aquatic realms have resulted in significant effects in these ecosystems, in Australia and globally, including habitat and biodiversity loss, dramatic shifts in vegetation composition and structure and altered ecosystem functions. Consequently, riparian and wetland vegetation has become a major focus for much recent environmental policy and many management interventions, including environmental flow delivery and revegetation initiatives. Decision-making regarding such interventions, however, involves many challenges ranging from the development of ecological objectives and targets through to the implementation of actions as well as their monitoring and evaluation. Here, I will consider our current understanding of the ecology of riparian and wetland vegetation with an emphasis on that in Australia's drylands, drawing on my own research in the Lake Eyre and Murray-Darling Basins over the past twenty years. In particular, I will explore the current paradigm underpinning our perspective of riparian and wetland vegetation especially in relation to present management strategies and discuss the role of ecological science in decision-making.

3

Quantifying the effects of altered hydrology and food-web structure on ecosystem carrying capacity in a floodplain river

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There is widespread evidence for a reduction in biomass of tertiary consumers such as large predatory fish in lowland rivers. These declines are caused by a myriad of factors such as overfishing, habitat loss and fragmentation, declining water quality and alterations to spawning cues. Recently research has also emphasized the role of altered food-webs and changes in energy production as factors that may limit the current carrying capacity of higher consumers in these systems. Here we present a novel ecosystem approach to quantifying the effects of altered hydrology and altered food-web structure on the carrying capacity of large-bodied native fish in the Murray River, southeastern Australia. We combine estimates of current and historical primary production with current and historic food-webs to estimate energy available to support native fish species such as Murray cod and golden perch. Our results suggest firstly that river regulation and food-web changes have reduced energy fluxes to these native tertiary consumers by roughly 70% relative to historic levels, due to reduced production and the presence of trophic dead ends (notably carp). Secondly, both limitations will need to be addressed contemporaneously if carrying capacity of native fish is to be effectively increased.

4

Demonstrating hydro-ecological responses to the return of low-flows in intermittent streams

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The hydro-ecological impacts of reducing the low-flow components of riverine flow regimes have been demonstrated worldwide. While long-term monitoring programs have the ability to assess trend or change in condition, they are insufficient to determine the effects of intervention activities such as the introduction

of low-flow restoration measures. Despite modelled evidence that the restoration of low flows will have a positive effect on the receiving environment, there have been few, if any, opportunities to empirically test these responses. Responses to restoration of low-flows are likely to manifest at multiple spatial and temporal scales, which are important to different stakeholders. Short term, local scale responses are of particular interest to individual landowners while broader-scale responses are the target of restoration programs. The design of a monitoring program must therefore include a suite of indicators capable of detecting short to long-term, fine to broad scales of response. The current monitoring and research program has been developed to assess the hydro-ecological response to the return of low flow through across multiple catchments using a Multiple Before-After Control-Impact design (MBACI). Short term indicators, such as wetted area, water quality and macroinvertebrates, have been selected to attempt to characterise the short-term response, while longer term indicators, such as fish and vegetation, will utilise existing condition monitoring programs, to monitor the effects in the longer term. The use of a MBACI design will provide a means to detect responses irrespective of natural variation and provide robust and defensible answers to inform the ongoing restoration of low-flows both in South Australia and worldwide.

5

Establishing the environmental water requirements for the Daly River, Northern Territory.

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4. NT Fisheries, Department of Primary Industries and Resources, Darwin, NT, Australia

The Daly River is a perennial river system in northern Australia that supports a highly diverse aquatic fauna and important recreational and commercial fisheries. The river, and its biota, also has significant cultural value to its Indigenous people. Agricultural development in the Daly Basin has been increasing over recent years, with concomitant increases in demand for its water resources. The NT Water Allocation Planning Framework (WAPF) currently allocates at least 80% of river flow or aquifer at any time, as environmental water (in the absence of science, or an agreed alternative under a Water Allocation Plan). This currently provides a high level of protection for environmental values and security for water licence holders. Previous studies have provided some knowledge of environmental water requirements in the river. However, more detailed evidence-based risk assessments on a range of ecological assets are needed to explore potential future water management scenarios. A current priority is the risk of reduced dry season flows to the river's ecology. This project aims to use a combination of existing knowledge and new targeted research activities to produce quantitative models that explore the relationships between flow and key environmental assets of the Daly River system. New research includes: studies on the movement and habitat use of sooty grunter and pig-nosed turtles; broad-scale modelling of fish habitat use; in-channel habitat mapping linked to hydrodynamic models; remote sensing of floodplain habitats; determination of dry season food webs, and; determination of hydrological spawning cues of fishes. This project is a collaboration between Charles Darwin University, NT Government and Griffith University; and, importantly, is a partnership between researchers, policy officers, managers and the Traditional Owners of the region.

6

Environmental flows and ecological response: it's not just the size of the allocation, it's how you use it.

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The Murray-Darling is one of the most regulated river systems in the world. In the lower River Murray, downstream of the Darling River junction, flow and connectivity are impacted by upstream dams, 10 sequential weirs and over 7 km of tidal barrages, profoundly impacting the ecological integrity of riverine and estuarine ecosystems. The Basin plan aims to rehabilitate aquatic ecosystems in the Murray-Darling Basin (MDB), primarily through the reallocation of water to the environment. To achieve this, substantial volumes of environmental water (1000s GL) are now available to augment flow in the Basin's rivers. Measuring ecological response to the allocation of environmental water is essential to inform future management and to justify water use to a multitude of stakeholders. Fish are an integral and charismatic component of aquatic ecosystems and form a major objective of environmental flow allocations throughout the MDB. In this paper, we use two case studies to review fish responses to environmental water delivered to the lower River Murray. Over a four-year period (2013–2016), 500–1000 GL/annum of environmental water was used to supplement the regulated flow regime of the lower River Murray. Over this period, fish assemblages in the main channel of the lower River Murray trended to those characteristic of drought conditions, being dominated by generalist species and with an absence of recruitment of flow-cued spawning species (e.g. golden perch). In contrast, abundances of diadromous fishes at the Murray barrages (the freshwater–saltwater interface) increased as environmental water was used to promote connectivity through the Barrages to facilitate key life history processes. We explore the mechanisms behind these responses, and relationships with flow volume and timing. This knowledge will inform future flow management to achieve ecological outcomes in the MDB.

7

Allochthonous carbon influx in riverine food webs; a role for environmental flows

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Flood events can play a critical role in mobilising nutrients and allochthonous energy for riverine food webs. This influx of allochthonous carbon and nutrients may have significant effects on the aquatic food web by influencing the microbial loop and metazoan communities. In highly regulated rivers where these natural flood events are greatly reduced, environmental flows may be used in an attempt to increase floodplain inundation and allochthonous input. This study focuses on the highly regulated Namoi River in central eastern Australia to understand how bacteria, phytoplankton and zooplankton respond to high flow events that cause floodplain inundation and how this may be affecting native fish communities. After a large flood event which inundated surrounding floodplains zooplankton communities shifted with rotifer communities changing and abundance decreasing while copepod and cladoceran abundance increased. Increases in DOC concentrations and turbidity were observed as well as a general decrease in phytoplankton concentrations. This suggests maintaining connectivity to the floodplain is important for metazoan production and allochthonous input can subsidise food webs in times of low primary production.

8

Stream nitrate uptake dynamics in a nitrogen-limited region

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Long-term trends in the Swedish boreal region show declines in total riverine nitrogen (N) export, likely due to the large-scale tightening of the N cycle caused by boreal forest management and climate change in an already N-limited environment. We used coupled measurements of whole stream metabolism and nitrate uptake in 8 boreal forest streams during summer (growing season) and autumn (during leaf abscission) to investigate the seasonal biological controls over in-stream N processing. Streams ranged in sub-catchment size, from 12 to 6790 ha. Nitrate uptake was measured using the Tracer Additions for Spiraling Curve Characterisation (TASCC) in order to quantify the influence of nitrate concentration on its biological uptake. Nitrate removal was observed at nearly all sites and appeared to be greater during the autumn than summer. This seasonal shift suggests that inputs of labile organic matter may play an important role in regulating nutrient use in these streams. Ongoing work is relating estimates of whole stream metabolism to rates of nitrate uptake. Overall, biological processes in streams draining forested boreal catchments appear to be N-limited during summer and autumn. Implications for boreal forest management and climate change are highlighted.

9

Stream Metabolism in turbid river systems in the northern Murray Darling Basin

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Stream metabolism is a fundamental ecosystem process that links organisms to their environment through the transformation of organic matter. This process focuses on the production and consumption of carbon in an ecosystem, sustaining both the food and energy resources of most aquatic food webs. Measurements of stream metabolism are increasingly used to assess aquatic ecosystem health and detect responses to human disturbance. Rivers in the northern Murray Darling Basin can have exceptionally high turbidity and nutrient concentrations, even when compared to other rivers in the Basin. This study aims to explore the key drivers of stream metabolism in response to flow in the northern Murray Darling Basin. Water quality, water column nutrients and stream metabolism indicators were measured in ten sampling sites in the Warrego and Darling Rivers in 2015-17 and linked to flow data. The higher flow and hydrological connectivity in the Warrego and Darling Rivers increased phosphorus loadings across the systems and boosted algal productivity, resulting in higher dissolved oxygen concentrations in 2015-16. The increase in rates of gross primary production and ecosystem respiration corresponding to the higher phosphorus availability revealed that phosphorus availability was a limiting factor controlling metabolism rates. However, despite high nutrient concentrations driving gross primary production, all sites were net heterotrophic and therefore a carbon sink, recording rates up to 7.23 mg/ O_2/ L/ day net oxygen consumption. We propose that the lower rates of gross primary production are driven by turbidity, regardless of high nutrient loading, suggesting light and not nutrients are regulating rates of production in turbid rivers of the northern Murray Darling Basin.

10

Pharmaceutical impacts on biogeochemical processes in artificial streams

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Pharmaceuticals and personal care products (PPCPs) are contaminants of concern in aquatic ecosystems and are now detected in surface waters receiving wastewater. PPCPs pose a considerable risk to aquatic biota as they are biologically active by design, and have largely unknown effects on non-target organisms including aquatic microbes. Research indicates that select pharmaceuticals can inhibit functioning of aquatic organisms at low, environmentally relevant concentrations. However, the effects of PPCPs on whole-ecosystem structure and function are only now being investigated. We conducted a 21d artificial stream experiment to examine the effects of 3 commonly detected PPCPs (fluoxetine, diphenhydramine and ciprofloxacin) on stream ecosystem function. We examine effects on biogeochemical processes, including denitrification, primary production and respiration. We also explore how PPCPs alter the relationship between community composition and algal exudate quality of biofilms and the structure and function of denitrifying bacteria. Our results suggest that although subtle, PPCPs are capable of altering ecosystem processes and we highlight important risks of PPCPs posed to freshwater systems and aquatic biota.

11

The killing of photosynthesis at environmentally relevant pharmaceutical concentrations - an inquest!

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This talk will examine the effects of two commonly found pharmaceuticals in waterways - the antidepressant fluoxetine (Prozac®) and the antihistame diphenhydramine - on the growth and photosynthesis of the common green alga, *Scenedesmus*. At environmentally relevant concentrations i.e. commonly found worldwide in urban streams, these drugs can have major effects on phytoplankton (and biofilms). In laboratory growth experiments, the effects of one drug in particular are quite startling. The mechanism for this will be discussed along with implications for food webs and future research in this nascent field.

12

Investigation of unexplained toxicity in cyanobacterial extracts

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Cyanobacteria produce a range of toxins with different modes of action including liver toxins (e.g., microcystins), neurotoxins (e.g. saxitoxins and anatoxins), and cytotoxins (e.g. cylindrospermopsin). Some of these toxins have been well characterised, particularly with regard to their effects on vertebrates, although much less is known about the effects of cyanotoxins on plants. However, comparisons of the effects of pure toxins with crude extracts, and investigations of unusual patterns of toxicity, have suggested the presence of other unidentified toxins in cyanobacteria. Toxic effects on plants may have implications for food crops irrigated with cyanobacteria-contaminated water, and if toxins are taken up into plant tissues there is potential for them to enter the food chain. In this study we have found evidence of toxicity to *Medicago sativa* (alfalfa) seedlings from extracts of a strain of *Anabaena circinalis* (now *Dolichospermum circinale*) containing no detectable saxitoxins, and of *Microcystis aeruginosa* with no detectable microcystins. Further studies are under way to investigate these effects on alfalfa and other species, and if possible identify the compounds responsible. This information will aid in setting water quality guidelines for cyanobacteria-contaminated waters, and also provide evidence about the risks of contaminated waters to agriculture and food supplies.

13

Cyanobacterial assemblages following flooding in the Fitzroy River system, Central Queeensland, Australia.

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Historically cyanobacterial populations in the Fitzroy River system, Central Queensland, Australia have been dominated by *Dolichospermum circinale, Sphaerospermopsis* spp. and *Cylindrospermopsis raciborskii*. However, the latter species has been more prevalent in years without major flooding (and higher water temperatures) whereas *D. circinale*, *Sphaerospermopsis, Chrysosporum ovalisporum*, and *Limnothrix redekei* have been more common in years with major flooding (lower water temperatures and higher conductivity). Following flooding in 2013, cyanobacterial populations were studied in the Isaac River, a northern, inland tributary of the Fitzroy River. The Isaac begins in Lake Elphinstone, a natural lake inland from the city of Mackay. Conditions in the river are extreme in terms of both flow and temperature. Floods can be followed by water depths of less than 30 cm approximately two weeks later. This river flows through the middle of the Bowen Basin and extensive grazing land. Cyanobacterial populations in Lake Elphinstone have historically been dominated by *C. ovalisporum*, *C. raciborskii* and *Microcystis panniformis*. Blooms of *C. raciborskii* were once common in deeper sections of the river and man-made impoundments downstream. In contrast, the water column following flooding in 2013 was dominated by *Sphaerospermopsis* spp., *C. ovalisporum*, *L. redekei* and also *Dolichospermum smithii* in deeper pools with larger nutrient inputs from cattle and wild pigs. Such assemblages represent a change from the *Cylindrospermopsis* of drier years. Late wet season samples were dominated by eukaryotic algae with only a trace of *Limnothrix* present. The assemblages found in Central Queensland are also common throughout eastern Australia. However, unlike the blooms of *C. ovalisporum* in the Murray system, the Central Queensland strains are toxigenic and produce cylindrospermopsin.

14

An algal bloom early warning system for NSW using satellite and near-surface observations

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6. Office of Water, NSW Department of Primary Industries, Sydney, NSW, Australia

Toxic cyanobacterial blooms are an increasing international concern, but traditional field monitoring for detection involving identification and cell counting imparts a lag time and can be limited in spatial extent. Overcoming the vast geographic distances needing sampling is a particular challenge; Recently launched satellite sensors offer the potential of high resolution, wide scale and frequent monitoring of water quality in inland water bodies of a range of sizes in support of the development of early bloom alerts for water managers; and provide an appealing complement to water managers for bloom monitoring. We report on continued Australian strategic investment in inland water quality remote sensing to develop tools to assess and visualise algal blooms across larger spatial scales to support cyanobacterial monitoring. The tool is built upon the Australian Geoscience Data Cube (AGDC) for NSW DPI Water, a 19 year time series of consistently pre-processed Landsat data for the Australian continent. New image acquisitions can be processed in near real time to provide a rapid state-wide overview of overall algal alert status, or finer scale bloom dynamics in individual water bodies. Current data can be displayed with historical data to allow the up to date situation to be put into a longer term context. To overcome spatial resolution limitations and to assist in satellite validation we have also developed a low cost, low maintenance optical sensor operating on similar principles for remote deployment in sensor networks. The presentation will outline the AGDC, processing and visualisation systems that have been produced, as well as introduce the near surface sensor. Their power in helping management decision making on algal bloom risk across wider spatial areas will be outlined.

15

Evolution of pollution tolerance in Australian *Cricotopus* midges (Diptera: Chironomidae)

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2. University of Queensland, Brisbane, Queensland, Australia

3. The Australian National University, Canberra, Australian Capital Territory, Australia

Freshwater ecosystem monitoring, critical for long-term management of impacted areas, relies upon accurate taxonomy, sufficient taxonomic resolution and can benefit from forewarning of sublethal impacts on populations. Within the Chironomidae (Diptera), the global genus *Cricotopus* Wulp has long been taxonomically confusing. The poorly known Australian fauna occupies a wide range of lotic freshwater ecosystems with marked variation among species, especially in their pollution tolerance. Although immature stages are collected routinely in surveys, tolerance is generalised at the genus level.This presentation summarizes research that explored: a) the systematics of the genus; b) the phylogenetic pattern of pollution tolerance; c) comparative larval transcriptomics between three sympatric species; and, d) differential gene expression among populations of a single species from habitats that differ in ecosystem health. For a) and b), we used a multilocus molecular phylogenetic approach and sampled all but one Australian species. *Cricotopus* was paraphyletic through inclusion of monophyletic *Paratrichocladius*, which we collapse as a subgenus of *Cricotopus*. However, morphological species concepts were largely corroborated. There was no significant relationship between a species' phylogenetic position and its pollution tolerance, suggesting that sensitive and restricted taxa have diversified into more narrow niches from a widely tolerant ancestor. For c) and d), we sampled larval transcriptomes from two locations near Brisbane at which they co-occur. Comparative analyses suggest broad similarities among species; however, some key differences were observed, involving chemorepellent, antioxidant, and fat body nutrient storage genes. Within a single species, differential expression was not associated with ecosystem health; instead, the greatest trend was between season, specifically start- and end-wet season rainfall. Higher water levels (end-wet) were characterised by upregulation of detoxification genes, suggesting significant influence of runoff, whereas developmental genes dominated the start-wet period. Taken together, this research provides important insight into the evolution of pollution tolerance in Australian *Cricotopus*.

16

How to develop rapid and cost-effective species-based biological monitoring using high throughput DNA sequencing of DNA barcodes

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DNA barcodes have been shown to be an accurate means for identifying a taxonomically diverse range of species. As a result, this has made DNA barcodes an attractive option for providing species identifications for environmental monitoring. We demonstrate the steps involved in using DNA barcodes to develop a rapid and cost-effective species-based biological monitoring program using macroinvertebrates from the Little Stringybark Creek, Melbourne, Victoria, as an example. We highlight the benefits of using this approach over traditional monitoring, which relies on the morphological sorting and often family identification. We also show how high throughput DNA sequencing (HTS) can be used to rapidly generate DNA barcodes from mixed macroinvertebrate samples. We discuss more broadly what is still needed for using DNA barcodes for routine monitoring and the limitations and pitfalls of this method and how they could be overcome.

17

Floods are good: evidence from a managed flood on the benefits for native wetland vegetation

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Managed floods are increasingly being promoted as a means to enhance ecological values; however, evidence for their effectiveness is often either lacking or unclear. We experimentally flooded a billabong by pumping water from an adjacent creek with the aim to promote native wetland flora and reduce the prevalence of terrestrial exotic plant species. We monitored water levels and surveyed the vegetation of three billabongs, including the one which we flooded, before and after the managed flood. Due to wet conditions, all billabongs flooded to some extent, so we assessed vegetation changes against a gradient of flooding duration (which was extended in the target billabong). The change in cover of amphibious vegetation was more positive, and the change in cover of exotics was more negative, with increasing flooding duration, with these effects amplified in the deliberately flooded billabong. Our study provides evidence for the use of managed floods to maintain and promote native wetland vegetation.

18

Condition-states and inundation sequences: a new way of describing plant water requirements

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Current practice is to describe the water requirements of riverine vegetation (usually as a dominant plant species) using a set of hydrological and hydraulic measures, collectively referred to as *water regime*. Water regime can be applied to any life-history stage but is generally limited to the two main stages: Maintenance (growth, persistence, reproduction of an already established plant) and Regeneration (germination, then establishment of new individuals). However, being based on statistical measures such as averages and ranges, water regime can be difficult to use predictively, as is needed when testing scenarios or setting priorities. A new way of describing water requirements based on *inundation sequences* and condition-states overcomes this limitation. A generic template in the form of a flow-chart comprises a series of condition-states (Good to Critical) arranged along two trajectories (Stress, Recovery). Each condition-state is defined in terms of severity of stress evident in the plant, and likelihood and ease of recovery; with recovery meaning persistence at that point in the landscape. One condition-state transitions to another, along a trajectory (or between trajectories), driven by the inundation sequence: and each transition has a specific inundation sequence. Vegetation or species water requirements are determined by fitting a species into this generic template. An understanding of its resistance and resilience characteristics are needed (physiological tolerances, propagule longevity, seed bank longevity) to fit the species or

vegetation type into the template. Each of the transitions is then quantified, as best possible, drawing on published information, field observations, and consensus as appropriate. This new way of describing water requirements evolved as part of flow scenario modelling and has now been applied to a number of growth forms and vegetation types in the southern Murray-Darling Basin, such as *Eleocharis acuta* sedgelands, *Vallisneria australis* herblands and Black Box *Eucalyptus largiflorens* woodlands.

19

Flooding drives a macroinvertebrate biomass boom in ephemeral floodplain wetlands

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3. CSIRO Land and Water, Wodonga, VIC, Australia

The Environmental Watering Knowledge and Research (EWKR) project is interested in the influence of flows on floodplain food webs, and incorporates existing information with new research to address knowledge gaps. The Food Web theme leadership group of EWKR has identified that the relationship between environmental flows and the provisioning of resources for plants and animals remains a critical knowledge gap in the Murray–Darling Basin. The Flood Pulse Concept conceived by Junk et al. highlights the importance of riverine–floodplain interaction in influencing character and condition. While developed within the context of a tropical basin, it has been broadly applied to diverse rivers around the world. Despite recognition of its importance, very few studies have provided empirical evidence to support a number of its hypotheses. Here we discuss results from an existing project that will contribute to research as part of the EWKR Food Web theme. The project discussed investigates the biological responses of ephemeral wetlands to a manipulated flood pulse. We compared and contrasted water quality, nutrient and macroinvertebrate community data, collected over a 22–week inundation period, between ephemeral and permanent floodplain wetlands. Ephemeral wetlands supported different aquatic macroinvertebrate communities to permanent wetlands and this was largely driven by differences in water quality and nutrient concentrations. Taxa richness and diversity was higher at permanent wetlands while ephemeral wetlands supported greater macroinvertebrate abundance and biomass. Community differences between hydrological treatments were driven primarily by Chironomidae, while early colonising Coleoptera contributed strongly to taxa richness in ephemeral wetlands. *Chironmus tepperi* was the dominant taxon among ephemeral wetlands, both numerically and by biomass. Analysis of functional feeding groups (FFG) indicated that ephemeral wetlands contained a higher proportion of detrital feeding collector–gatherers compared to permanent wetlands, suggesting an increased reliance on heterotrophic energy pathways. Here we show that a manipulated flood pulse mimicking a natural flood can mobilise latent terrestrial energy sources within ephemeral floodplain wetlands and support a boom of aquatic invertebrate biomass with important implications for both terrestrial and aquatic food webs. These results contribute to our knowledge of the effects of environmental flows on the passage of energy through floodplain food webs and provide managers with useful information about abiotic and biotic responses of ephemeral floodplain wetlands following a manipulated flood pulse.

20

Fish and flows: Delivering flows for Murray Cod and Golden Perch in the Lower Darling River

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A management framework for fish and flows was developed using best available science linking the relationships between hydrology, life history requirements and population dynamics for native fish in the Murray-Darling Basin (MDB). Recent research has highlighted an important breeding pathway for Golden perch involving spawning in the upper reaches and downstream dispersal of egg and developing young. During larger flow events (which historically occurred most years, often multiple times within a year) many of these young are transported as far as the Menindee Lakes. In these productive floodplain habitats they demonstrate strong growth and survival. Subsequent flow events then facilitate dispersal south to the Murray River system, as well as back upstream to the Northern Murray Darling Basin. Whilst this sort of breeding pathway was likely to historically occur throughout the MDB, the Darling appears to be the last system in which regulation of flow has not substantially compromised the flow requirements for completion of the cycle. Unfortunately river extraction in the Northern MDB has (and continues to) reduced the potential for this Darling Breeding pathway to be realised. In 2016-17 NSW DPI Fisheries, in partnership with other government agencies and stakeholders have adapted and applied the *Fish and Flows* in the Lower Darling river to ensure the Darling Breeding pathway for Golden perch was completed through delivery of environmental water. The project also supported breeding and recruitment of a vulnerable Murray Cod population at a time in which blackwater precluded successful breeding by this iconic species elsewhere in the Southern MDB.

21

Waterbird recruitment and movement: Responses to flooding, stressors and threats

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Environmental watering events in Australia are frequently targeted to support completion of waterbird breeding. While knowledge exists regarding key breeding locations in the Murray-Darling Basin and the flows required to trigger and complete nesting events, there is limited knowledge about recruitment, habitat variables, pressures and threats. Consequently it is difficult to model or predict population outcomes relevant to management at different scales. The Waterbird Theme of the Murray-Darling Basin Environmental Water Knowledge and Research Project addresses this through research focusing on two main questions:

1. Where and what are the critical foraging habitats during and after breeding events that support recruitment? How might these be affected by water management and threats such as habitat change?
2. What are critical nesting habitat characteristics we need to maintain and how do these affect recruitment? How might environmental flows, vegetation management and threats such as predation interact with nesting habitat characteristics to affect recruitment?

We describe our research rationale, methods and preliminary results from on-ground data collection in waterbird nesting colonies in 2015-16 and 2016-17 and satellite GPS tracking of 20 straw-necked ibis starting in spring 2016. This research aims to provide information to enable better targeting of water, vegetation and predator management actions to maximise chick survival during flooding events, 'event readiness' at nesting sites, and juvenile and adult survival between flooding events. It is funded by the Department of Environment Commonwealth Environmental Water Office and is a collaboration between the CSIRO, University of New South Wales, University of Canberra, Royal Botanic Gardens Sydney, and Murray-Darling Freshwater Research Centre.

22

Elevated magnesium concentrations in tropical fresh surface waters can affect phyto- and zooplankton communities.

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Saline mine water discharges from mines are a common global water quality issue. Typically, saline constituents of mine waters are Na2+, Cl-, K+, Ca2+, Mg2+, HCO3- and SO42-, but the relative composition of these can differ between mines. For Ranger Uranium Mine in tropical northern Australia, the saline constituents of concern are Mg2+ and SO42-. To determine the effects of these constituents on ecological communities present in the creeks adjacent to Ranger Mine, a mesocosm experiment was undertaken. The experiment consisted of 25 mesocosms (2700 L tubs), placed in the creek bed during the recessional flow and dry season periods of 2002. Tubs were filled with sand, leaf litter and water from the adjacent creek. The sand and leaf litter provided habitat for colonising fauna and also seeded the tubs with faunal and floral communities. The tubs were left for four weeks to allow for aquatic communities to establish. Diatoms, zooplankton and macroinvertebrate communities were then sampled (pre-treatment) and the tubs were randomly assigned and spiked with one of four MgSO4 treatments (2.5 to 68 mg/L Mg) and a control. After MgSO4 addition, the same communities were sampled again after four and eight weeks. Phytoplankton and zooplankton communities responded to MgSO4 exposure, but no community-level response was detected for macroinvertebrates or diatoms. Phytoplankton response, as measured by chlorophyll *a*, decreased by 10% at concentrations of 2 mg/L Mg and 5 mg/L Mg at four and eight weeks, respectively. Changes to the zooplankton community were measured by modelling 95% extirpation of individual species in a SSD, resulting in a 99% species protection value of 5 mg/L Mg. Results from this study will be used as a supporting line of evidence for a site-specific magnesium standard for water bodies surrounding Ranger Mine.

23

Efforts in barcoding Australia's aquatic invertebrates: introducing the Aquatic Invertebrates of Australia (AIA) DNA database

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Genetic methods for species identification are increasingly being considered for use in biological monitoring programs. Getting the most value out of DNA barcode data requires having reliably identified reference specimens that link DNA barcodes to morphotypes. In a recent publication we compared the DNA barcoding effort within Australia to that globally. We found that currently, DNA barcodes are available for only around 6% of the Australian aquatic invertebrate fauna and representation across taxa is uneven. We have developed a strategy for producing a comprehensive national DNA database and presented some initial efforts in creating this database. The Aquatic Invertebrates of Australia (AIA) DNA database was erected to house DNA barcode that is freely available for public use. Here, I will present the AIA along with the main findings of our recent publication.

24

Disturbing flows: recovery capacity of macroinvertebrate assemblages and traits to natural flow extremes

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Disturbance regimes, such as floods and droughts, place great stress on freshwater environments and their associated flows. Resilience and resistance to these flows is essential for maintenance of community processes and dynamics. However, untangling and understanding community *trait* responses to these flows provides insight to the underlying processes and ecosystem drivers required to sustain viable freshwater communities in an ever-changing environment. This paper discusses macroinvertebrate assesmblage and trait responses to drought and flood flows within the subtropical-humid world bioregion (coastal Manning River Catchment, New South Wales, Australia). Using a reference condition approach, resistant, resilient and affected macroinvertebrate traits within these flow regimes, and their significance, are discussed.

25

How Healthy is our Aquatic Ecosystem? Ask the Fish – Development of a Fish Health Index for the Fitzroy Basin of Central Queensland

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Fish may not speak, but changes to their assemblage, population structures and other fish health indicators can tell us a great deal about the current state of an aquatic ecosystem. Being abundant and responsive to changes in habitat conditions, fish present a useful biomonitoring tool for assessing ecosystem condition. Fish health indicators which respond to habitat degradation have been integrated into Multimetric Indices (MMIs) such as the Index of Biotic Integrity, and such MMIs are now widely used for environmental monitoring around the world. Within the Fitzroy Basin of Central Queensland, decades of land use including cattle grazing, cropping and mining activities have resulted in large impacts to fish habitats. Despite this, the effects of habitat degradation on the Fitzroy Basin's freshwater fish populations remain poorly studied. Thus, the aim of this study was to identify indicators for integration into a novel MMI: the Fitzroy Basin Fish Health Index (FHI). Potential indicators for the FHI were tested over two years at 12 sites within the Fitzroy Basin. Several fish indicators were responsive to changes in water quality and habitat condition, including novel indicators developed using local fish species. For example, percentage abundances of Atheriniform fish species fell with increasing levels of several water and sediment pollutants, and vice versa for Clupeiform and Hypseleotrid species. Nine indicators in total were

thus identified for inclusion into the FHI, which was then validated at 20 sites across the 11 freshwater catchments of the Fitzroy Basin. The novel FHI developed was able to distinguish between sites which were in degraded vs. more pristine conditions, and was also responsive to localised habitat disturbances. Overall, the FHI has a potential for integration into regular monitoring programs, and could aid in providing a better understanding of ecosystem condition throughout the Fitzroy Basin and beyond.

26

Inside the Australian Research Council: advice for applicants and reviewers

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Freshwater ecology has generally had a lower success rate in applying for Australian Research Council (ARC) grants than other ecological disciplines. Based on my experience sitting on the College of Experts, I will summarise the grant review process and suggest that there are some consistent challenges in getting freshwater research funded. Referring to recent funding rounds for ARC Discovery, Linkage, DECRA and Future Fellowships, I will provide some reflections and advice on what made a really great proposal. I will also discuss how freshwater ecologists review grants, and identify some features of reviews that seem to be particular to freshwater ecology.

27

Responses of freshwater macrophytes to low concentrations of additional nitrogen

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Nutrient status of freshwater ecosystems has a significant influence on biological invasions, species richness and community structure. The role of phosphorus in driving these effects has been widely reported while that of nitrogen is being increasingly considered. In a glasshouse experiment, we investigated the growth responses of two invasive exotic (*Egeria densa* and *Salvinia molesta*) and one native (*Vallisneria spiralis*) macrophyte species to additional low concentrations of nitrogen (NO_3-N). The species were grown across five levels of low nitrogen treatments (0.02, 0.05, 0.1, 0.5, and 0.9 mg NO_3-NL^{-1}). We hypothesised that the invasive exotic species will produce more biomass in the higher range of tested nitrogen concentrations while *V. spiralis* growth will be favoured in the lower ranges. The invasive *E*. *densa* growth responded positively to increasing nitrogen concentration as hypothesised. Contrary to our hypothesis, *V*. *spiralis* produced more biomass in the higher nitrogen treatments, and biomass production of *S*. *molesta* was more favoured by the mid-range nitrogen concentrations of 0.05 – 0.1 mg NO_3-NL^{-1}. We conclude that increasing N at these low concentrations results in greater growth for *E*. *densa* and *V*. *spiralis*, but *S*. *molesta* growth is less strongly linked to N concentration.

28

Seed germination in response to flooding: tangled lignum (*Duma florulenta*) and nitre goosefoot (*Chenopodium nitrariaceum*)

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The flooding regime of lowland river systems governs the distribution and abundance of floodplain vegetation by influencing the movement of propagules between the river channel and the floodplain, and through the creation of suitable habitat. The distribution of trees and shrubs in a floodplain depends on their tolerance to, and requirements for flooding. Floodplain vegetation is significantly affected by human activity, primarily through the changes to water regime resulting from damming, flow regulation, and flow extraction. Providing water as an environmental flow, to improve or maintain vegetation communities requires an understanding of the watering requirements of key floodplain species. This study describes an experiment to determine the relationship between inundation duration and the germination and recruitment of two shrub species common to the floodplains of the Murray Darling Basin: tangled lignum (*Duma florulenta*) and nitre goosefoot (*Chenopodium nitrariaceum*). Five inundation treatments were applied to the seeds of both species: rainfall, constantly soaked soil, 20, 40 and 60 days of inundation to a depth of 2.5 cm. Three additional treatments were applied to nitre goosefoot seeds: 5, 10 and 15 days of inundation. Tangled lignum established under all inundation scenarios with the highest germination occurring in the constantly soaked soil (43.5% ± 5.98) and lowest in the rainfall treatment (8.38% ± 2.02). Nitre goosefoot also established under all inundation scenarios, but the highest germination of seeds occurred after inundation of five days (17.25% ± 2.17) and the lowest occurred after inundation of 60 days (0.38% ± 0.24). These results support the observed distributions of these species across floodplains, tangled lignum occurs near semipermanent aquatic habitat and nitre goosefoot occurs on the flood margins. This information can be used by water resource managers looking to support floodplain vegetation communities with watering actions.

29

Restoring hydraulic connectivity of a small billabong in an urban context

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2. City of Greater Dandenong Council, Dandenong, VIC, AUSTRALIA

The health of fragmented indigenous ecosystems in urban areas is declining and water stress is believed to be a key contributor. Fotheringham Reserve in The City of Greater Dandenong contains a revegetated billabong system (EVC Floodplain Riparian Woodland), dependent on streamflows from Yarraman Creek. The hydrological behaviour of this incised urban waterway is likely to have been altered by the recent construction of major road infrastructure and *constructed wetlands* upstream. Subsequent changes in the inundation regime caused by the land use changes are likely to have contributed to the decline in condition of the billabong vegetation. Further loss may reduce the long-term viability of the billabongs and associated *riparian* vegetation and facilitate the transition to a terrestrial ecosystem. A monitoring program is on-going to capture ecological values and key hydrological parameters, including rainfall and water levels, to assist Council in understanding current billabong water regime. The data will be subsequently used to calibrate and validate hydrological and hydraulic models, to assess future inundation frequency. Ultimately, the project will lead to a better understanding of the system and the model findings will inform future management plans for the reserves and its vegetation. This may include identifying possible mitigation measures to reinstate a suitable water regime to restore a healthier billabong,

including artificially triggering inundation periods. Or alternatively, it may lead to the conclusion that the changes are irreversible and a “do-nothing” approach is best. The presentation will provide an overview of results to-date and the management approach considered to restore a more suitable water regime for the billabong.

30

Infrastructure modifies movement patterns of seeds drifting in lowland rivers

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2. The Murray-Darling Freshwater Research Centre, Wodonga, Victoria, Australia

The unimpeded movement of seeds and other propagules within riverine networks is believed ot be important in maintaining regional diversity. Changes in flow regimes, or hydrological connectivity, are therefore likely to significantly impact the distribution of aquatic and riparian plants. Changed connectivity may occur through the disconnection of components of the landscape caused by changes in flow regime, construction of barriers that physically impede dispersal, and the physical removal of riparian plants. In this study we investigate the influence that the use of infrastructure (pumps/levees) have on the movement of seeds from the Murray River into adjoining wetlands. Results demonstrate that pumping of water into wetlands appears to have filtering effect with less seeds entering the wetland compared to what is present in the main river channel

31

Long term condition monitoring shows improvement in wetland vegetation

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Since the millennium drought, wetlands at Hattah Lakes have experienced a return to favourable environmental conditions through delivery of environmental flows and flooding. The health of these wetlands are threatened by changes to the frequency, size and duration of overbank flows from the Murray River. The Living Murray initiative has played an important role in protecting and improving the health of wetlands and the surrounding floodplain at Hattah Lakes. Three large environmental flows were delivered to the lakes in 2013, 2014 and 2015, between two floods (2010–11 and November 2016), inundating the majority of lakes on multiple occasions. Emergency pumping of environmental water was also undertaken during the drought (between 2005 and 2010) to provide habitat in a number of wetlands. Through long term condition monitoring data, this study looks at the ability of flow responsive vegetation to regenerate after extended drought. Wetland vegetation monitoring was undertaken annually from 2007–08 to 2016–17. Community composition is now largely dominated by aquatic, amphibious and damp loving species due to a combination of environmental flows and floods. Therefore, a return to favourable environmental conditions, particularly since 2010–11, has helped to maintain healthy wetland communities at Hattah Lakes. This project was funded by The Living Murray initiative of the Murray–Darling Basin Authority. The Living Murray is a joint initiative funded by the New South Wales, Victorian, South Australian, Australian Capital Territory and Commonwealth governments, coordinated by the Murray–Darling Basin Authority.

32

Water Policy Innovation: Consideration of Cultural Flows in Decision Processes

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Environmental flows represent a social-ecological innovation that seeks to sustain healthy riverine ecosystems and human well-being, but capturing Aboriginal interests and values in environmental flow assessments remains challenging. To facilitate the articulation of place-specific cultural, social, and economic water flow needs of Aboriginal peoples, the concept of cultural flows has emerged from the environmental flows literature. An example of a cultural flow comes from the Peace Athabasca Delta in northern Alberta, Canada, termed Aboriginal Flow, which prescribes the minimum water flows in the lower Athabasca River necessary to maintain waterway navigability and prevent disruption to treaty rights. The Mikisew Cree and Athabasca First Nations developed the concept of Aboriginal Flow, which has been advanced through federal and provincial water use decision processes as a potential regulatory limit to be imposed on oil sands water withdrawals. The outcomes of these decision-processes specific to Aboriginal Flow are examined using innovation implementation theory to understand the factors at the individual, structural and cultural levels that act as barriers to and opportunities for integrating Aboriginal perspectives into water policy.

33

Managing freshwater ecosystems in New Zealand. How to measure success?

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Freshwater ecosystems underpin economic, social, and cultural wellbeing in New Zealand. In recognition of this, the National Policy Statement for Freshwater Management 2014 (NPS-FM 2014) makes Ecosystem Health a compulsory value that Councils must manage. A healthy ecosystem is described as one where ecological processes are maintained, there is a range and diversity of indigenous flora and fauna, and there is resilience to change. Both local and national government face a number of barriers to effective management of ecosystem health, including how to evaluate the extent that this critical value is being provided for. These stem from gaps in our knowledge of ecosystem health outcomes (for example the current state of fish species), and the lack of a consistent and robust approach to assessing ecosystem health. This project aims to inform the management of ecosystem health in New Zealand. It includes a review of approaches within New Zealand and overseas, the role of outcome indicators compared to diagnostic metrics, and the types of barriers that exist for their implementation and management outcomes. If successful, the project will develop a tool, such as a multi metric indicator, which government (and their communities) could use to measure and describe ecosystem health, and help identify the actions necessary to improve it.

34

Fish and Flows: Developing flows for freshwater fish in NSW

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Native fish populations in the Murray-Darling Basin (MDB) are in poor condition, with altered flow regimes being a major contributor to their decline. Implementation of the Basin Plan provides the opportunity to improve flow regimes and contribute to the restoration of native fish populations. To effectively manage water for native fish, we need to understand the flow drivers that support healthy fish populations. NSW DPI Fisheries used the latest management and scientific information to develop an understanding of the relationships between hydrology, life history requirements and population dynamics for native fish in the MDB (the *Fish and Flows* project). Using these relationships five different 'functional groups' of fish species were identified based on shared life history characteristics and responses to flow. The flow components that support these life history characteristics were then developed. These functional groups and flow relationships are now being used to simplify water management targets for fish. Achieving more sustainable long-term outcomes for native fish through improved flow management will be significantly enhanced by undertaking parallel complementary actions that address other threats to native fish, in addition to altered flow regimes. Complementary actions include activities such as habitat restoration and enhancement (e.g. re-snagging, instream and riparian zone management); mitigating cold water pollution or hypoxic black water impacts; improving fish passage and connectivity; screening diversions to minimise fish entrainment; pest species control, and; conservation stocking or translocations in cases where native species are unlikely to recolonise rehabilitated habitats. The use of the *Fish and Flows* framework at regional scales, in combination with site specific information and complementary actions, will guide water management decisions that support the recovery of native fish in a healthy working Basin.

35

Managing estuarine wetlands at Sydney Olympic Park requires local innovation and adaptation

Swapan Paul[1]

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Sydney Olympic Park in Australia inherits a suite of estuarine and freshwater wetlands; many of which are either purpose built, modified or remnant. Prior to the Sydney 2000 Olympics, many degraded wetlands were rehabilitated and some new wetlands were constructed to perform biodiversity, flood mitigation, recreational and educational experiences. Together, they form the largest contiguous wetlands on the Parramatta River system and host a range of threatened species, ecosystems and communities. They are interlinked or separated by features such as public recreation spaces, educational facilities, commercial and residential establishments and other infrastructure. These highly urbanised wetlands pose many challenges in regard to their day-to-day maintenance, in addition to meeting the obligations for biodiversity conservation as well as provisioning of Ecosystem Services. Over the past two decades a multitude of tools and techniques have been developed to manage these wetlands. Many of these tools and techniques are uniquely local but still offer appeal to other wetland managers. Some of the tools are timeless yet others require fast adaptation in response to local influences as well as Climate Change and Sea Level Rise. Sitting at the receiving end of several catchments, these wetlands face enormous pressure from urban development, public amenities, residential and industrial development as well as tourism. Many rehabilitation and restoration programs have been successfully implemented and by now those programs show benefits and values. Particularly, projects in response to Climate Change and Sea Level Rise are important examples The Authority's Wetland Education and Training (WET) Program provides a platform for sharing those innovative and creative solutions to problems that are common to many. Over the past 15 years this program has provides training to more than 1,500 wetland practitioners across the country. In this presentation some examples of the above will be shared.

36

Using Wetlands to Treat and Dispose of Landfill Leachate at Sydney Olympic Park

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Sydney Olympic Park Authority (the Authority) is responsible for managing and developing the 640 hectares that comprise Sydney Olympic Park, its town centre, 430 hectares of parklands, and 7 sporting venues. The Authority also manages 105 hectares of remediated lands that were once one of Sydney's largest areas of uncontrolled landfill and are now part of the Park's recreational open space. The Authority is committed to the sustainable development and management of Sydney Olympic Park. This includes finding options for cost effective, sustainable treatment of 40 to 60 ML of leachate generated by the Park's remediated lands each year. An EPA approved bioremediation process has been used at the Park since 2000, to treat groundwater contaminated with hydrocarbons, originating from a historical town gas plant. In a series of treatment ponds which optimise the conditions for hydrocarbon-degrading bacteria, pollutants are degraded to below detection limits so that the treated water can be released back to the Parramatta River. This leachate treatment system has demonstrated over 17 years that natural biological processes are capable of reliably removing contaminants from landfill leachate, and can be used as an alternative to expensive industrial treatment. In 2010 the Authority's Board endorsed an Alternative Leachate Treatment Strategy for sustainable, onsite management of landfill leachate. To date, the Authority has spent approximately $2 million on the construction and commissioning of two new sustainable leachate treatment systems. These systems are treating landfill leachate using low cost, low energy solutions that rely on natural wetlands to breakdown pollutants. This innovative approach is not currently used elsewhere in Australia and has generated interest from other landfill managers. The Strategy also creates new wetland habitats for native flora and fauna, provides educational opportunities for local and international visitors, and improves the local amenity and park experience.

37

Physiological tolerance and behavioural response to drought in the freshwater mussel, *Westralunio carteri*

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Freshwater mussels are among the most endangered groups of organisms on earth. They are particularly sensitive to environmental threats such as climate change, because of their sedentary nature. The freshwater mussel, *Westralunio carteri*, which is endemic to south-western Australia, has undergone a 38% reduction in range in the last 50 years, and with global climatic models predicting an increasingly warmer and drier climate in the region, reduced water flow presents a substantial extinction risk. In laboratory tolerance experiments, the mortality rate of mussels in drying conditions was much greater when they were

exposed than when they were shaded. In both shaded and exposed environments, the mortality rate was also influenced by mussel movement. A survey of microhabitat occurrence found that the abundance of *W. carteri* was significantly negatively correlated with substrate grain size, which also may influence the vertical and horizontal movement of mussels. We discuss the implications of these results for the future survival of *W. carteri*.

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How the swamps work, views from the Blue Mountains

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Upland peat swamps in the Blue Mountains provide significant environmental resources. Holocene in origin on sandstone escarpments west of Sydney, NSW, these valley fill and hanging swamps[1,2] are protected as endangered ecological communities[3] under Commonwealth (EPBC Act 1999) and NSW (TSCA 2005) legislation. Major threats include the multiple effects of urban development, including altered vegetation communities, storm water runoff severity and associated erosion and channel development[3]; local excavation, elevated nutrients and other pollutants[4-6]. Soils in and runoff from these swamps are naturally acidic and low in nutrients, leading to highly endemic and bio-diverse xeromorphic plant communities[7] and fauna. This study investigated leaf litter decomposition, microbial and invertebrate use in six small streams associated with upland peat swamps on sandstone near Katoomba, west of Sydney, NSW. Streams were chosen with increasing catchment impervious cover and distance to stormwater and sewage infrastructure, to understand whether processes such as the Urban Stream Syndrome[8] are applicable in these unusual swamps. In May 2015, six replicated litter bags containing mixed (fresh and aged air dried) eucalypt leaves and of differing mesh size (150 micron, 1 mm, 9 mm) were placed in pools within and downstream of swamps and harvested sequentially for 10 months. Leaf litter decomposition increased with urbanization up to thresholds where dissolved oxygen levels were depleted and iron reducing bacteria proliferated. Ratios of microbial to total mass loss varied between 64% for pristine and urbanized sites, to 88% for excavated sites with high anoxia. Shredding invertebrates including Leptocerids used aged leaf material preferentially as retreats however generally, aged leaf litter was poorly utilized. While invertebrate communities were dominated numerically by Chironomidae and Oligochaeta, the EPT taxa provided better discrimination between sites. These results suggest complex relationships at multiple scales driving upland swamps and provide better knowledge for future management.

39

Zooplankton response to a hypoxic blackwater event in the Hunter River estuary

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3. Australian Water Life, Hobart

Hypoxic blackwater floods constitute a major disturbance event in aquatic ecosystems. Zooplankton are generally considered to be relatively resistant to hypoxic conditions, however their responses to hypoxia instigated by blackwater floods have been rarely examined. In this study we monitored the response of zooplankton to the 2013 hypoxic blackwater event in the Hunter River estuary. Major shifts in zooplankton abundance and assemblages occurred during and following the event. Prior to the flood copepods were dominated by the calanoid *Galdioferens pectinatus*, during the event these were replaced by the cyclopoid *Mesocylops sp.,* and in the months after adults had been replaced largely by copepodites and high numbers of nauplii. Cladoceran populations shifted from a relatively small but diverse assemblage dominated by daphnids to larger populations almost exclusively of Moina sp. and *Bosmina meridionalis*, before declining in the months after the event. Rotifer abundance declined during the event however increased significantly afterwards, dominated by high numbers of *Polyarthra*, *Filinia*, and *Brachionus*. Whilst the event significantly impacted zooplankton communities, it appeared different genera were able to take the place of those displaced. The results provide insight into the food resources available to higher trophic organisms repopulating estuaries following hypoxic blackwater events.

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Application of the Ecological Character Descriptions for Australian Ramsar sites to achieve sustainable outcomes for an iconic perched Lake in the Southern Highlands of PNG.

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**Publish consent withheld

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Saltmarsh Restoration in the Hunter Estuary – a Partnership Approach

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2. National Parks & Wildlife Service, Hunter Region, NSW

Hunter Wetlands National Park (HWNP) contains large areas of saltmarsh, which is listed as an Endangered Ecological Community (EEC) under state and federal legislation, and contains significant habitat for threatened and migratory shore birds. Saltmarsh habitat in HWNP is under threat from weed invasion from *Juncus acutus*, and anthropogenic mangrove recruitment, which both displace saltmarsh vegetation, reducing the area available for shorebird foraging and roosting. A collaborative approach is being used to manage these threats in HWNP. NPWS and CVA are working alongside Hunter Bird Observers (HBOC), Newcastle Coal Infrastructure Group (NCIG), and Worimi LALC undertaking *Juncus acutus* control and selective mangrove removal within the Park to improve the condition of saltmarsh and shorebird habitat. This work also forms part of CVA's Revive Our Wetlands national program targets. National Parks and Wildlife Service, CVA, and HBOC recently collaborated on a shorebird habitat restoration project over 2 years, funded by the NSW Environmental Trust. The main focus of this project was to restore 144 ha of shorebird habitat in saltmarsh by reducing the density of *Juncus acutus* infestations by 80%, and removing mangroves from saltmarsh and

mud flats over 115 ha. CVA and NPWS developed an ecological monitoring program as part of this project to assess the effectiveness of various chemical treatments to control *Juncus acutus*. A partnership with Hunter Tafe was also established for Conservation and Land Management student to continue long term data collection after completion of the project so that monitoring can continue into the future. Newcastle Coal Infrastructure Group also manage compensatory shorebird habitat areas within HWNP, and provide CVA with funding to undertake mangrove removal and *Juncus acutus* control. This work contributes to the community engagement outcomes of both organisations by using supervised community engagement teams consisting of local and international volunteers.

42

The use of central Australian waterbodies by native and feral mammals

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For the past ten years we have documented the use of remote water places in central Australia by native and feral mammals. Many sites were severely degraded by large feral animals, mainly camels and horses. Not surprisingly, large feral herbivores can have profound negative impacts on aquatic biodiversity. Less understood was the extent that feral herbivores impact on native terrestrial wildlife using these same sites. Since 2008 we have used camera traps at multiple sites across central Australia to document native wildlife visitation, and to examine if feral animals "interfered" with this usage. We used circular statistics to evaluate activity budgets for feral camels, dingoes and native birds, as well as species co-occurrence and niche overlap. In dry times camels dominate individual water sites and readily exclude all other species, including birds and dingoes. When camels were present at night, dingoes used waterholes during the day and displaced birds. Thus, camels impacted on native species in three ways: directly through exploitation and interference, and indirectly through an "interference cascade", whereby camels displaced dingoes which displaced seed-eating birds. Interestingly, we found no evidence that dingoes interfered with waterhole usage by cats and foxes, and all three species regularly used the same waterholes. These data suggest that although many animals have adapted to the dry conditions of arid Australia, those species that do rely on a regular source of water are easily denied access by camels.

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The Hawkesbury River: a Social and Natural History

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Australians share a 50,000 year-long history of interacting with their rivers. This presentation focuses on interactions with one particular river: the Hawkesbury. The Hawkesbury River lies ~50 km north of Sydney and is part of the longest coastal river system in NSW, the Hawkesbury-Nepean. The river has an Aboriginal history going back at least 42,000 years, and the catchment is festooned with evidence of Aboriginal occupation: rock engravings, line drawings, and shell middens. The British colonised the river in 1794, a mere six years after the establishment of the colony at Sydney Cove, and within a few decades had managed to almost totally alienate the lands immediately surrounding the river. The rich alluvial flats of the upper Hawkesbury played a critical role in the survival of the early colony, and until the 1820s was the breadbasket for Europeans in NSW. The presentation will discuss various aspects of the way the river has been modified by humans, but equally importantly how it has influenced our society − the way we have variously tried to harness it, work with it or against it, admired it, feared it. The way the river's floodplain was used by Europeans is discussed in detail, with a focus on how they cleared the land and the impacts this had on river navigability and on water quality. The talk then moves onto how the river has acted as a barrier and as a conduit for human movement, and finishes with an overview of how the river has inspired artists, poets and other creative folk since the earliest times. There's also a short section on how the Hawkesbury has maintained great military and strategic importance to Sydney, with military planners from at least the middle of the 19th century considering it a springboard for possible Russian and Japanese invasion of NSW.

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Effects of climate change on stream organisms

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Increasing water temperatures and frequencies and intensities of extreme weather events, (e.g., droughts and floods) associated with climate change have important consequences for stream organisms. I will present four examples of investigations done in collaboration with my students and colleagues at the Rocky Mountain Biological Laboratory of the negative effects of climate change on algae, insects and trout in high elevation streams of western Colorado, USA. First, increasing water temperatures accelerates development, increases mortality and decreases fecundity of *Baetis* mayflies. Second, recruitment of *Baetis* is threatened by early drying of oviposition sites during drough years. Third, the prevalence of a nematode parasite of *Baetis* is higher in years when snow melt and peak stream flows occur earlier, a trend observed over the past 40 years. Fourth, earlier seasonal snowmelt and peak flows also facilitate proliferation of the nuisance diatom (*Didymosphenia geminata*), which changes the composition of stream insects from predominance of mayflies to lower quality food species (midges) and thereby reduces growth rates of trout. *Didymo* blooms also create habitat favorable to oligochaetes, which are the intermediate host for a debilitating parasite of trout (whirling disease). These findings have implications for the consequences of managing flows leaving too little flow in trout streams. Such disruption of the natural flow regime via climate change and inappropriate management strategies could jeopardize the sustainability of otherwise pristine mountain streams.

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Australian rivers in the Anthropocene

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Scientists have played a pivotal role in the identification of ecological problems, management and protection of rivers in Australia. Perhaps because of this, science has sometimes come under attack. Like climate change science, river science is also increasingly the focus for criticism for providing the 'wrong' answers for major public policy decisions. This attack is particularly conspicuous on the science of the Murray-Darling Basin rivers, our most developed major river basin. The building of large dams primarily for hydroelectricity generation and supply for irrigation and urban water has incurred major ecological and social costs to the rivers and

wetlands of the Murray-Darling Basin. Recognition of the poor ecological state of many rivers and wetlands led Australian Governments to invest >$12 billion in the rehabilitation of the Murray-Darling Basin Rivers, including the return of environmental flows. The volume of this environmental flow target has continued to decline with powerful stakeholder pressure, particularly from the irrigation industry, persuasively arguing about significant socio-economic impact. At the same time, rivers of northern Australia are now the 'new frontier' for development, with considerable investment of public resources. Science remains pivotal to the success of the Murray-Darling Basin Plan but implementation mechanisms need a serious overhaul. Scientific effort also needs to be driven by management objectives, which are rarely adequately specified. Science also needs to deliver 'real-time' data for management, not just 'the paper', more than three years later. Finally scientists need to continue to 'stand-up' publicly for Australian rivers and ecosystems, whether providing evidence for improved implementation of environmental flow management or protection of free-flowing rivers in the Lake Eyre Basin and tropical Australia. We can't afford to make the same mistakes on our other river systems.

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Evaluating inundation regime outcomes for the vegetation of a floodplain wetland landscape

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Floodplain wetlands support high biodiversity, including mosaics of vegetation which reflect variable river flows and consequent flooding regimes, characterised by unique variations in extent, duration, frequency and dry time between floods. Environmental water is used to sustain ecological structure and function of floodplain wetlands, and to restore components affected by altered flow regimes. Floodplain vegetation is often the target for environmental water but with relatively little information on key components of the inundation regime over large spatial and long temporal scales. Few studies have quantified inundation regimes required for heterogeneous wetland vegetation types of large floodplains at the landscape. Using novel methods, we evaluated how the inundation regime after the breaking of the Millennium Drought, influenced the dynamics of broad vegetation states of the Macquarie Marshes in the Murray-Darling Basin, Australia. We used multi-temporal inundation maps, classified from the 25 year Landsat archive, to measure extent, duration, frequency and time since last flood, over short-term (5 year) intervals and long-term (20 year) intervals. Using spatial analyses of vegetation distributions from two dates (2008 and 2013) we mapped areas of vegetation change and no change and linked these responses to inundation patterns. Understanding these linkages is critical for evaluating the inundation outcomes of environmental flow management over long-term inundation regime scales.

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Building ecological reference models for wetland vegetation communities in inland floodplain wetlands in NSW

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Wetland vegetation communities are mostly composed of species that depend on moist conditions or flooding for part, or all their life cycle. Their structure and species composition have been shown to change in response to hydrologic alterations, with increased hydrological connectivity and flooding driving floristic structure and composition towards more flood-dependent species, while increased drying promotes the establishment of more terrestrial species. Many human-related alterations to the environment act to degrade wetland ecosystems causing shifts in the structure and species composition in plant communities that can be quantified. Such shifts can be used as an indicator to evaluate best management practices for wetland resources such as environmental water, and to assess the efficacy of restoration actions and mitigation activities. We quantified a range of condition-indicator classes for wetland vegetation communities based on floristic composition and structure, in two large inland floodplain wetlands of NSW. We modelled the relationship between condition class and hydrologic and abiotic variables to build ecological reference models for each vegetation community. By quantifying reference conditions in relationship to ecological drivers, as well as conditions at degraded states that deviate from reference conditions, our results show that robust quantitative ecological reference models provide an advantage in temporally changing wetland vegetation communities in contrast to other approaches that use reference conditions. Our ERMs can provide tools for long-term, cost-effective management of environmental water in these wetlands.

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Landscape position affects the resilience of floodplain vegetation communities to climate anomalies

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The continuous provision of ecological services by wetlands is largely dependent on the stability of ecosystem functions such as biomass production. Biomass production is in turn strongly impacted by the frequency, duration and intensity of climate extremes such as droughts and floods. This is particularly true for the floodplain wetlands in the Murray-Darling Basin, which exhibits high inter-annual and inter-decadal climatic variability. In this study, I evaluated the ecological resistance and resilience to climatic anomalies in terms of maintaining biomass production for the major floodplain vegetation function types (VFT) in the southern-west New South Wales of MDB including river red gum forest, black box woodland, and open grassland. The hypothesis is that different VFTs have the same trend of biomass production over time on condition of their landscape position. Landscape position was defined by the integrated moisture index and weighted distance to water courses. Biomass production stability in response to climatic anomalies was modelled using time series (2000 - 2016, 17 years) of the Normalized Difference Vegetation Index (NDVI), temperature and drought index. More specifically, ecosystem resistance (i.e. the ability to tolerate climatic anomaly) and resilience (i.e. the recovery rate) were derived using a vector auto-regression model. I subsequently compared the stability metrics 1) between different VFTs within the same landscape position; and 2) between the same VFT at different landscape positions. The comparisons were conducted in a generalised linear mixed model (GLMM) framework. The study found that different VFTs at the same landscape position exhibited similar resistance and resilience. However, the same VFT at different positions had distinct responses to climatic extremes. These results underline the need to reassess the wetland conservation strategies.

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Species diversity and distribution of aquatic microfauna for wetland condition assessment

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Information on species diversity and distribution of aquatic microfauna such as Rotifera, Cladocera, Copepoda and Ostracoda across wetlands can assist with interpreting wetland processes, water sources and hydrological connections, and water quality. We sampled the aquatic microfauna from 36 wetlands across the Lachlan catchment divided into semi-arid, temperate inland and temperate upland zones. Among over 100 species of aquatic microfauna recorded overall, one notable aspect was the occurrence of two Tasmanian rotifer species of *Brachinus lyratus tasmaniensis* and *Lepadella tyleri* in the semi-arid zone. This raises intriguing questions about possible dispersal and biogeographical distribution. Migratory waterbirds may be important as potential vectors of microfauna, as has been suggested for the Macquarie Marshes, another large floodplain wetland in the Murray-Darling Basin of south-eastern Australia. We conclude that the conservation and maintenance of diverse wetland habitats across different geographical zones should ensure the survival, diversity and effective dispersal of the microfauna and help maintain the ecological structure and function of the Lachlan wetlands.

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Management of cold water pollution using a thermal curtain; assessing varied release mechanisms on thermal regimes and algal communities

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Cold water pollution occurs below large dams when hypolimnetic water is released during periods of thermal stratification, with water temperatures being up to 16°C below predicted natural temperatures. Hypolimnetic releases can impact the thermal regimes of downstream river systems for up to 300 km. These temperature changes can affect the health of aquatic biota such as algae, macroinvertebrates and fish. An innovative thermal curtain, being a large polymer structure suspended within the water column, was installed on a large dam on the Macquarie River, Australia in 2014 as an economical solution to mitigate cold water pollution by drawing epilimnetic water to the low-level fixed valve. Following implementation of the curtain, temperature improvements of 2.5°C were observed during summer whilst the dam was at low capacity. In 2016, the dam filled to full capacity and a cyanobacterial bloom occurred, leading to a mixture of curtain, spillway and bottom releases. The varied releases from the dam will be discussed in terms of their impact on downstream thermal regimes and algal concentration, assemblages and potentially toxic cyanobacteria.

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Is turbidity in a shallow Tasmanian lake controlled by wind or by the extent of macrophyte coverage?

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Historically, Woods Lake in the Central Highlands of Tasmania has been considered a turbid (normal range 20 – 40 NTU) and meso-eutrophic lake. Woods Lake was impounded in 1962, largely to supply irrigation water to downstream agriculture. The turbidity has been a concern, since this lake contains a significant population of the threatened *Galaxias tanycephalus*. However, Crook (1995) showed that high turbidity was persistent and strongly linked to low water levels and strong winds. This correlated with small particle size and high phytoplankton biomass. Macrophyte coverage was limited to sheltered areas (Hydro Tasmania, unpublished). A series of sediment traps were used to determine sediment resuspension rates at a range of depths. Initial results indicate that resuspended sediment is largely composed of organic material and rapidly falls out of the water column. Maintenance of higher water levels and expansion of macrophyte beds across the lake may have reduced sediment resuspension. Chlorophyll *a* concentrations were generally low during the study period. Nitrogen and phosphorus concentrations indicate that the lake is oligotrophic. Our conclusion, based on the sediment trap data, is that turbidity levels in the lake are no longer a concern, unless there are major changes to macrophyte persistence or water levels.

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Tracing water quality changes in water level manipulated lakes in central Tasmania using high resolution core scanning and isotopic dating techniques

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Great Lake and Woods Lake, located on the Central Plateau of Tasmania, are shallow lakes that are water level manipulated by Hydro Tasmania for power generation and irrigation supply. This has led to concerns regarding the ecological stability of these lakes under varying water levels. Hydro Tasmania has been maintaining and recording lake levels since their damming in the early and mid 1900s: Water level measurements for Great Lake exist since 1916, and for Woods Lake since 1968. These unique long-term water level records show that both lakes underwent significant water level fluctuations over the past few decades. In this project we reconstructed the history of sedimentation during the past 150 years to investigate changes in nutrient fluxes since and prior to damming of the lakes in the early 1900s, using ^{210}Pb dating techniques and high resolution X-ray Fluorescence core scanning (ITRAX). Most lakes in Tasmania are not suitable to

investigate recent (<150 years) changes in environmental conditions due to extremely low sedimentation rates. However, the damming of Woods Lake and Great Lake has caused significant increases in sedimentation rates, making them also suitable for investigating changes in atmospheric deposition of anthropogenic pollutants. Our results suggest that water level changes due to water level manipulation since the damming of the lakes have not significantly affected the ecological functioning of the lakes, but the damming itself increased sedimentation rates and burial rates of nutrients (nitrogen, phosphorus). ^{210}Pb dating has also revealed that sediment resuspension does not occur to a depth >1 cm, even at times of low lake levels. Comparison of sediment core proxies (e.g. for water temperature) with 3 decades of water column data demonstrates the limitations of such proxies for paleo-climatology.

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Effects of a fish kill on water quality; potential impacts from the release of the Cyprinid herpesvirus as a biological control for carp.

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Outdoor mesocosm experiments in a reservoir were used to examine the changes in water quality and the response of bacteria and algae to increase loading of dead fish biomass that simulated a release of the Cyprinid herpesvirus-3 (CyHV-3) as a biological control for carp. A series of replicated manipulations conducted between November-December 2016 demonstrated the effects of a large fish kill at different biomass concentrations. We found dissolved oxygen dropped to zero within four days in all treatments. There was an increase in E.coli and total coliforms in all treatments with dead carp. There was an increase in total nitrogen and total phosphorus with increase in biomass of dead carp. There was also increase in total algal counts in all treatments with dead carp. The excess in nutrients from the dead fish was utilised by algae and dominated by *Chlamydomonas sp.* followed by *Scenedesmus sp.* The timing between bacteria dominated and the algal dominated was determined by the amount of fish biomass. These results show that a fish kill at high biomass volumes can have serious detrimental effects on water quality over the first month.

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Food web responses to hydrologic regimes in floodplain rivers

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Environmental water is used to restore elements of the hydrological regime altered by human use of water, yet there has been little specific empirical evidence showing how river-floodplain trophic dynamics interact with hydrological regimes or research on incorporating food-web and trophic dynamics into the monitoring and evaluation of environmental flow programs. The Environmental Water and Knowledge Research (EWKR) program sets out to better understand the links between hydrology and aquatic food webs to inform the adaptive management of water in the Murray Darling Basin, Australia. We present a model conceptualising how hydrological regimes affect energy production and transfer in river-floodplain systems, and develop a generic framework for incorporating trophic dynamics into monitoring programs to identify the food-web linkages between hydrological regimes and population-level objectives of environmental flows. We identify key opportunities underway as part of the EWKR program for further research to enhance the conceptual basis and empirical knowledge underpinning trophic dynamics in river-floodplain systems. An improved understanding of how the hydrological regime influences spatial and temporal patterns of production and the movement of energy through river-floodplain networks is essential to determine whether the restoration of flow regimes through environmental flows will achieve targeted ecological outcomes for high-order consumers.

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A predicted change in the amino acid landscapes available to freshwater carnivores

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Anthropogenic impacts lead to non-random alterations to macroinvertebrate communities, which in turn may lead to alteration of the 'micronutrient landscapes' experienced by higher consumers. Given the fundamental roles of amino acids in biochemical processes, understanding how amino acid composition varies among taxa and guilds is an essential step towards predicting how micronutrient landscape alteration will affect carnivores. In this study, we determined 1) whether wild macroinvertebrate prey varied in their amino acid compositions; 2) whether this variation in amino acid composition was correlated with functional feeding groups, or simply due to phylogeny; and 3) whether anthropogenic change in the composition of macroinvertebrate communities affects the amino acid composition of the nutrient landscape. Amino acid composition varied significantly among taxa and correlated strongly with phylogeny, but not functional feeding groups. Simulated deterioration of macroinvertebrate communities changed the amino acid landscape, resulting in lower availability of threonine, phenylalanine, proline and tyrosine to carnivores. Our work suggests that amino acid availability to carnivores is likely to respond largely to the loss of taxonomic lineages rather than loss of a prey functional feeding group. Our study provides a critical first step towards understanding how changes to macroinvertebrate communities will affect the availability amino acids to higher consumers.

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The effects of the common Carp (*Cyprinus carpio*) and Weather Loach (*Misgurnus anguillicaudatus*) on emerging zooplankton community abundance and composition

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Zooplankton are a valuable food source for both native and exotic freshwater fish species and play a key role in the survival of species during larval and juvenile phases. Fish can alter the abundance and community composition of zooplankton, via a number of mechanisms including sediment disturbance, predation and altering nutrient water chemistry. This study describes the impact of the common Carp (*Cyprinus carpio*) and Weather Loach (*Misgurnus anguillicaudatus*) on the abundance and composition of emerging zooplankton communities. Using replicated mesocosms, the experiment was designed so that the three main effects of Carp and Weather Loach on zooplankton (sediment disturbance, water chemistry and predation) could be studied individually and as a whole. Total zooplankton abundances increased in the presence of both Carp and Weather Loach in comparison to the Control treatment. Zooplankton community composition was also altered in the presence of both Carp and Weather Loach in comparison to the Control treatment. Overall increases in abundance were driven by shifts towards rotifers which increased and declines in cladocerans. The cladoceran *Moina micrura* appeared to be particularly sensitive to Carp and Weather Loach. It was dominant in the Control treatment and absent in the presence of both fish. Our findings show that Carp and Weather Loach can have profound impact on zooplankton communities. They impact both directly and indirectly, by predating larger cladocerans, altering emergence from sediments and potentially increasing abundances through altered nutrient water chemistry.

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Longitudinal trends in land-use, spatial subsidies and food-webs of north-eastern Victorian perennial streams.

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Spatial subsidies are resources that flow from one ecosystem to another, either actively in terms of dispersing organisms or passively as a result of abiotic factors. The seasonal emergence of aquatic invertebrates, for example represents an active spatial subsidy. Adult aquatic invertebrates disperse from stream systems and become available as a food source for terrestrial predators, such as spiders and insectivorous bats. Conversely, the shedding of leaves and bark from riparian trees represents a passive spatial subsidy. Wind conditions and flooding regimes transport resources otherwise suspended in terrestrial systems, into adjacent streams. This process then couples these ecosystems by providing allochthonous (external) resources that are energetically significant to local consumers. While the flow of resources is an ecologically significant process, disturbance and habitat fragmentation disrupt these linkages. According to the 2016 State of the Environment Report, as much as 60% of native vegetation has been cleared with significant flow-on effects in local food-webs. This study seeks to investigate trends in land-use and aquatic spatial subsidies along a land-use gradient, and how they influence community dynamics of terrestrial consumers (i.e spiders) in north-eastern Victorian perennial streams. We used digital canopy photography to characterise vegetation structure as well as light and sticky traps to quantify aquatic invertebrates emergence. Spider communities were also surveyed as vector for aquatic resources to entered terrestrial systems. We found a close association between vegetation structure and invertebrate communities. These surveys forms the first phase of an on-going project relating to food-web responses and habitat fragmentation.

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Aboriginal Water Rights: A path to national reform

Virginia Marshall

The Australian Government through its statutory research corporation, Land and Water Australia, identified that a key theme emerging from their literature review on the effective engagement of Indigenous peoples in natural resource management, was the 'nexus' in the Indigenous relationship between land, water and health. My doctoral thesis research identified that Aboriginal water values exhibit far more than symbolic expressions of Aboriginal peoples' relationship to the land, the waters and resources; they are a life-blood connection of Aboriginal identity. I argue that any government interest and policy shift towards acknowledging the concepts of Aboriginal cultural values in water is a result of the activism and the increased agency of Aboriginal peoples and their peak bodies. The incorporation of Aboriginal values in water within the framework of national water reforms did not occur until Aboriginal organisations urged government to recognise Aboriginal rights and interests. An Aboriginal 'ecological' economy has always existed through barter, trade and environmental stewardship. The First Peoples in Australia maintain the oldest continuing cultures in the world, and are knowledge holders of ancient science, intergenerational water management and familial connection to the creation of the tangible and intangible. However, the national water blueprint, the National Water Initiative, includes only three discretionary clauses on Aboriginal water requirements. Professor John Burrows, international legal scholar, Anishinabe/Ojibway and member of the Chippewa of the Nawash First Nation in Ontario, Canada, argues that Aboriginal rights are continually 'downgraded and infringed by governments and the courts' in order to 'dictate how the laws and traditions of Aboriginal peoples can be reconciled with non-Aboriginal interests'. In this changing world of climate change, the lack of geo-political stability and the unrestrained exploitation of natural resources coupled with global water scarcity, I argue that the case for securing Aboriginal water rights across Australia has never been more critical.

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TBC

Sonia Cooper

***Not Available at time of print*

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How development has effected Murrawarri Cultural Values on the Culgoa and Bokhara Rivers.

Fred Hooper[1]

1. Northern Basin Aboriginal Nations, Tamworth

The Culgoa and Bokhara Rivers head waters are the Condamine and Balonne rivers which have their beginning around Warwick in Southeast Queensland and runs into the Darling River just northeast of Bourke in NSW.

The Northern Basin Aboriginal Nations (NBAN) represent Sovereign First Nations of the Northern Murray Darling Basin. It was established in 2012 so that First Nations can have input into the Murray Darling Basin Plan and to represent First Nations of the Northern Basin on a Federal, State and Regional level on water and other issues. The Murrawarri Nation is a member of NBAN and is one of 22 Sovereign First Nations. The Murrawarri Nations is 85,000 square Kilometres straddling the NSW and Qld Boarder in the western and southwestern part of both those States. The heart of Murrawarri country is Weilmoringle on the Culgoa River, The eastern Boundary of the Murrawarri Nation is the Bokhara River where the township of Goodooga is situated and also have a very significant Murrawarri population. These two communities have been effected by the development up stream over the past 30 years. Members of the Murrawarri community has observed changes in the rivers over the past 30 years which included lower and non-existent river flows, longer periods between flows, changes in water quality and loss of fish species etc. The Northern basin Aboriginal Nations is involved in the Cultural Flows Research Project and one of the trial site for component 4 was Gooroman Swamp at Weilmoringle on the Culgoa River. In this presentation I will present some of the findings of that research. This presentation will cover what the Murrawarri have observed over the years, Some Murrawarri Cultural Values, Our responsibilities under Law and development threatens these value. It will also cover how the Northern basin review is contributing to these threats.

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Australia's First Peoples water values and knowledge, and the challenge to fit into the ever changing cycle of water politics.

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Australia is still the driest inhabited continent on earth, and still the traditional lands of its original inhabitants the First Peoples for thousands of generations, because of their knowledge of water in the landscape. This reliance on surface water and groundwater, has been the case for generations primarily to ensure their survival in a dry landscape using traditional knowledge to find, re-find and protect water, this is a high priority as it is a cultural obligation to do so. The ongoing challenge ahead for Australia's First Peoples is to keep up with the ever changing cycle of water politics which may include changes in government or departmental leadership, changes in government names, new policy and legislation, new terminology, environmental water allocations, legislation "fixes" and increases and/or decreases in sustainable diversion limits. To maintain relevance First Peoples must have the opportunity to identify their water dependent cultural values and fit them into water policies and planning to ensure their value and relationship with water are heard and not diminished.

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Indigenous water allocation – a New Zealand perspective

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Like many First Nations Peoples across the world, Ngāi Tahu and other Iwi have yet to establish ownership, or gain reliable access to, the freshwater resources of Aotearoa. The current freshwater allocation model under the Resource Management Act (1996) locks in the historic "first in, first served" system and largely denies traditional owners access to this resource. To recognise Iwi's rights and interests in freshwater a new approach may be needed – one that moves away from allocating water based on (recent) historic use and property rights, provides a pathway towards the social, cultural and economic health for mana whenua, and yet recognises the political and social landscape that it must operate within. A possible method to achieve this may be the adoption of a "water market" system that is decoupled from property rights and uses some of the existing mechanisms established under the Ngāi Tahu Claims Settlement Act (1998) and other similar Treaty of Waitangi settlements. Under this system, the economic burden of transition to indigenous ownership is not shouldered by the local community, yet the Crown is able to give effect to its Treaty responsibilities around freshwater allocation. In developing this approach, it is important that we not only recognise opportunities, but acknowledge the risks and learn from the experience of other indigenous communities in using market-based systems in freshwater management.

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Mahitahi: Cultural Health Monitoring and co-management frameworks between Iwi and local government

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Since the traditional waka (canoes) came to rest on New Zealand shores Māori have been collecting knowledge (Mātauranga) and understanding of the natural world. In developing New Science for a Changing World, it is essential that we are able to also acknowledge the "old science for the changing world" New Zealand resource management is driven largely through the various legislative documents detailing our responsibilities. One key responsibility in New Zealand resource management is the inclusion of indigenous values. This provides the landscape that is enabling the exploration of the interface between mātauranga māori and "western science". The relationship between regional authorities and mana whenua (local māori who have authority over the land) is changing and the move towards a true partnership space where mana whenua can successfully engage in operational kaitiakitanga (environmental stewardship) and contribute to the decision making process! There is an increasing need to reassess the basis of the traditional relationships and explore new ways work towards shared objectives and mutual benefits. Greater Wellington Regional council (lower North Island) has been developing a process to encourage and enable cultural/Kaitiaki monitoring that will address capacity and capability questions as well as moving to a true mutual benefit model. Although this process is on-going there is already a lot of valuable learning to help the wider cultural monitoring conversation across New Zealand.

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Investigating the links between feral ungulates, billabongs and Indigenous health.

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Freshwater ecosystems across northern Australia are significant places for Indigenous communities as food and drinking water sources, as well as cultural and recreation sites. Feral ungulates, including Asian water buffalo (*Bubalus bubalis*) and pigs (*Sus scrofa*), are prevalent throughout The Top End of the Northern Territory and, due to their foraging and wallowing behaviors, they increase the turbidity of waters and excrete zoonotic organisms that are pathogenic to humans. *Cryptosporidium* and *Giardia* are the most common cause of waterborne gastroenteritis throughout the world. They are transmitted via the faecal-oral route, through contact with other people, animals, water, food and contaminated environments. When compared with other developed countries with similar surveillance systems, Australia has the second highest reports of cryptosporidiosis, after New Zealand. Reported rates of cryptosporidiosis in Australia share distinct geographic and demographic patterns in favour of warm, remote areas with high Indigenous populations. *Giardia* is also disproportionately represented in remote Indigenous populations. The aim of this study is to build a cross cultural knowledge base of the environmental impacts and health implications of sharing freshwater ecosystems with feral ungulates, via the use of local Indigenous Knowledge and Western Science techniques around the remote Aboriginal community, Ngukurr in the Northern Territory. The research involves interviews with local elders to understand perceptions of threats and how people assess water quality and safety. It involves microbial source tracing methods using PCR and DNA sequencing, which uses molecular characterisation to determine species specific and sensitive microbes making is possible to attribute microbial species to a host source and determine zoonotic potential. Considering the disproportionate representation of enteric disease in remote Aboriginal communities from the Northern Territory, determining the potential role of billabongs in environmental disease transmission will be valuable for Aboriginal communities across Northern Australia.

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The Aboriginal Riverkeeper Team Project, Georges River, Sydney

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Australia is both the driest inhabited continent on Earth, and home to the longest surviving culture, that of Indigenous Australians. Aboriginal water and stream management knowledge builds off millennia of continuous connection to, and caring for Country. Through the process of colonisation there has been significant disruption to Aboriginal culture and knowledge. To mitigate this, efforts are being made to reconnect and strengthen both Aboriginal peoples, and Country, through a variety of programs. One such environmental program is the Aboriginal Riverkeeper project that operated within Sydney's Georges River catchment between 2014-2017 and employed and trained a small team of Aboriginal people in ecological restoration with strong Aboriginal cultural components. With the Georges River as a focal point, the Aboriginal Riverkeeper project extended from Saltwater Bidigal Country in Botany Bay, to Fresh/Sweet water Dharawal Country near Campbelltown and Appin. During the three years the Aboriginal Riverkeeper Team achieved numerous environmental outcomes such as: bush regeneration, weed removal and increased habitat. The eight young Aboriginal trainees also engaged in deeply personal development of their Aboriginal identities which was facilitated by establishing regular cultural days throughout the project which saw the trainees spend time with Aboriginal Elders, knowledge holders and Local Aboriginal Lands Councils to learn about local Aboriginal history, culture and connections to Country. Through this culture-rich traineeship, the project continued the concept of Indigenous Caring for Country in a modern and highly urbanised setting, in this case, south-western Sydney which is also home to a large and young Indigenous population - thus targeted traineeships also positively contribute to long term social benefits for this community. This paper reviews the project and explores some lessons learnt, it reflects the project's successes and identifies how Indigenous knowledge of Country, including water, can be maintained through investment in Indigenous specific environmental programs like the Aboriginal Riverkeeper Team.

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Restoring remote wetlands in central Australia

Terence Abbott, Victor Dobson, Veronica Dobson

Alice Springs, ACT, Australia

In central Australia, the maintenance and restoration of waterbodies are often listed as the highest management priority by local Aboriginal Traditional Owners and rangers, often because these waterbodies have high cultural value as sacred sites and support local plant and animal species. For the past decade we have documented the severe degradation of central Australian waterbodies by large feral animals, mainly camels and horses. These waterbodies, large and small, have also suffered from a lack of active management by Traditional Owners and custodians, who historically cleaned out and protected these sites. The recent removal of large numbers of feral herbivores through various government programs has afforded an opportunity to restore some of these damaged sites. Terence Abbot and other Anangu Luritjiku rangers are leading the effort to restore Ilpili springs in the southern Tanami Desert, while Victor and Veronica Dobson are restoring springs near Ltyentye Apurte community. Terence, Victor and Veronica will discuss the history of their projects, the techniques they are using to clean out and rehabilitate the springs, and the ecological and cultural benefits expected from helping these fragile and rare sites. Restoration efforts such as these are essential if aquatic biodiversity is to be recovered and maintained in this arid region.

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Aboriginal engagement in Australia's water markets: A New South Wales case study

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Water markets are maturing significantly in Australia's Murray-Darling Basin and are beginning to spread to other parts of the country. Yet, very little research has examined the implications water markets may present for Aboriginal peoples and there is a real need to understand the current state of Aboriginal market engagement. In this presentation, I will share preliminary findings from interviews with Aboriginal organisations throughout New South Wales that have engaged in water trading in some capacity since 2004. Through describing the stories of these organisations and their unique experiences of water trading, I will address questions such as (a) why and how are Aboriginal organisations are engaged? (b) what or whom has helped or facilitated engagement? and (c) what obstacles,

barriers and difficulties have Aboriginal organisations encountered? I will conclude by exploring possible key opportunities the water market may offer Aboriginal organisations into the future, including opportunities that tie to environmental water and management.

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Lake Experiments to Test Early Warnings of Resilience Loss

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Inland water ecosystems can undergo abrupt change transforming rapidly to a different state. Theory indicates that a detectable loss of resilience may occur in advance of some state changes. Using time series data, rolling window measures of increased variance and autocorrelation approaching one are key indicators of pending changes. We tested this theory with two types of whole lake manipulations - apex predator additions and nutrient fertilization. Adding largemouth bass (*Micropterus salmoides*) gradually to a lake destabilized the food web. Warnings of a regime shift to dominance by piscivorous bass were evident in time series of phytoplankton, zooplankton, and small fishes more than a year before the transition was complete. No warnings were observed in an unmanipulated reference lake. Whole lake inorganic nitrogen and phosphorus additions were used to study early warnings of phytoplankton blooms. We developed an automated alarm system based on continuously monitored phytoplankton pigments and dissolved oxygen percent saturation. We observed alarms in two fertilized lakes prior to blooms. More alarms were observed prior to large blooms while weak blooms produced few alarms. We tested if we could reverse the effects of nutrients in response to warnings. Transition to sustained blooms was reversed by halting nutrient additions in response to alarms. Overall, the lake manipulations demonstrated the potential of early warning statistics to detect loss of resilience. Prior knowledge and models as well as the availability of reference lakes greatly aided application of the approach.

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Environmental DNA and Freshwater Biomonitoring: From promise to delivery, and future directions.

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Advances in DNA related technology hold significant potential for application to biomonitoring but also hold risks and challenges. An important advance has been the adoption of ancient DNA approaches for the detection of environmental DNA (eDNA) - DNA that exists in the environment. All organisms shed DNA and much finds its way into the environment and can be detected by sampling water, soil, air, or faecal material. This provides a non-invasive approach to biodiversity surveillance and holds considerable promise for applications such as the detection of rare species, presence of invasive species in the early phase of the invasion curve, or for whole community inventory. The main risks lie in inadequate delineation of the limits of detection leading to the potential for incorrect diagnoses of species presences or absences and in the inadequate databases and systems to fully interpret the information that emerges from multispecies DNA profiles. In order to overcome some of the implicit challenges, we have developed a framework to estimate the sensitivity of both the field and laboratory components eDNA survey methods, and can demonstrate how these can be used to estimate the overall sensitivity. We have applied this framework to species-specific eDNA surveys to estimate the sensitivity, or probability of detection, for three invasive aquatic species present in Australia; *Perca fluviatilis, Cyprinus carpio*, and *Misgurnus anguillicaudatus*. We have also developed a method for the detection of spawning in a threatened species, *Macquaria australasica*, and how eDNA can also detect the presence of terrestrial vertebrate species at water sources. Examples from each of these applications will be presented and how eDNA can potentially transform species monitoring with the overall caveat of robust, and scientifically defensible interpretation of results.

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The effect of a weir on stream insect drift

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Dams and weirs are a significant source of environmental degradation in rivers. One hypothesis explaining how they reduce species diversity is that dams and weirs are barriers (i.e. breaks in connectivity) to dispersal along rivers. Such connectivity can be pivotal to population persistence and also to restoration of degraded reaches. However, it is unknown whether and how dams or weirs block or impede dispersing species, hence diminishing the likelihood of successful downstream restoration. The aim of this study was to test whether and how a weir on a tributary of a regulated river impeded dispersal of stream insects. First, in order to understand the effects of a weir and its associated pool, we determined how drifting insects were affected by natural, slow-moving pools. Insect drift entering and exiting 13 natural pools was measured twice, autumn and early summer. Second, we measured drift entering and exiting a weir when the weir was over-topping. We then tested whether drift rates through natural pools differed from drift through a weir. We found the weir reduced drift to a greater extent than natural pools for three of five study species (*Offadens* spp., *Austrophlebioides* spp., *Austrosimulium* spp.), and the caddisfly, *Cheumatopsyche* sp. AV4, was significantly impeded only during early summer. The reduction was potentially caused by the interaction of drifting insects with the unique hydraulic character of the weir pool, where the water depth at the downstream end of the pool decreased abruptly due to the weir wall. This substantial alteration of flow profiles may have limited movement through the weir pool to insects drifting near the water surface. The obstruction of drift by the weir suggests that any attempts at downstream river restoration may become predominantly reliant on dispersal of flying adults from populations elsewhere within the river system.

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Urban influences on freshwater shrimp (*Paratya australiensis*) across two phylogeographic regions of Greater Melbourne

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The freshwater shrimp *Paratya australiensis* is often found in urbanised streams north and west of Melbourne, however, it is rare or absent from similarly disturbed streams south and east of the city. We wanted to know whether this difference was due to biological differences among populations of *P. australiensis*, or an effect of physiographic variation across the region. We applied phylogeographic distributions of *P. australiensis* in Melbourne to long-term presence absence

records (from both urban and non-urban streams). We then assessed the relative plausibility of five generalised linear mixed effects models (GLMMs) for predicting the occurrence of *P. australiensis*, in each region, that included effective imperviousness (EI) and four physiographic variables. We found that the two lineages of *P. australiensis* responded similarly to the effects of stormwater drainage (as indicated by EI). Thus, differences in occurrence of *P. australiensis* were related to physiographic variation rather than biological difference between lineages.

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The importance of pool microhabitats as dry period refuges for aquatic invertebrates

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Rivers systems globally are experiencing longer dry periods with increasing water demands and climate change. While persistent pools are widely identified as important refuges for biota during dry periods, little is known of the dynamics of within-pool refuge use by aquatic invertebrates and the limits to pools functioning as viable refuges. We investigated pool refuge use by aquatic macroinvertebrates under flowing and no-flow conditions, in a temporal study, predicting that persistent river pools would provide stable refuges from drying for diverse macroinvertebrates due to microhabitat heterogeneity. Macroinvertebrate taxa richness under no-flow conditions was equal to that of flowing conditions in persistent pools. Macroinvertebrates formed distinct assemblages between pool microhabitats (littoral, profundal, channel and snags) under no-flow conditions. Thermal stratification of pools appeared to provide refuge for taxa tolerant of low oxygen conditions. Specialised microhabitat use contributed to high overall diversity of aquatic invertebrates in persistent pools during dry periods, providing an important potential source for recolonisation when flow returns and providing buffering from climate and human-induced flow and temperature changes.

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Dissolved organic carbon composition differs between circumneutral and naturally acidic waters and climatic regions

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Dissolved organic carbon (DOC) plays an important role in both abiotic and biotic processes within aquatic ecosystems. DOC is often defined as: allochthonous (terrestrially-derived), and/or autochthonous (within the water body), dominant components generally classified as humic acids, fulvic acids and/or proteins. DOC from different waterways also differ in their aromaticity, and molecular weight. This study collected and characterised DOC from various climatic regions and freshwater types (circumneutral; naturally acidic; lentic and lotic waters) around Australia to investigate differences in DOC composition among freshwaters. DOC was characterised using optical methods: absorbance and fluorescence spectroscopy. Excitation emission scans followed by parallel factor analysis (PARAFAC) showed that Australian DOC was characterised by three main components: protein-like, fulvic-like and humic-like compounds. DOC quality varied between circumneutral and naturally acidic waters, and circumneutral waters were further categorised by climatic zones (temperate versus tropical). There was no observed difference in DOC quality between lentic and lotic systems. Naturally acidic sites were dominated by highly aromatic (as indicated by the specific absorbance co-efficient at 340 nm: SAC_{340} (32 - 53 cm^2 $mg^{-}1$) and the specific UV absorbance co-efficient: $SUVA_{254}$ (3.9 - 5.8 mg C^{-1} m^{-1})) allochthonous humic-like DOC of high molecular weight (as indicated by $abs_{254/365}$ (3.6 - 4.2)). In contrast, the circumneutral waters were dominated by more autochthonous fulvic-like DOC of lower aromaticity and molecular weight (SAC_{340}: 4 - 20 cm^2 mg^{-1} and $SUVA_{254}$: 0.8 – 2.9 mg C^{-1} m^{-1}; $abs_{254/365}$: 4.9 – 7.8). Tropical circumneutral sites were characterised by DOC higher in protein-like components, with lower aromaticity and molecular weight than DOC from circumneutral temperate sites.

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The effect of subsidence from long wall coal mining on the ecology and water quality of streams

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Underground long wall coal mining has the potential to impact on surface aquatic environments via subsidence, cracking of underlying rock and increased connectivity between surface and ground water. This would result in reduced surface water, changes in water chemistry (water quality) as a result of water flowing over newly cracked rocks and these changes may ultimately affect biota living in surface streams. Changes in macroinvertebrate, diatoms and water quality were investigated in streams which overlie long wall coal mining and thus potentially have subsidence. The study was conducted in headwater streams on the Woronora Plateau in eastern New South Wales, Australia where the geology is predominantly sandstone. Water depth and water chemistry, macroinvertebrate and diatom assemblages were analysed. Both reference and mined areas were chosen because they were otherwise relatively undisturbed. Trace metals were used as tracers of altered exchange between surface and ground waters as a result of subsidence. These metals are virtually absent from undisturbed streams but are released when groundwater flows through newly cracked sandstone of the study area. Li was detected in significantly higher concentrations at mined than reference sites. Sites downstream of mining also had significantly higher temperature and electrical conductivity, and concentrations of bicarbonate, barium, calcium, sodium, iron, and chloride. Edge and riffle macroinvertebrate assemblages at both mined and reference sites were dominated by chironomid dipterans. Significantly lower EPT (Ephemoptera, Plecoptera and Trichoptera) taxa richness (3.4 vs 5.5 and 2.4 vs 5.4, in edge and riffle habitat respectively), number of Trichoptera genus (7 vs 19 and 8 vs 22, in edge and riffle habitat respectively) was observed at mined sites relative to reference sites. Diatom communities also differed between mined and non-mined sites with significant reductions in abundance but a greater number of genus observed at mined sites.

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Challenges associated with the adaptive management of environmental flows in the MDB

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The Basin Plan is being implemented within an adaptive management framework in recognition of the uncertainty around the water requirements of all but a few key species. This presentation presents some observations on the challenges of adaptive management in the MDB derived from engaging with managers as part of the MDB EWKR project and implementation of the Commonwealth Environmental Waterholder's Long-Term Intervention Monitoring (LTIM). A survey of environmental water managers revealed they each have their own knowledge seeking methods and preferences, however, the most common strategy was to have conversations with a small number of trusted experts. This approach is effective because it enables water managers to quickly access information and apply it to their situation. The approach is most effective when management objectives are consistent through time and can be managed at a single scale. In contrast, implementation of the Basin Plan seeks to achieve a diverse portfolio of environmental objectives with the priority assets and outcomes varying through time in response to water availability, the condition of the system and constraints. In addition, the Basin Plan seeks to achieve outcomes at a variety of scales ranging from individual wetlands, through river valleys to the Basin as a whole. This complexity increases the risk that the information available from a small number of experts will not represent the best information available in terms of either achieving the relevant objective or contributing to the achievement of large scale objectives. Achieving effective adaptive management both across scales and to variable objectives will require refinement of the relationships between decision makers and knowledge custodians which will represent both a challenge and an opportunity for freshwater scientists.

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Validation of the success of feral pig management in tropical wetlands

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Feral pigs are a major threat to the ecological, social and economic values of aquatic ecosystems in northern Australia. They damage the natural environment, displace native species, impact on food resources used by Indigenous groups and reduce agricultural production. Resources used to control these feral pig impacts are extensive; however, there is little evidence that specific control activities are achieving their desired outcomes. This collaborative project within the Northern Australia Environmental Resources Hub of the National Environmental Science Programme aims to provide a conceptual understanding of the threats feral pigs represent to ecological values of wetlands in Northern Australia and what management controls achieve; and validate these concepts using targeted comparative research. Field research is taking place in the Archer River Basin in Queensland's Cape York Peninsula to take advantage of control fencing undertaken by Indigenous groups over the past five years. Initial results indicate that fencing can control the access of feral pigs to wetland areas and therefore limit the physical damage occurring in wetland areas. Further data collection in conjunction with management activities undertaken by Indigenous groups will provide for the detailed analysis of the most effective and efficient approaches and will define how to measure success in feral pig management. These measures and approaches can then be applied to other parts of Northern Australia and other areas where feral pigs are a threat to aquatic ecosystems.

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Are we on track? Developing plausible future trajectories for *Ruppia tuberosa* in the Coorong for assessing environmental watering targets

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Environmental watering plans, including those associated with the Basin Plan for the Murray-Darling Basin, frequently include quantitative environmental outcomes for the distribution or abundance of key taxa. For example, the Basin-wide environmental watering strategy includes outcomes for the distribution of, and number of seeds present for *Ruppia tuberosa* in the Coorong, to be achieved in 2019 and 2029, respectively. However, variation in local weather, changes in water availability and other factors interact to complicate any assessment of the trajectory of change through time. Thus, in many instances there is no objective method for assessing plausible future trajectories of change to determine whether the targets are likely to be met or not. In a collaboration with the Murray-Darling Basin Authority, we combined a number of existing tools in a novel approach to develop plausible future trajectories to determine whether *Ruppia* in the Coorong is on track to meet those targets. We used an existing hydrodynamic model for the Coorong linked to an updated life-history model for *Ruppia* (developed by CSIRO and SARDI Aquatic Sciences). We developed plausible baseline, wet, dry and moderate future scenarios and linked the likelihood of completing each life-history stage to existing monitoring data collected by the University of Adelaide. This enabled us to calculate an approximate extent and number of seeds for *Ruppia* in each future year to 2042. We then incorporated variability in response associated with local weather conditions using a Markov Chain approach. This approach resulted in a set of plausible future trajectories for *Ruppia* in the Coorong, enabling a scientifically-credible, transparent and objective method for assessing progress towards the relevant quantitative ecological objectives.

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Comparison of macroinvertebrate communities in concreted and non-engineered urban stream reaches

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Urban streams are degraded through multiple mechanisms, including severely altered flow regimes, elevated concentrations of waterborne contaminants and the loss of a mosaic of heterogeneous habitats. To counter urbanisation impacts, restoration resources are often directed at enhancing reach-scale habitat heterogeneity, because it is more tractable than management strategies requiring broader-scale actions. To assess the effect of reach-scale habitat structure on macroinvertebrates, we compared communities from urban reaches with natural substrates to those from engineered concrete channels, given that such engineering is a widespread and extreme case of habitat simplification in urban streams. The communities from all urban reaches were distinctly different from

more diverse communities in forested reference streams. The structures of communities in non-engineered and engineered urban reaches were generally similar, being dominated by hardy Diptera. Despite low habitat heterogeneity, engineered channels supported very high abundances of those hardy taxa, likely owing to nutrient enrichment. The family-level richness was only slightly higher in non-engineered reaches than in engineered channels, with similarly low SIGNAL scores indicative of major ecological impairment in both urban reach types. The results add weight to the growing evidence that in urban regions the provision of increased habitat heterogeneity at reach-scales is insufficient to support diverse macroinvertebrate communities without addressing catchment-scale changes in flow regimes, water quality and connectivity.

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Characterising the microbiomes of arid zone springs and waterholes

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Aridification has driven significant environmental change in central Australia over millennia. Most of the Australian continent did not undergo the extensive Pleistocene glaciation experienced in the Northern Hemisphere. Instead, ongoing aridification resulted in perennial freshwater systems in the arid interior contractingto isolated groundwater-fed springs and a network of intermittently flowing rivers. The latter exist as isolated waterholes for most of each year. We recently completed the first study of the microbiomes of arid zone outcrop springs and riverine waterholes in central Australia. Our results suggest that local, rather than landscape processes, are an important driver of the composition of the microbiomes at these sites. We found that the composition of biofilm microbial communities varied greatly within a site, whilst the water column microbial communities were more homogenous and displayed considerable site fidelity. A much larger spatial study (over the entire arid biome) is now planned to better understand the patterns and processes driving arid zone aquatic microbial communities.

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Regional seasonal seasoning; invertebrates in Paroo salt lakes

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Ephemeral saline lakes in Australia generally fill in the south in winter, but in the eastern inland they fill in summer. In both areas water lasts 4-8 months before evaporating to dryness again. The phenology of their invertebrates has been studied in two sets of southern lakes, but details are lacking for any remote inland set. For the Paroo, I examine the phenology of a summer fill in 1995 and compare it to invertebrate colonization in a rare winter fill in 2016. In the southern sites crustaceans dominated in winter and insects were absent or rare. In the inland, crustaceans dominated in both winter and summer fills, but insects were common only in the Paroo summer fill in 1995 and also towards the late spring of its 2016 winter fill. Also succession is more pronounced in the inland as salinity changes are more directional and severe. The meaning of these scenarios will be explored.

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The nature of the lower lakes and the MDB plan: time for some truth

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Lake Alexandrina lies at the end of the Murray Darling Basin. The 7000 year diatom record from core LA2 reveals that Lake Alexandrina was strongly influenced by tidal waters during the 5000-2200 year BP dry phase but these were relatively rare after as regional climates once again became humid. That said the greatest change in the condition of Lake Alexandrina over the last 7000 years was to a freshwater state which occurred after the commissioning of the barrages after 1940, which controlled the tidal flux, although 1946-76 was also characterised by an extended wet phase. At the time of its listing as a Ramsar site in 1985 it was described as being mostly fresh and this was reinforced in 2004 where it was described as being 'predominantly fresh' prior to European settlement based on anecdotal accounts. Saline invasions were considered unusual prior to 1900 and locals lamented the increasing salinity from 1902. This was attributed to drought and the increasing diversions in the upper course of the Murray and drove the decision to commission barrages from 1935-40 to prevent the inrush of salt water. The rainfall reconstruction from 1788 to present for south-east Australia (SEA) reveals the Interdecadal Pacific Oscillation to have been mostly negative in the 1800s driving a long term positive rainfall anomaly across SEA. This abruptly turned positive in 1899 driving a drought dominated phase through to 1945. As diversions were much lower than today, these anecdotes likely reflected a stepped change in climate. From 1997-2008 Australia experienced its worst historical drought at the end of an extended drying phase over millennial time frames. Historically, under these conditions (and those that lie ahead) the natural state of Lake Alexandrina would be a variable fresh-tidal system. The ongoing use of the barrages to prevent the inflow of marine water, even in extreme drought, and the allocation of scarce and highly contested fresh water flows to preserve a freshwater state ignores the multi-scale variability in the long term natural character of the lake and the prevailing influence of climate in regulating the interplay between fresh and marine waters.

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Mosquitoes and Multi-Criteria Assessment (MCA): Risk assessment for a large number of wetlands

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Introduction

In a changing world of urbanisation and climate change mosquitoes are an important consideration for wetland management. Mosquitoes can be a general nuisance to humans but certain species of mosquitoes are able to act as vectors for disease, posing a potential health risk. Mosquitoes breed in a range of waterbodies, these may vary in size, and permanency, with various habitat attributes. Melbourne Water has over 350 wetlands that have not been assessed for their mosquito risk, including natural wetlands, stormwater retention basins, sewerage treatment lagoons and billabongs. Most wetland sites have limited monitoring data for mosquito species and abundance. A robust and efficient way was required to assess the mosquito risk each wetland posed.

Methods

The approach was to use Multi Criteria Assessment (MCA) to prioritise the likelihood of high risk mosquito conditions at each site. Specific wetland characteristics were established that are known predictors of mosquito breeding likelihood. Weighting for the predictor variables was developed based on known thresholds and conceptual understanding of significance of each factor. Risk ratings of wetlands were tested with key mosquito managers in Victoria to validate findings and refine the results.

Outcomes

The use of MCA allowed for a large number of sites to be assessed for mosquito risk without the need for physical monitoring or assessment. Risk was defined for wetlands enabling prioritisation for management based on robust science and validated criteria. Knowledge gaps and sites with insufficient data were also identified during the processes allowing these sites to also be prioritised. The technique, allows for the data set and risk to be updated if there are wetland changes or more data becomes available. The approach demonstrates that MCA is an excellent technique for assessment of mosquito risk for a large number of wetlands when mosquito monitoring data is not always available.

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Science, adaptive management and Basin-scale environmental watering

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The *Water Act 2007* established the Commonwealth Environmental Water Holder to manage a large and complex portfolio of water entitlements to protect and restore environmental assets of the Murray-Darling Basin. Environmental water management on a scale created by the Murray-Darling Basin water reforms is unprecedented internationally. The management of a large water portfolio presents many opportunities and challenges in such a dynamic landscape – climatically, biophysically and politically. How we use and integrate science in the management of environmental water is critical to the success of the reforms. Environmental watering in the Murray-Darling Basin occurs in a working river system alongside other water users and competing interests. Managing large volumes of water is a working river basin operated primarily for human and productive water needs, requires careful consideration to avoid 3rd party impacts and in doing so requires a shift in approach to the engagement and involvement of science. With an increasing understanding of watering requirements of ecosystems and the potential for whole of system watering actions, the management of environmental water to deliver environmental outcomes has needed to continuously and rapidly adapt. Expectations from the community to demonstrate the effective use of environmental water to deliver ecological outcomes have increased with the making of the Murray Darling Basin Plan (2012) and the legacy of the millennium drought. Our ability to demonstrate and communicate the outcomes being achieved is dependent on scientifically robust and defensible science, as is our capacity to adaptively manage environmental water. The Commonwealth Environmental Water Holder's monitoring, evaluation, reporting and improvement framework along with the Long-term Intervention Monitoring program provide an ideal platform to build collaborative partnerships with scientists and the decision makers. Such partnerships will allow contemporary science to shape in real-time decision making, improving environmental outcomes both in the short and longer-terms – ultimately influencing policy approaches.

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Drugs in bugs: a wide diversity of PPCPs in aquatic insect and spiders

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Pharmaceuticals are important contaminants of concern in aquatic environments and are now detected in surface waters worldwide. However, the ecological impacts of PPCPs as well as their bioaccumulation potential (via trophic transfer) are not well understood. We sampled 6 streams across an urban-rural gradient seasonally for 2 years. Using a conceptual model based on two chemical traits, water solubility and metabolic transformation rate, we were able to predict which pharmaceutical compounds had the greatest potential to bioaccumulate. To test bioaccumulation predictions we collected freshwater insects and riparian spiders and analyzed their pharmaceutical concentration. PPCPs were detected in benthic freshwater insects and in riparian spider tissue; suggesting that some PPCPs do have the potential to bioaccumulate. Further, we then quantified the standing stock of PPCPs occurring in benthic freshwater insects (PPCPs/g insect/m^2) in order to calculate the flux of PPCPs to higher consumers via insect consumption. These findings raise important concerns regarding the fate of PPCPs in stream food webs and potential exposure risks to stream and riparian predators feeding on PPCP laden insects.

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Damsels In Distress: Effect of Water Quality and Disturbance on the Morphology of Coenagrionidae Damselflies

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Morphological deformities noticed, by Sydney Water taxonomists, in Coenagrionidae damselfly nymphs were believed to be more common in damselflies collected from the Botany Wetlands and were believed to be linked to a degraded environment. To assess this, damselfly nymphs were collected from five sites located in the greater Sydney area. Sampling occasions over three seasons consisted of a 3 minute sweep net followed by a 20 minute collection of damselflies. Damselflies were then inspected under a microscope for Antennae, Prementum Setae, Lateral Setae and Palpal Setae deformities. Physico-chemical water parameters were measured each sampling occasion. Water and soil samples in spring for chemical analyses. Results of Analysis of Variance (ANOVA) showed no significant difference in overall deformity occurrence between sites. Results of the first collection showed deformity occurrence in Botany Wetlands Pond 3 (BWP3) was significantly greater than the Hacking River while deformity occurrence in the second collection did not differ significantly between sites. A Chi – square test indicated that the relationship between deformity occurrence and site was not random. Principal Component Analysis of environmental parameters indicated that physicochemical parameters had a positive relationship with deformity occurrence with overall deformity and Prementum setae deformity displaying significant correlations with pH. Results of this study indicate that there could possibly be a link between deformity occurrence and environmental conditions, although it is not conclusive in regards to what the main drivers of such deformity are.

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Macroinvertebrate community succession under variable flow regimes in subtropical Australia.

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Seasonal changes in hydrology are important in influencing abiotic conditions and subsequently the biota. Whilst these impacts have been studied in tropical catchments and in central arid Australia, subtropical ephemeral streams have largely been ignored. This research studied three ephemeral streams in Central Queensland over 15 months. We hypothesised that macroinvertebrate abundance would gradually increase following the initial flow pulse and that abundance would increase until the pools began drying with sensitive taxa only present during higher flow. A total of 69 Families from 14 Orders were collected in 128 samples. Significant relationships were not detected between low flow conditions and taxa richness ($P > 0.05$). Principal component analysis showed that the macroinvertebrate communities did not change in response to the drying of pools. Significant differences were not observed between taxa richness, abundance nor tolerant taxa during varied periods of flow ($P > 0.05$). Sensitive taxa were most abundant during high flow periods with comparatively less abundance during no flow and drying periods. This study provides novel information on the flow-linked succession of macroinvertebrate communities in subtropical ephemeral streams and the results are important in informing the development of riverine indices and models used to manage subtropical environments.

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Using fractal dimension to capture ecologically-relevant physical variation in streams

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Increasing complexity of physical structure in an environment creates a greater diversity of resources, and results in higher species diversity. This pattern begs an explanation, but quantifying physical complexity is difficult. Most measures are intrinsic to particular ecosystems, but this system-specificity precludes general tests of hypotheses and comparisons among ecosystems. A 'universal' method for quantifying physical complexity is a measure called the fractal dimension, which has values lying between the well-known dimensions of 1, 2 or 3 (line, surface and volume). Fractal dimensions are increasingly used in aquatic ecology to describe complexity of patterns. Various geomorphological aspects of river channels are known to be fractal, but few studies have examined physical features that have direct ecological consequences. Emergent rocks are essential egg-laying sites for many stream insects and thus are vital resources for their populations. Previous research shows that insect abundance and diversity varies with the supply of emergent rocks over some scales. In this study, we tested whether the spatial distribution of emergent rocks can be described as fractal over long stream lengths (~700-1000 m), in seven streams across two countries (Australian and Scotland). Fractal dimensions ranged between ~0.7 and 1.0, which reflected regional differences in lithology, particle size and shape (platy-shaped sedimentary rocks vs. more equant or spherical igneous rocks), and also channel-specific constraints on the development of longitudinal structure (e.g. interruptions to riffle-pool sequences). Our findings therefore illustrate the utility of fractals for capturing variation in physical structure in the environment, enabling appropriate comparison across streams and countries. Importantly, fractal dimensions were constant for each river over two to three orders of magnitude, which suggests that the distribution of emergent rocks will appear consistent to flying insects at the scales over which they search.

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New directions in monitoring, reporting and evaluation for the Victorian Waterway Management Program

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Victoria's strategies for the management of land, water and biodiversity are supported by evidence-based decision-making. The government's new *Water for Victoria: Water Plan* provides a plan for a future with less water as Victoria responds to the impact of climate change and growing population. Policy directions for improving waterway and catchment health focus on protecting waterways and their catchments from the adverse impacts of future human use and major investment of $222 million over four years to improve the health of priority waterways and catchments. Management and investment effort will be focused on large-scale projects for 36 waterways, with 10 of these trialling a new approach to track progress towards management objectives and report back to communities, incorporating citizen science. Victoria is establishing a waterway research hub to support a more coordinated, strategic research and monitoring approach that will improve information and knowledge about catchments and waterways. Existing waterway health monitoring programs will be refined to have a better mix of evidence to support continued improvements in decision making and a greater focus on monitoring the changes that result from management actions. Demonstrating the progress and value of management efforts back to communities will increasingly include information on social, cultural and economic benefits arising from waterway management.

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Victorian environmental water monitoring and assessment in a policy and management context

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The development and implementation of environmental watering programs in Victoria is a collaborative process between state and commonwealth government agencies, land managers and water authorities. Understanding how to maximise the benefits of environmental watering requires the support of robust ecological data, and underpins the evidence-based decision-making processes used in policy development and environmental water management. Monitoring ecological responses to environmental water is required to evaluate whether management objectives are achieved and to inform ongoing improvement to the efficiency and effectiveness of environmental water planning and delivery within an adaptive management framework. The Victorian Government funds two state-wide environmental water monitoring programs, the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) for rivers, and the Wetland Monitoring and Assessment Program (WetMAP). These monitoring programs are based on the latest scientific knowledge and conceptual understanding of ecological responses to managed water regimes and inform the development and adaptation of Victoria's Seasonal Watering Plans and Environmental Water

Management Plans. VEFMAP and WetMAP also play a key role in communicating the value of environmental water to a broad range of stakeholders, including the Minister for Water and the Victorian community. This presentation will outline the framework of Victoria's environmental water monitoring and assessment programs in a policy and management context.

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Environmental flow responses of fish populations in Victorian tributaries of the Murray River

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Recent research suggests that immigration and dispersal is a key driver of population dynamics of some native fish species in the southern Murray Darling Basin, with this process likely linked to patterns of hydrology. As such, a key objective of environmental watering across several rivers in the southern MDB includes flows to enhance migration or dispersal opportunities, to potentially assist population recovery. Here, we report on the findings of a joint Murray Darling Basin Authority/Victorian Environmental Flows Monitoring & Assessment Program project aimed at assessing the outcomes of coordinated environmental flow releases, spanning multiple jurisdictions and waterway managers, on facilitating movement of native fish into and throughout tributaries of the Murray River. Early findings suggest a positive response in both immigration of juvenile fish from the Murray River and dispersal throughout tributaries. Whilst continued monitoring of a range of flow conditions and long term population outcomes is required, we suggest appropriately designed and coordinated environmental flows, across river networks represent an important targeted management action to promote tributary fish population recovery.

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Building the evidence base underpinning riparian management in Victoria

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Victoria's strategy for waterway management is framed around the central ideas of evidence-based decision making and adaptive management. Investment and management programs for Victoria's waterways must be able to demonstrate the impact and effectiveness of on-ground activities in achieving management outcomes. To date there has been only modest and haphazard progress in gathering evidence that builds confidence in the effectiveness of management interventions. In response, a long-term, state-wide riparian intervention monitoring and research program has been developed that will: (i) provide rigorous evidence of riparian responses to management, (ii) understand sources of variability due to local and landscape contexts and (iii) improve conceptual models of expected outcomes of riparian management. The program has established 32 paired intervention and control sites across Victoria since 2014 where riparian vegetation condition and bank stability attributes are monitored before management and up to 10 years following management. Management interventions examined include weed control, livestock exclusion and revegetation. To provide early insights of long term responses to management, the program has used aerial imagery to assess rates of change in woody cover over time at 20 past intervention sites across the state that are up to 15 years old. An overview of the program and preliminary results will be discussed.

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The geomorphic influence on riparian seed banks

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Erosion is a natural process which provides a source of riverine seed bank materials. It allows seed banks to be re-distributed and rejuvenated across different geomorphic features within a river corridor. Erosion mechanisms are generally a combination of highly visible mass failures and less evident fluvial scour or stripping of floodplain surfaces. When considering water quality, mass failure is considered the dominant source of sediment. However, fluvial scour and stripping of floodplain surfaces are capable of contributing as much or more sediment. Thus, scour and stripping may be greater drivers of seed bank dynamics. This study divides the river channel of the Upper Brisbane River into geomorphic features and examines the relationship between these features and their associated seed banks. The aim of the study is to determine the relative contribution of sediment from these features and examine the capacity of erosion mechanisms to form or restructure their associated seed banks. Five surfaces were identified associated with the compound channel of the Upper Brisbane River, with only three of the five features currently reworked by contemporary fluvial processes. These include a floodplain, inset floodplain and active bedload material. Our results indicate that fluvial scour and floodplain stripping from the inset floodplain yielded nearly twice the fine sediment volume as sediments derived from mass failures from the floodplain. These results suggest that the seed banks of the inset floodplain may be more diverse. We will present a characterization of the geomorphic features within the compound channel along with preliminary findings of a seed bank study of the geomorphic features.

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Effective restoration strategies in rapidly changing subtropical river systems

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In early 2013 the city of Brisbane came within a few hours of running out of drinking water – why? The Brisbane water supply is threatened by sediment and nutrients from upstream agricultural catchments, with the problem exacerbated in wet years. World-wide river restoration is a multibillion-dollar industry with annual expenditure in Australia alone estimated at around $100 million. There are two main drivers for river restoration: the protection and improvement of

drinking water quality and general aquatic ecosystem health. In Southeast Queensland (SEQ) the water authority (Seqwater) is committed to protecting supply by establishing catchment riparian vegetation that will both reduce erosion rates, but will also trap sediment before it reaches the waterway. While intuitively sound, the scientific evidence to support this management strategy at the scale of intervention required (i.e. catchments) is poor. Previous research indicates that nearly 70% of the region's sediment loads originate from less than 30% of the catchments. However, little research has been conducted into the specific areas that contribute most sediment. Even less research has been conducted beyond simple vegetation mapping, into the ecology of riparian vegetation in SEQ specifically, or subtropical river systems in general. In particular, there are considerable knowledge gaps concerning the capacity for passive regeneration of riparian vegetation and the resilience and recovery of established or establishing vegetation in the face of flood disturbances, and weed invasion. Such knowledge is critical for informing restoration decisions regarding approaches to revegetation in different locations at different times. This paper explores the links between fluvial disturbance and riparian vegetation traits and outlines restoration trajectories for riparian vegetation in sub-tropical streams, with a special focus on reducing sediment and nutrient pollutant loads.

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Rivers behaving badly? The influence of fluvial geomorphology on aquatic ecosystem metabolism

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Metabolic processes are critical for carbon cycling and trophic dynamics in rivers and wetlands. Gross primary productivity of phytoplankton (GPP) and planktonic respiration (PR) – together, aquatic ecosystem metabolism – fluctuate spatially and over time due to variations in channel morphology, flow, inundation, nutrients, microbial diversity, and other factors. The balance of GPP:PR determines whether an aquatic ecosystem exhibits net autotrophy (i.e. carbon consumption) or net heterotrophy (i.e. carbon production). Rivers tend to be viewed as efficient transport pathways of energy, and they act as meta-ecosystems and downstream conveyors of organic carbon in the landscape. However, we question generally accepted models of biophysical controls on carbon flux in rivers when systems suffer from major biophysical disturbances, or do not exhibit commonly assumed downstream trends in biophysical conditions and processes. We draw on examples from inland and coastal catchments of New South Wales to highlight 1) the role of channel enlargement as a disturbance mechanism, and 2) non-conformity of longitudinal biophysical conditions in rivers with significant wetlands, both of which appear to significantly effect aquatic ecosystem metabolism within in-channel habitats. Our findings show that 1) GPP and PR can be enhanced in enlarged reaches leading to a dominance of PR and greater heterotrophy than in intact reaches; and 2) downstream changes in GPP and PR do not necessarily lead to persistent increases in PR and declines in net ecosystem production (GPP – PR), rather, that distinct peaks, troughs and threshold values of GPP and PR can be identified and are important. While we know that the short-term response of carbon, nutrients and planktonic communities to flow and inundation can be highly variable, there is a pressing need to characterise the variability of and relationships between hydrological, geomorphological and biological conditions in rivers and wetlands, as well as their abiotic controls.

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Relationships between diatom communities and environmental attributes in Cape York wetlands

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Previous studies have shown that diatoms are sensitive to environmental changes in aquatic ecosystems and therefore can be as useful indicators for biological monitoring and assessment. These known sensitivities have also been used in palaeoenvironmental studies to infer past habitat conditions from dated sediment layers where the fossils of diatoms are present. However, identified relationships are often not transferable spatially across the landscape and the use of diatoms is often limited by available information specific for a region. We collected diatom and associated environmental data with the aim to investigate relationships between diatoms and environmental conditions in Cape York wetlands and where possible develop inference models for use in future palaeoenvironmental investigations. 238 species from 53 genera were identified from 52 samples across sites from 16 catchments in Cape York. Multivariate analyses showed that nine collinear variables had a significant relationship ($p < 0.5$; $r^2 >= 0.5$) with the diatom species ordination. Species environmental optima and preferences were used to develop weighted averaging models for inferring values of Conductivity, Total Alkalinity, Bicarbonate and pH. The developed models had high Goodness of fit (e.g. $r^2 > 0.9$) and cross validation showed good predictions ($r^2 > 0.65$). A test dataset (21 sites) for validation of conductivity predictions showed good results ($r^2 > 0.65$). This information provides a tool for future investigations to reconstruct past conditions from diatom fossils identified in Cape York wetlands.

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Are all rivers equal? Perceptions of ecosystem services and values across three continents

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Temporary rivers are prevalent yet often under-protected and overlooked. This may be because society holds them in low esteem, combined with inadequate understanding of their ecosystem services. Evidence of such perceptions, however, is scant, rendering this assumption largely untested. We investigated the validity and extent of this assumption by surveying undergraduate students from Australia, the UK and USA on their agreement or disagreement with positive statements about perennial and temporary rivers, and specifically temporary rivers when they cease flow. Survey statements concerned perceptions of the aesthetic value, recreational amenity and biodiversity of rivers, and their provisioning of ecosystem services; levels of concern over water removal and using rivers for human activities; desires for conservation and restoration action; moral obligations to maintain river condition; and reactions to harming rivers. Students were surveyed at the start and end of teaching units, which covered general ecology and biology or focused on freshwater ecosystems. Disagreement with statements was uncommon and perceptions of temporary rivers were mostly positive. However, perennial rivers were valued more highly than temporary rivers, especially when the latter cease flow and regarding their aesthetic and recreational provisioning. Results were similar between repeated surveys, teaching units and countries. The overall positive response to statements, regardless of river type or survey round, may reflect underlying, environmentally aware attitudes of

students studying ecological and environmental science and management programs, but not necessarily specific knowledge of temporary rivers or education in freshwater ecology. This suggests some general environmental or ecological education across the wider community could improve the (assumed low) public perception of temporary rivers and support positive protection measures and innovative, inclusive management of these ecosystems.

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Waterwatch and citizen science: from better data and beyond

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The Waterwatch program was created as an educational program to engage the community with their local waterways. Over time the program has moved from a tool to increase scientific literacy about waterways to a scientific monitoring program performed by citizens looking at the water quality of local catchments. In the past five years there has been a concentrated effort to increase the integrity of the data collected by the volunteers of the Upper Murrumbidgee Waterwatch (previous ACT Waterwatch). The Waterwatch program delivers a number of science-based products based on the data collected by its volunteers; however the uptake of the data generated by the program by policy makers has been low. We will present the experience of Upper Murrumbidgee Waterwatch to improve data reliability, to secure long-term funding, and to ensure the long-term viability of the program by delivering products that can be accessed and used by community members and policy makers alike; and will discuss how to increase the corporate trust in the data originated by citizen science.

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Critical evaluation of smartphone apps as tools for water quality monitoring in SEQ inland waters

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Tools are required to assist water managers to support under-resourced in situ water quality monitoring programs. Citizen science is one solution to obtain data over wider areas, more often. Smartphone apps may provide a useful complement to traditional methods if reliable. Two such apps are EyeOnWater and Hydrocolor. **EyeOnWater** (http://www.eyeonwater.org) evaluates water colour using the Forel-Ule (FU) scale, a 21 level scale used to measure the colour of natural water bodies. Users take a horizontal photo of the water surface and match the water colour recorded to the FU scale. The result is uploaded to an international database of measurements. **Hydrocolor** (http://misclab.umeoce.maine.edu/research/HydroColor.php) uses an iPhone camera to measure surface reflectance. Users deploy a photographer's grey card and separately take images of the card, the sky and water surface at observation angles guided by the app. Using the three images, HydroColor calculates water body reflectance in the RGB colour channels and uses these to determine water turbidity in NTU based on relationships for North American waterbodies. We evaluated app performance using replicated measurements made in 13 reservoirs across SEQ and NSW covering a range of water qualities (Chl a from 2.5 to 180 $mg.m^{-3}$). The presentation will report on the performance and utility of the apps in comparison to separate determinations of high spectral resolution reflectance made using a Satlantic underwater spectroradiometer and water quality parameters measured from concurrent sampling. The value of such approaches for informing on water quality will also be highlighted using SEQ examples.

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The Algal Resource Kit; a new citizen science tool to increase monitoring for freshwater cyanobacterial blooms

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A new "Algal Resource Kit" has been developed that will allow expanded monitoring of cyanobacterial blooms across NSW. The kit will be distributed to community groups and interested parties such as council staff, fisheries, caravan parks and other recreational businesses near waterways to allow them to test for potential blooms. The kit comprises of several simple tests, sampling resources to send samples for testing and a new App that will allow the identification of scums.

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Evaluating the role of dispersal constraints: from one field experiment to a multi-site restoration programme

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Most restoration programmes seek to increase species diversity at degraded locales but few are successful. This failure could be caused by species' poor dispersal ability, unsuitable environmental conditions (including a lack of essential resources), or by the inability of species to "invade" established communities. However, most research has been unable to separate these different processes. In a recent multi-site experiment in Hughes Ck (Victoria), 26 of 54 common taxa responded to experimental retention of small packs of detritus (leaves, bark) on the stream bed, while 28 showed no response. During the experiment, we captured animals drifting into sites and numbers of winged adults present along stream margins. These data allow us to evaluate whether there were systematic differences in dispersal ability between responding and non-responding taxa. Many species were widespread along the creek and were found in the drift at many locations. Almost all species were found in the drift at some times of the year. However, non-responders inhabiting primarily upstream locations did not drift outside of this zone, whereas upstream-inhabiting responders drifted into downstream areas. For three taxa (two responders and one non-responder) drift was related to benthic densities at manipulation sites but not at control sites, suggesting a strong role for drift dispersal in effecting change. Overall, there were no strong differences in drift rates between responders and non-responders. Likewise, there were no differences in adult numbers trapped at manipulation and control sites. Our results suggest that relatively few species had possible dispersal constraints. Instead, non-responding taxa were more likely blocked either by unsuitable environmental conditions or by an inability to invade established communities. Nonetheless, this study was conducted in a single stream. A new research project is evaluating whether the retention of detritus can improve the diversity of multiple streams degraded by land clearance in Victoria.

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New methods reveal the relationships between riparian vegetation, retention-capacity, and standing stocks of CPOM in streams.

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One benefit of riparian revegetation is it delivers CPOM (Coarse Particulate Organic Matter) to streams and hence resources of food and living space for aquatic species. However, revegetation of cleared stream banks has not obviously increased CPOM loadings. One reason may be that streams have lost retentive capacity, i.e. the capacity to trap and retain CPOM within the channel. In this study, we explicitly tested how changes in CPOM inputs (riparian vegetation) and channel characteristics (retentive capacity) affect CPOM loadings. We predicted positive relations between riparian vegetation, retentive capacity, and CPOM loadings. We surveyed riparian width (GIS data), retentive capacity and CPOM at 36 sites (length 100 m) in Victoria. CPOM loadings (gm^{-2}) were estimated from 35 random benthic samples per site. Retentive capacity was surveyed using transects (15/site) to estimate the amount (m) of retentive structure (e.g. large wood, cobbles/boulders) per metre of transect. This measure of retentive capacity is more intuitive and easily comparable between streams than existing measures of retention, e.g. average distances that leaves drift before being retained. Channel retention was also surveyed for 300 m upstream of each site. Supply and retentive capacity both affected CPOM loadings but the results were context-dependent. As expected, CPOM loadings were lowest at sites with poor local retention, but also at sites with high retention but low supply. CPOM loadings were highest at sites with high local retentive capacity and supply, but also at sites where low retentive capacity upstream of the site increases the longitudinal supply of CPOM. Our findings demonstrate that retentive capacity can have large effects on CPOM stocks. Restoring retentive capacity may complement revegetation efforts, and our rapid survey method will be useful to prioritise resources to sites and rivers where increasing vegetation and/or retention-capacity is likely to increase CPOM.

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The Victorian Index of Estuary Condition: benchmarking estuary resource condition with tested biotic indicators

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Victoria's strategies for the management of land, water and biodiversity are supported by evidence-based decision making. A mix of evidence is required to support continued improvements in decision making. Information on the condition of natural resources assists in prioritizing management investment and communicating the status of environmental assets to the community. The Victorian Waterway Management Strategy identified a need to align estuarine assessments with the state-wide condition assessment and reporting tools used for rivers, streams and wetlands. As such, an Index of Estuary Condition (IEC) has been developed for the purposes of: i) reporting on the condition of estuaries, ii) assisting the prioritization of management investment among estuaries, and iii) providing a baseline for assessing long-term changes in resource condition. The development of the IEC has drawn on research on the connection of estuaries to their catchments. Several indicators that have demonstrated relationships with pressures and stressors including catchment land use and nutrient loading, are incorporated into the IEC. These include the dominance of macroalage over macrophytes, planktonic chlorophyll a concentrations, and the representation of demersal species in fish assemblages. The first state-wide IEC assessment is being implemented in 2017-2019, for reporting in 2020. Citizen scientists contribute to the IEC by monitoring physical water quality parameters and chlorophyll a.

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Aggregating our knowledge using a coupled hydrodynamic-biogeochemical/ecological model to enhance our understanding of the environmental and ecological conditions of the Gippsland Lakes

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Aquatic ecosystems are difficult to manage owing to the myriad of ecological and physical processes driving these systems. Two complex yet fundamentally important processes within these systems are the mixing dynamics of dissimilar water masses and biogeochemical cycling between organic and inorganic forms. Coupled hydrodynamic-biogeochemical models can integrate these fundamental processes, enhancing our conceptual understanding of system dynamics while identifying knowledge gaps and informing management actions. Here we illustrate two applications of a hydrodynamic-biogeochemical model to better understand nutrient-bloom dynamics as well as juvenile fish dispersal in the estuarine Gippsland Lakes. Our model consists of a hydrodynamic component simulating transport and mixing in the water column and a biogeochemical/ecological model describing processes in the water column and sediment compartments. Apart from standard processes common to these models, we also included benthic bioirrigation and salinity-dependency grazing as potentially significant yet poorly understood factors influencing nutrient cycles and phytoplankton population dynamics (highlighting two important knowledge gaps). We used the model to explore the sensitivity of *Nodularia spumigena* bloom development to different physical, biological and ecological factors. We found temperature and salinity are the primary factors initialising *Nodularia* blooms in the lakes; phosphorus controlled the duration, size and severity; bioirrigation amplified sediment-nutrient exchanges and the formation of *Nodularia* blooms; and sediment phosphorus release supplied most of the phosphorus supporting *Nodularia* bloom development. We combined the hydrodynamic model with field sampling to explore the relative importance dispersal and habitat quality in distributions of juvenile black bream *Acanthopagrus butcheri*. Preliminary results showed that dispersal of juvenile bream within the lakes was limited to areas directly influenced by river plumes; recruitment was absent in areas remote from the plumes (even those with ideal seagrass habitat). These findings highlight the utility of hydrodynamic models for identifying critical nursery habitats for fishery species and prioritising habitat-focused management actions.

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Remote sensing and spatiotemporal analysis of surface water dynamics and environmental change at subcontinental scale

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Surface water (SW) is a critical resource in semi-arid areas. The Murray-Darling Basin (MDB) of Australia, one of the largest semi-arid basins in the world has suffered significant water shrinkages during the Millennium Drought (1999-2009), followed by extensive flooding. To synoptically quantify changes in SW extent and flooding dynamics over MDB, we used seasonally continuous Landsat TM and ETM+ data (1986 – 2011) and generic machine learning algorithms. We further mapped flooded forest at a riparian forest site that experienced severe tree dieback due to changes in flooding regime. We used a stratified sampling design to assess the accuracy of the SW product across time. Accuracy assessment yielded an overall classification accuracy of 99.94%, with producer's and user's accuracy of SW of 85.4% and 97.3%, respectively. Overall accuracy was the same for Landsat 5 and 7 data but user's and producer's accuracy of water were higher for Landsat 7 than 5 data and stable over time. Our validated results document a rapid loss in SW. The number, size, and total area of SW showed high seasonal variability with highest numbers in winter and lowest numbers in summer. SW extent per season per year showed high interannual and seasonal variability, with low seasonal variability during the Millennium Drought. The approach developed here is globally applicable, relevant to areas with competing water demands (e.g. Okavango River delta, Mekong River Basin).

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Using flexible mesh modelling to simulate turbidity in a shallow, oligotrophic lake

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Woods Lake is an oligotrophic, polymictic, impoundment in Tasmania. It hosts several endemic species, as well as native charophyte and macrophyte beds. Hydro Tasmania manipulates the water level which is linked to increased turbidity and changes to the trophic status of the lake that may have undesired consequences to the lake ecosystem. To facilitate proactive environmental management Hydro Tasmania aims identify the role of water level manipulation in driving turbidity and fostering biological resilience. While field monitoring and experimental work have provided valuable insight into some aspects of the lake's response to water level manipulation, a modelling approach is essential to providing comprehensive picture of system dynamics. We use a flexible mesh finite volume numerical model (TUFLOW-FV), coupled with an aquatic ecodynamics library (AED2) and surface wave model (SWAN) to simulate hydrodynamic, sediment transport and water quality processes. With a range of water levels and wind conditions we use the model to investigate sediment resuspension and consequent turbidity under different combinations of wind speed and water level. Since we use a 3D mesh to define the lake area we are able to explore responses to water level and wind speed in different regions of the lake. In Woods Lake the critical areas of interest are littoral zones and vegetation beds and using the 3D mesh these areas can be specifically targeted with fine resolution modelling. We simulated vegetation response to water circulation, sediment resuspension, and changing light climates, which allows us to explore the threshold where turbidity has a detrimental effect on ecosystem processes as a function of lake depth. Outputs from the model are validated against values collected in the field. Overall, the model output provides further evidence about the depth thresholds where lake turbidities become excessive and can be used to refine operational risk bands.

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Aquatic Sciences Data Reference Model

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Context: To inform effective decision making, aquatic ecosystem scientists are required to integrate and interpret information from a variety of sources and domains such as biology, chemistry, hydrology, geology, meteorology, climate science and geophysics.

Problem: Preparation, analysis, interpretation and communication of data from disparate sources in different formats is a challenging task. Data from different domains can often be stored differently and is subject to multiple interpretations. This suggests a need to define a taxonomy of aquatic ecosystem data.

Solutions: To address the problem in hand, this paper proposes the Data Reference Model (DRM) to facilitate the understanding of data entities, topics and relationships of data within the Aquatic Science domain.

Research Method: A series of brainstorming exercises with experienced aquatic ecologists identified a range of data entities and an analysis of existing data standards provided clarity to the entity selection process. Adherence to the Open Geospatial Consortium (OGC) WaterML-WQ Best Practice and the data standards of the Atlas of Living Australia provided guidance to the development of the Aquatic Sciences DRM. The DRM is documented as a tree structure diagram and presented as a poster of data entity taxonomy, to enhance communication. Finally, it is applied to a ten-year aquatic ecosystem monitoring dataset, to demonstrate implementation.

Impact: The DRM is aimed to be an important tool for the facilitation of communication between practitioners of aquatic ecosystem science and information systems specialists. It establishes a vocabulary that the two, almost opposing parties, can comprehend and provides a structured and tested approach to data interpretation and governance.

Conclusion: The DRM is not intended to be a static document that covers the entirety of its subject matter, but rather an evolving model that, through ongoing collaboration, will facilitate communication and understanding, ultimately leading to improved data driven ecological outcomes.

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Determining key wetland hydrological parameters using analysis of Landsat imagery

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The Queensland government regularly assesses the impact of water resource use on key ecological assets. One asset used to assess impacts is the Eastern snake-necked turtle (*Chelodina longicollis*). Modelling risks to *C. longicollis* requires a wetland commence-to-fill threshold (ML river discharge) and persistence (days) as input variables. Previously, these values have been coarsely estimated. We developed an approach combining spatial analysis, time series analysis of Landsat imagery, river gauge flow observations, and post processing in Microsoft Excel to determine (a) commence-to-fill thresholds and (b) the persistence time of selected floodplain wetlands. A wetlands shape file (ArcMap) was sourced from Queensland Wetland Mapping (wetlandinfo.ehp.qld.gov.au/wetlands) and filtered to select >800 floodplain wetlands of interest within the Condamine-Balonne, Moonie and Dumaresq-Macintyre catchments. A newly optimised Landsat-based water mask was used to identify patterns of filling and drying within the selected wetlands for the period from 1988–2015. This resulted in a sequence of dates, listing each wetland as wet or dry, including the number of wet pixels in each wetland. Two Excel macros were then developed: Firstly, to correlate wetland filling dates with overbank flow events at the closest river gauge, and define a commence-to-fill range, and secondly to identify drying sequences to estimate wetland persistence. The approach successfully generated commence-to-fill thresholds and persistence times for wetlands throughout the three catchments, and was used to model risk profiles for *C. longicollis* under a number of water resource development scenarios. The next step in this work is to conduct surveys/bathymetry and install depth loggers at a sub-set of wetlands to validate this method. Key wetland complexes providing breeding and foraging habitat for *C. longicollis* will be identified for this purpose. This approach can potentially be applied to other catchments throughout Queensland and Australia to determine these parameters over broad spatial areas.

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Preliminary Key to Mature Female *Paratya* (Decapoda : Atyidae) from Australian inland waters.Putting a face to a name!

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The Australian shrimps of the genus *Paratya* are widespread throughout eastern Australia from Queensland to South Australia and in Tasmania (Cook et al., 2006; Williams, 1977; Williams & Smith, 1979) (Fig 1). The first species of *Paratya* from Australia, *Paratya australiensis*, was described by Kemp (1917). Since first being described the taxonomic history of *Paratya* in Australia has been one of confusion due to the high morphological variability within material collected from a wide range of locations. Riek (1953) recognised five taxa but Williams (1977) did not consider Riek's revision to be valid and in a subsequent paper (Williams & Smith, 1979) all Riek's taxa were formally synonymised with *Paratya australiensis* Kemp. A series of papers on the genetic characteristics of Paratya (Baker et al., 2004a; Baker et al., 2004b; Cook et al., 2007; Hancock et al., 1998; Hurwood et al., 2003; Page et al., 2005) and which culminated in the paper by Cook et al. (2006) demonstrated nine distinct lineages over the geographical range of *Paratya*. A further lineage was discovered by McClusky (2007) from the south west of Victoria. A key that links morphological and molecular data is presented enabling the identification of all the separate lineages of "*Paratya australiensis",* with the exception of the one from SW Victoria. To avoid the variability caused by sexual dimorphism only female characteristics are presented here but the key seems to work for males too, but not all lineages have been compared.

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Australian freshwater molluscs

Winston Ponder

This presentation will outline the composition of the Australian freshwater molluscan fauna, as it is currently understood and highlight some areas where future work is most needed. It will also introduce a recent Lucid interactive key and information resource for all of the named native and introduced taxa. The use and limitations of the key will be discussed.

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Revision of the genus *Dinotoperla* Tillyard, 1921 (Plecoptera: Gripopterygidae).

Julia Mynott[1]

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The larval taxonomy of Australian stoneflies (Plecoptera) shows a large disparity in knowledge when compared to the adult taxonomy with many species having undescribed larval forms. The importance of stoneflies as an indicator group for monitoring aquatic ecosystems means knowledge of the larval taxonomy and the ability to identify species is essential. This study combined morphology and mitochondrial gene sequences to associate the adult and larval life-stages for species of *Dinotoperla* Tillyard. Morphological identification of adult males was recognised for 17 of the 35 *Dinotoperla* species and combining molecular data with morphology confirmed eight new adult-larval life stage associations. Further, molecular data supported the larval taxonomy for five morphospecies that remain unassociated. The combination of molecular and morphological methods enabled the larval morphology to be reassessed for the genus *Dinotoperla* and this has led to the establishment of two new genera, *Odontoperla*, and *Oedemaperla*, and the new species *Dinotoperla aryballoi*, *D. tasmaniensis*, and *Oedemaperla shackletoni*, as well as the new or updated descriptions of the larvae of 31 species and a comprehensive dichotomous key to these larvae.

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Taxonomic implications of DNA barcode data for Trichoptera.

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DNA barcoding is a useful tool for informing taxonomic studies. Over the past seven years, we have compiled a DNA database of the Australian Trichoptera, which includes over 1600 sequences from around 220 species. These data have been made publically available on the Aquatic Invertebrates of Australia (AIA) DNA database, through the Barcode Of Life Database. The data have highlighted groups that contain cryptic diversity. These are likely to undergo future taxonomic changes. However, some groups have genetic delineations that are not distinct and interpretation remains difficult. In this presentation I will discuss these findings and issues as well as provide an overview of the AIA database.

122

How are Australia's listed dragonflies doing?

Gunther Theischinger[1]

1. NSW Department of Planning and Environment, Office of Environment and Heritage, Water Science, Lidcombe

The Australian dragonfly fauna is briefly introduced following a recently (2013) by world-wide consensus established and since generally recognised classification. A photo of an adult and when possible an illustration of a larva of at least one member of every larger taxonomic group is presented and the number of genera and species included is given. Following this the listed Australian dragonfly species are introduced by presenting their conservation status and its original reasoning, and their habitat and distribution. The habitat photos generally include only one particular habitat per species. The specific distribution maps show the available records with those from before the listing and those since the listing pointed out. The records are superimposed on maps showing the species' potentially suitable range predicted on matching environmental conditions (climate and habitat characteristics) from the recorded locations for the present and for 2080, considering a scenario with average temperature rising by approximately 5°C. Also presented is some information on behaviour, ecology, biodiversity, taxonomy and systematic status and position gathered at least partly by increased attention due to the listing. It is concluded that, in spite of additional records and sometimes considerable range extensions, the conservation status of the listed species is still appropriate as anthropogenic impact is increasing, in particular from population growth and climate change.

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A dichotomous key for aquatic Diptera pupae to family level

Chris Madden[1]

1. Freshwater Macroinvertebrates, LOCKLEYS, SA, Australia

A dichotomous key to pupae of aquatic Diptera families will be presented. The key will be illustrated with photographs of Australian taxa where possible. For some families keys to sub-family or tribe will also be provided when pupae are distinctive.

124

Keys to the Australian clam shrimps (Crustacea: Branchipoda: Laevicaudata, Spinicaudata, Cyclestherida).

Brian Timms[1]

1. University of NSW, SYDNEY, NSW, Australia

The morphology and systematics of clam shrimps is explained followed by a key to genera and then each genus is examined, including its diagnostic features, list of species with their distributions, and references provided to papers with keys or if these are not available, then a preliminary key to species is included herein.

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The recovery of riffle macroinvertebrates after river drying: the role of low flow access rules

Daniel Coleman[1], Tim M. Haeusler[1], Andrew J. Brooks[1, 2]

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2. University of Melbourne, Melbourne

Flowing water environments and the dependent communities within these habitats are vulnerable to natural and human induced river drying. Recovery of macroinvertebrate communities after drying is initiated by epilithon-browsers and filter feeders with shredders and predators late arrivals. Low flow access rules are designed to reduce anthropogenic drying and protect aquatic ecosystems from water extraction. The aim of this study is to assess recolonisation of macroinvertebrate communities following a drying event and test whether low flow access rules provide adequate protection for these communities. In order to understand what taxa are affected by inadequate low flow protection we will be measuring macroinvertebrate recolonisation after one or more drying events in five Murray Darling Basin intermittent streams. Quantitative macroinvertebrate samples (identified to genus), flow and water quality will be collected over a period of 24 months at three sites (riffles) within each of these streams. We will then identify the time required to reach a point of equilibrium or climax community and use this information to assess the ecological significance of low flow protection rules in providing refuge for flow dependent macroinvertebrates between periods of higher flows.

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Bacteria to birds: Tracing the flow of energy through a wetland to understand ecosystem responses to environmental watering

Lindsey Frost[1], Darren Ryder[1], Paul Frazier[1], Mark Southwell[2], Wing Tsoi[1]

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2. Eco Logical Australia, Armidale, NSW, Australia

Environmental water comes at significant economic cost and requires many political, social and cultural trade-offs. Accordingly, managers are being held increasingly accountable for demonstrating tangible outcomes from flow management strategies. Monitoring programs generally focus on population level responses in iconic, higher-order consumers. however, these 'flow-ecology' relationships do not specifically investigate the mechanisms underlying the observed responses. The production and transfer of energy within an ecosystem (energetics) is a fundamental driver of ecosystem structure and function. We know that patterns of biodiversity and trophic interactions change in response to altered hydrological regimes. Energetics provides a framework to map and quantify the changes in energy resources underlying these responses. Energetics has been applied in fisheries management to estimate carrying capacity for target species but has rarely been applied in environmental management. We propose that the application of an energetics approach to environmental flow monitoring in a near-terminal inland wetland will inform and improve environmental flow management for that system. Our study will combine biodiversity sampling of primary producers through to secondary consumers through several phases of inundation events to investigate community structure responses and construction of food webs to investigate trophic pathways within the wetland. Attributes measured will include taxonomic and functional richness, abundance, density and biomass. The study will encompass two distinct wetland vegetation communities, representative of long-term hydrological patterns and explore the connectivity and patterns of energy production and consumption within and between communities. We expect that the two vegetation communities will display different carbon assimilation pathways - one microbial, the other algal. The source, abundance and nutritional quality of basal resources will be investigated to assess the relative 'value' of each community. We aim to produce empirical food webs that can be used to inform predictive models of the trophic carrying capacity of the wetland under different inundation scenarios.

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Effects of Simulated Browsing on Brisbane Riparian Seedlings

Amanda M McArthur[1], Amy George[1], Fran Sheldon[1]

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Ecological restoration aims to assist in the recovery of an ecosystem that has been disturbed by human activity or natural disaster. Cattle are a serious threat to restoration efforts, shown to stunt seedling growth and reduce survival, preventing restoration from reaching success. Riparian areas h at higher risk, as fencing around riparian sites is often incomplete on the water-facing side, leaving that point open to browsers. Additionally, the maintenance and monitoring of restoration sites is often underfunded, leading fencing, particularly on leased land, to fall into ill-repair. Along the Brisbane River, many restoration sites are on land used for pasture, making cattle an immediate hazard. In the past, studies on the effects of cattle browsing have focused on North American species and their responses when grown in the field. In this study we examine the effects of simulated browsing on seedlings of three tree species, *Melaleuca viminalis, Casuarina cunninghamiana, and Eucalyptus tereticornis.* These species have been used in recent Brisbane riparian restoration projects are native to the Brisbane area. The seedlings will be grown in controlled conditions, with browsing simulated by 'pulling' photosynthetic material. There will be six levels of browsing intensity: 0%, 15%, 30%, 60%, 90%, and 100%. We aim to present the impacts of these simulated browsing regimes on absolute and relative above- and below-ground biomass, as well as observed morphological differences in species responses. Our results may be of use to inform future restoration projects about the relative resilience of the selected species to browsing damage.

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10 years after active and passive riparian restoration: riparian and geomorphological condition

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Riparian zones are productive and dynamic habitats, which possess a diverse range of ecological processes. Many riparian areas across the world are degraded, affecting form and function. Riparian restoration has, therefore, become an important objective for landscape managers. Riparian restoration is based on an underlying assumption that on-ground works improve the ecological function of the riparian zone. Unfortunately, long-term monitoring and assessment of ecological restoration projects is rare. This study investigates the legacy or value of 'one-off' restoration activities in terms of a long-term change. Between 2000 and 2003, a large scale restoration project was undertaken in the Upper Murrumbidgee Catchment using three restoration methods (two active: planting of tubestock, and direct seeding; and one passive: fencing to exclude livestock). The objectives were to reduce sediment and nutrient delivery into the Murrumbidgee River by controlling erosion and protecting and enhancing riparian vegetation. In 2014, 10 years after restoration, a riparian vegetation (using RARC) and a geomorphological assessment (using ESA) were performed at a subset of sites that had undergone different restoration methods, in addition to unrestored sites. Aerial imagery was also used to compare width of riparian canopy vegetation and projective foliage cover before restoration and ten years after. Restoration has led to significant improvements in total riparian vegetation condition and in particular riparian attributes. Width of riparian canopy vegetation, native mid-storey cover, native canopy cover and seedling recruitment were significantly better in sites that had been actively restored compared to the unrestored sites. The width of riparian canopy vegetation and projected foliage cover had improved in sites in all restoration methods, especially those actively restored. After ten years geomorphological condition was found to be significantly better in sites in all restoration methods compared to the unrestored sites, demonstrating the importance of livestock exclusion to improve bank and channel condition.

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Macroinvertebrates in tropical ephemeral streams: ecological patterns, biomonitoring and management

Leigh Stitz[1]

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Ephemeral streams represent a particular management challenge, due to their characteristic wet/dry phases. There is a mismatch between the science used to underpin surface water monitoring tools, and the natural state of key ecosystems. There is a critical need to understand baseline patterns in ecological data and to establish regional tools for assessing the health of the ephemeral streams in the Fitzroy catchment.

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Scaling biodiversity responses to hydrological regimes

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5. Kansas State University, Manhattan, USA

Understanding natural and anthropogenic factors driving patterns of biodiversity is a fundamental goal in ecology. Despite the importance of the hydrological regime for aquatic ecosystems being well understood, we still lack a clear and unified conceptual understanding of how hydrology influences aquatic biodiversity from regional to local spatial scales. Much of our current understanding is based on the taxonomic and functional richness of communities at individual locations and how these facets of biodiversity are shaped by natural hydrological disturbances (e.g. floods, droughts) or altered by anthropogenic changes to hydrological regimes due to human water use and hydrological regulation. We review and synthesise published literature on hydrology-biodiversity relationships to (i) determine how scale-dependent components of freshwater biodiversity respond to hydrological gradients and hydrological regimes and (ii) identify the specific underlying ecohydrological mechanisms responsible for patterns of biodiversity across spatial scales. Different ecohydrological mechanisms vary in their effect on freshwater biodiversity across spatial scales; hydrological disturbance regime is an important driver of biodiversity across local-regional scales, and both hydrological connectivity and the effect of hydrology on habitat strongly influence landscape and local scale biodiversity. We highlight that there remains a lack of research to understand how hydrological regimes influence both functional and phylogenetic aspects of freshwater communities across spatial scales and identify six research priorities necessary to improve our understanding of multi-scaled biodiversity responses to hydrological regimes. Addressing these gaps in understanding is critical, as a central goal of freshwater conservation policy is to manage hydrological regimes to protect or enhance freshwater biodiversity.

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Feral animal exclusion is key to the restoration of waterholes in central Australia

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Feral animals have caused major damage to waterholes in central Australia. These animals are much larger than the native fauna and often occur in large numbers. Due to their size and hooves, they can cause significant erosion to the fragile soils around waterholes. In very dry times feral animals routinely perish in waterholes, further damaging these sites and making their waters unusable for both people and native animals. The recent degradation brought about by feral animals to important water places in arid Australia has led to an urgent need to restore the ecological and cultural values of these sites. While fencing sites is often used to exclude feral animals, it can have mixed success. This study looks at the effect of feral animal exclusion by fencing on terrestrial vertebrate communities and vegetation at two waterholes. While the fencing worked at one of the sites, at the other site feral animals were not effectively excluded in times of drought.

Vertebrate communities altered in response to feral animal exclusion. Vegetation cover increased, but both sites are now being invaded by exotic buffel grass C*enchrus ciliaris*. The next step of the restoration will need to focus on the control of invasive plants but also maintain the exclusion of feral animals.

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Building a wetland inventory for NSW

Joanne E Ling[1], Megan Powell[1], Grant Hodgins[1], Alie Cowood[1], Michael Hughes[1]

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Wetlands deliver valuable ecosystem services but we don't have consistent and comprehensive maps to characterise and manage these wetlands. An inventory of NSW wetlands is a fundamental to support risk assessment and adaptive management. A comprehensive inventory of wetlands will ensure that high quality regional scale data and information are available to the community and to those decision makers who are responsible for monitoring and managing our wetlands for current and future generations. The development of semi-automated techniques for wetland mapping and assessment is a key step toward development of a statewide inventory and a more coordinated approach to management across NSW. We developed and tested semi-automated techniques for rapidly generating inundation histories (a key-driver for wetlands) over large arid and semi-arid areas. This level of automation requires management of uncertainty, which can only be satisfactorily achieved with a rigorous field validation program. Regional stakeholders and the historical knowledge that they hold are also critical for accuracy assessment and management of uncertainty, because any field validation exercise represents only a snapshot in time, within a dynamic wetland landscape. Through the two-year pilot project in the Lachlan River catchment and along the NSW coast (Lake Macquarie and Central Coast), we developed the tools to build an inventory of wetlands. Our toolkit includes frameworks, method guidelines for mapping and classification of wetlands, a wetland map for the Lachlan and Central Coast/Lake Macquarie (preliminary), and a wetland plant indicator database (preliminary). The potential uses for a NSW Wetland Inventory are extensive. Examples range from identification of environmental assets, through monitoring and evaluation of wetlands over time, to comparing similar wetland types for priority protection through Ramsar. State-wide management of wetlands will benefit from consistent and comprehensive mapping of wetland locations, extents and types across the state.